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# Problem solving in technology-supported learning environments

Gwyn Brickell  
University of Wollongong

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# **Problem Solving in Technology-Supported Learning Environments**

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**B.Sc. (NSW), Dip.Ed. (W'gong), M.Ed. (W'gong).**

A thesis submitted in partial fulfilment of the requirements for the degree of  
Doctor of Education  
from the Faculty of Education, University of Wollongong.

April, 2002



# Abstract

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The increasing availability of technology-supported learning environments designed to enhance the development of skills for life-long learning in the classroom and the wider community provides opportunities for student-centred and cooperative learning. Researchers experimenting with these learning environments are attempting to use cognitive tools to scaffold learners in the process of a cognitive task, usually presented in the form of a problem.

Constructivist approaches to learning shifts the focus for organising knowledge construction from the teacher to the learner. Learners therefore need to develop a range of information processing skills to cope with this approach to learning. When faced with the responsibility for knowledge construction, they are thrown on their own management resources. While some may have the metacognitive skills to cope, many fend poorly in the increased complexity of such a learning environment. Many see the task as daunting and complex and feel ill-prepared for such creative freedom and choice of direction. Such learners need tools to help them represent the knowledge they are acquiring.

This study explores ways in which a range of support frameworks may be used to assist learners when solving problems of an ill-structured nature. The main objective was to gain a better understanding of how learners identify, organise and present information when problem solving in technology supported learning environments. The research has focussed on the three main areas: *problem clarification* (identifying the nature of the task and what information was required or provided); *solution formulation* including data collection and the solution process (sorting out the resources and generating new information as required); and *presentation of argument* for the solution (identifying propositions and the appropriate evidence for support or refuting the argument).

The primary data gathering strategies adopted for the study focussed on individual participants' notes, audio transcripts of think-aloud protocols, participant observation and participant interviews.

The results from the analysis of the collected data indicate that many learners have underdeveloped skills and find it difficult to adopt a systematic approach to both information gathering and in the analysis of supporting information. In constructing a response to the problems under investigation many participants preferentially consider one or two pieces of information rather than discriminating between issues. As a result of poor search strategies a number of participants missed access to essential information. Consequently this resulted in the formation of poorly constructed responses when developing an argument to support the answer to the problem under investigation.

Of the four frameworks introduced into the study, the Six Hats framework and the Critical Thinking framework appear to offer clearer strategies to assist learners with problem clarification and solution formulation. There was little difference in the quality of argument produced by participants using the different frameworks. The findings arising from the research suggest that many learners would benefit from cognitive support tools when engaged in solving ill-structured problems within technology supported learning environments.

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# Acknowledgement

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Without the help, support and encouragement of a number of people, this thesis would neither have been started nor completed. I would like to take this opportunity to publicly thank all those involved.

In total, thirty-two pre-service teachers participated in the study and I would like to extend my appreciation to each of them for their cheerful and generous contributions and for their time and commitment associated with the data collection.

Specific acknowledgement is also due to my two supervisors, Professor Barry Harper and Doctor Brian Ferry who provided constant, prompt and supportive feedback that helped maintain my enthusiasm and direction.

I am also grateful to my peers and colleagues at the University of Wollongong for their guidance, support and friendship throughout this study.

To my wife Dianne, and our sons Scott, Evan and Paul, thankyou for being there in helping maintain a focus on the important things in life.

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# Declaration

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I, Gwyn Brickell, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Education, in the Faculty of Education, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged.

The dissertation has not been submitted for qualifications at any other academic institution.

Signed:

Date:

17th July, 2002.

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# Chapter 1

## Introduction

# Chapter One

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## 1.1 Background

In recent years a major growth in the development and application of technology-supported resources for learning has occurred through changes in information technology, specifically related to CD-ROM and Web-based development. This technology has the potential to provide an information-rich learning environment that encourages the user to explore and interact with the visual environment by collecting, organising and interpreting information to solve problems that support specific learning outcomes. In an effort to develop an understanding of the nature of successful problem solving, researchers over a number of years have tended to compare the performances of 'novices' and 'experts'. However, it may be more informative to examine more closely the learner's views of problem solving and the 'theories and actions' (Land & Hannafin, 1996) they employ during their investigation process.

Initial investigations to examine student perceptions of the problem-solving process and the strategies they employ in moving from novice learners to expert practitioners have indicated considerable differences in problem-solving skills between students (Brickell, 1998). It was found that the majority of the year nine students studied appeared to be competent users of the technology but had difficulties with clarifying the problem and developing a plan of action towards achieving a 'solution'. Also, little evidence of re-checking or reflective analysis of the problem was observed. While recognising that ill-structured problems may have several acceptable solutions, assessment of the written responses of students indicated that their perceptions of a 'correct' solution varied considerably. Most students reported they had no difficulty in developing a solution and had clearly understood, from the introduction to the ill-structured problem, what the issues were. However, analysis of their written 'solutions' showed a lack of structure and a lack of clarity of ideas. For a number of students the 'solutions' showed that they did not understand what the problem actually required. This is possibly a reflection of the varying ways in which students make decisions based on their

individual learning patterns or some other influence(s) on their individual learning outcomes that may include:

- lack of domain knowledge (Chi, Glaser & Farr, 1988);
- lack of experience with ill-structured problems (Voss & Post, 1988);
- lack of suitable support structures, such as 'scaffolding' or 'coaching' (Shabo, Guzdia & Stasko, 1997).

Researchers experimenting with technology-supported learning environments are attempting to scaffold learners during a cognitive task that is usually presented in the form of a problem. The scaffolding is provided in the form of a cognitive tool (Jonassen, 1996) that provides both cognitive and computational support to guide and assist the learner in defining the issues and developing strategies for problem solving and learning. In a recent study on the use of cognitive tools in supporting learning outcomes in interactive multimedia environments, Gordon (1998) found that students who used a genre' template had a framework to use in their decisions about the presentation of the data/information they had gathered as they constructed a possible solution to an assigned problem. However, there was no significant difference between those students who used the genre' templates and those who did not in either the effective use of evidence collected in supporting possible hypotheses or in the quality of the argument presented as a solution. In a previous study, Atkins and Bissett (1992) found that the computer-based tools were only used to a limited degree by the learner. Rarely were the tools used to refine the learners' initial strategies or understanding and for the most part learners continued to use random strategies within the learning context of the assigned task.

The next stage in developing an understanding of solutions generated through problem solving is to further examine the strategies used by learners in developing responses to ill-structured (Jonassen, 1997) or open-ended problems (Land & Hannafin, 1996). Based on this data it should be possible to develop specific cognitive tool(s) (Jonassen, 1996) that assist learners with problem identification and the construction of a solution.

### 1.1.1 The Problem

The issue of teaching broad-based thinking processes, rather than more content-specific skills, continues as a theme both nationally and internationally. Recent curriculum documents in Australia into the use of computer-based technologies emphasise the development of cognitive skills through the use of investigation, reflection and analysis, synthesis and evaluation to generate or refine knowledge (Department of Education & Training, 1997). Such skills are more widely associated with the more complex ('higher order') learning strategies proposed by Bloom (1956) where thinking takes place in the upper levels of the cognitive processing hierarchy. It has been suggested by Jonassen (2000) that the development of the 'higher order' cognitive skills can be achieved through problem solving in environments that present tasks in ill-structured domains.

When a learner encounters a problem-solving exercise within technology-supported learning environments, s(he) may find that the individual cognitive strategies that were previously successful do not support them as well in this setting. Reasons for this may relate to :

- *Individual learning style* – learning style is a biologically and developmentally imposed set of personal characteristics that make the same learning strategy effective for some and ineffective for others. Learning style refers to the way learners select, process and retain information (Jonassen & Grabowski, 1993; Davidson, 1990; DeBello, 1990; Kolb, 1984). These styles are information processing habits a learner uses to perceive, think, problem solve and remember (Messick, 1984);
- *Learner prior knowledge* – numerous studies have shown that learners need help to link new information with prior knowledge to enable construction of meaning in developing well-formed schema integration (Clarke, 1992; Hannafin, 1989; Jonassen, 1988);
- *Complexity of the presentation of information* – for many users the cognitive load that is placed upon them due to the complexity of the multimedia learning environment is sufficient to detract from the purpose of the task. This cognitive load has the potential to reduce schema acquisition (Sweller, 1994; Chandler & Sweller, 1991);

- ❑ *Factors that relate to transfer* – research into the self-regulation of cognitive skills and learning strategies suggests that many learners need help in transferring prior knowledge to new situations such as those experienced in problem-solving (Lin, 1995; Guzdial & Soloway, 1993; De Corte, 1990; Hannafin, 1989).

From a constructivist view of learning, effective learning situations are those in which the learner is immersed in the resolution of the problem where the learner's skills in qualitative reasoning, self-questioning and reflection can be applied and developed. However, within the field of educational technology it seems that many students need to be supported in acquiring and developing these information-processing skills as the technology is integrated into the classroom. Therefore it is timely to investigate whether computer-based cognitive tools may be of use in assisting the development of 'higher-order' cognitive skills.

### **1.1.2 Terminology used in Study**

#### *Cognitive tools*

David Jonassen has described cognitive tools as "... technologies, tangible or intangible, that enhance the cognitive powers of humans during thinking, problem solving and learning" (Jonassen & Reeves, 1996). For the purpose of this study, the tools in question refer to external computer-based devices that extend the thinking processes of the user together with the four support frameworks (Appendix 1) to strengthen the cognitive strategies of the participants.

#### *Constructivism*

This is a theoretical perspective on learning where knowledge is viewed as a constructed entity based on individual experiences and social interaction rather than the transfer and absorption of information through direct instruction (Duffy & Jonassen, 1992).

#### *Informal Reasoning*

Informal reasoning is a process that involves the evaluation of evidence to support a claim or conclusion within a problem-solving scenario.

The process is more directly applicable to situations where the problem is ill-defined and requires the use and evaluation of evidence relevant to the problem (Means & Voss, 1996).

### *Ill-structured problems*

These problems have vaguely defined or unclear goals, possess multiple solutions and contain uncertainty about which concepts, rules and principles to apply (Jonassen, 1997).

### *Metacognition*

Metacognition refers to the control and regulation of one's own cognitive processes. It has been described as "..... the executive decision-making process in which the individual must both carry out cognitive operations and oversee his/her progress"(Jo, 1993, p.416).

### *Problem Solving*

A problem is generally regarded as a question or circumstance involving uncertainty in its resolution. Shunk (1990) suggests that problem solving encompass the efforts required in achieving a goal for which one does not have an automatic solution.

### *Scaffolding*

This refers to the support structures provided to assist the thinking and communication skills of learners in their path to new knowledge. It is a means of providing a bridge between what they know and new information they acquire (Vygotsky, 1978).

### *Situated Cognition*

Situated cognition is a theoretical approach emphasising higher-order thinking skills and has developed from research that explored ways in which people reason and solve problems in everyday life. According to Choi and Hannafin (1995, p.54), "Situated cognition emphasises the importance of context in establishing meaningful links with learner

experience and in promoting connections among knowledge, skill and experience”.

### **1.1.3 Cognitive Tools**

This study was based on the theoretical assumption that the most effective use of computer technology in an educational setting is when learners use it as a cognitive tool. However, to be used effectively as a cognitive tool, they must apply problem solving processes and employ higher-order reasoning strategies leading to cognitive growth. As such, the technology becomes a “mind-extension cognitive tool” (Derry & Lajoie, 1993, p.5).

Many cognitive tools facilitate metacognitive learning strategies and function as ‘mindtools’. These ‘generalisable tools that can facilitate cognitive processing’ (Jonassen, 1992, p.2) make it easier for the learner to process information. In this study four support frameworks were used to assist with the development of problem-solving strategies. The frameworks may be regarded as internal ‘mindtools’ that enhance knowledge construction. During the process of knowledge construction learners may utilise critical thinking skills to evaluate, analyse and correct concepts; creative thinking skills to elaborate, synthesis and visually link concepts and ideas; and complex thinking skills to assess, revise and provide alternative supported arguments (Jonassen, 1996).

External computer-based tools that extend the thinking processes of the learner are a feature of the software used in this study. These tools provide opportunities for the learner to engage in meaningful processing of information and collection of data and are more fully outlined in the following discussion.

### **1.1.4 Discussion of Research Materials**

#### ***The Support Frameworks***

Several frameworks have been suggested that assist learners in the problem-solving process. Four of these - Critical Thinking, (Ennis, 1991), Six Thinking Hats, (De Bono, 1992), Venn Diagram, (Gunstone & White, 1986) and Concept Mapping, (Novak, 1990) - were chosen for this study. Each of the



frameworks was chosen on the basis of the relevance to enhance 'higher-order' thinking skills and the capacity for the framework to be presented in a possible computer-based format.

- ❑ Critical Thinking is a process that encourages questioning or inquiry as the learner seeks to understand, evaluate or resolve an unfamiliar situation. Contemporary views of critical thinking involve analysing, planning and inferring skills associated with 'higher-order' approaches.
- ❑ The Six Hats framework encourages the development of thinking skills through the metaphor of changing different coloured hats to encourage different aspects of thinking at specific points in the process of problem resolution.
- ❑ Venn Diagrams are pictorial representations (usually interlocking circles) displaying relationships among different sets of information. Items common to these sets of information are found in the circles' intersection.
- ❑ Concept mapping encourages learners to visualise concepts and the hierarchical relationships among them. These schematic representations may act as visual roadmaps that show pathway connections among concepts.

### *Exploring the Nardoo*

For this study the CD-ROM software package *Exploring the Nardoo* (1996) was chosen as the medium for providing learners with problems set in a technology-supported learning environment. *Exploring the Nardoo* portrays a simulated inland river catchment environment that can be navigated through four time zones representing the river's evolution from its pristine state to the present day. The software contains measurement tools for investigating the physical, chemical and biological characteristics of this ecosystem and provides a variety of media information (newspaper articles, television and radio reports) to support the available investigations. This affords the learner the opportunity to record data, write notes, collect source text material to support the problem scenario and reflect upon or rework these ideas. This set of cognitive tools is available through the metaphor of a Personal Digital Assistant (PDA). The learner is able to use the tools and techniques of environmental science to construct knowledge in an authentic setting. A more detailed description of the features of the PDA will be presented in Chapter 3. Additional information

sources are provided through access to a Plant and Animal book and a filing cabinet containing a series of folders with articles relevant to a range of environmental issues.

Inquiry and problem-solving techniques are used as a primary learning strategy in the software package through learner engagement in a series of investigations. The investigations were developed from actual cases encountered in inland river catchment systems in Australia. When selected, each of the investigations is introduced by a 'Water Research Officer' who situates the relevant issue in the context of a 'real world' setting by inviting the user to actively engage in assisting with 'solving' the problem. These 'guides' also provide additional hints to direct the focus of inquiry.

Such technology-supported learning environments are important as they provide both teachers and students with innovative learning scenarios that support a constructivist approach to learning.

### **1.1.5 Purpose of the Study**

The study has two main goals:

1. To review a range of theoretical support frameworks which could help learners organise ideas and focus problem-solving strategies.
2. To understand how learners clarify, analyse and organise information when developing solutions to complex problems in technology-supported learning environments.

### **1.1.6 Significance of the Study**

In an effort to develop an understanding of the nature of successful problem solving, researchers have concentrated their efforts on comparisons of the performances between 'expert' and 'novice' problem solvers. These studies were confined to observed differences in cognitive structures between expert and novices in well-structured problem domains. In several subject-specific areas - Physics (Chi et al, 1981; Ross & Loftin, 1994), Chemistry (Comacho & Good, 1989,

Altwater & Alick, 1990), and Genetics, (Smith & Good, 1984) - clear distinctions could be seen in the strategies used during problem investigation and the degrees of success obtained by the participants in the two categories. Each of the studies demonstrated that the strategies of 'experts' were associated with a deeper understanding of the problem resulting from greater domain knowledge and better developed metacognitive strategies.

However, this research takes a different approach because it attempts to examine more closely learners' views of problem solving and the 'theories and actions' they use when they engage with the problem under investigation. This study describes how learners try to understand and engage the problem-solving process and the strategies they employed as they achieve appropriate learning outcomes. Essentially the study will focus on "... what students do, how well they do it and when it is done" (Pea, 1985).

The findings from this study should add to a deeper understanding of the cognitive strategies learners use when engaged in solving ill-structured problems. The identification of strategies employed by learners should guide future refinement of specific cognitive tools designed to assist them in future ill-defined problem solving tasks. Such tools have the potential to play a small but significant role for learners with 'weak' metacognitive strategies in the reduction of cognitive load associated with synthesising a written response to ill-defined problems that require the use of informal reasoning. The methods employed in this study, together with the associated findings, should provide some assistance to instructional designers, other educational practitioners and researchers as they seek to develop and evaluate further cognitive resources in similar contexts.

## 1.2 Overview of Methodology

This research was conducted on the premise that learners use a variety of strategies to solve problems. In order to provide a mechanism to focus on specific strategies, four alternative approaches to guide the problem-solving process were introduced. This study presents a methodology for examining the differences in these approaches.

### 1.2.1 Theoretical Perspective

Due to the exploratory and qualitative nature of the research questions, the study was conducted using a naturalistic inquiry approach. Tesch (1990, p.50) defines a naturalistic inquiry as "... a non-positivistic approach to research in which the researcher is the instrument, and the focus is on understanding the meaning the people under study give to their experiences."

The nature of the research questions suggested an emphasis on qualitative methods that would provide detailed information about learners' interpretations of the assigned questions and ideas, and actions they use in their approaches to reach a problem solution. The investigation followed a case study methodology described by Bogdan and Biklen (1982) as a detailed examination that is limited in scope to a single setting, subject, depository or event that is examined in detail.

This study is based on a constructivist paradigm which de-emphasises instruction and performance and places more responsibility for deciding what and how to learn on the learner. Constructivists argue that knowledge is constructed only in the mind of the learner. The learner individually constructs knowledge through the interpretation of experiences of the external world. Evaluation of constructivist learning emphasises higher-order thinking through identifying topics or issues, locating resources, planning investigations and activities, practising self-evaluation and formulating principles (Volker, 1992; Jonassen, 1991). This theoretical viewpoint is dealt with in more detail in Chapter two.

### 1.2.2 Research Questions

The main focus of the research was to address the question:

*How can learners be supported in problem-solving processes within technology-supported learning environments?*

To support this research question the following sub-questions were used in guiding the research:

1. What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?
2. What strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task within a technology-supported learning environment?

For sub-questions 1 and 2, the study focussed on the strategies employed by learners as they explored the problem space in developing their understanding of the problem in order to generate a solution. Based on previous research (Brickell, 1998; Gordon, 1998) it was assumed that the learners would exhibit a wide range of views in their responses.

This exploratory study (Yin, 1994) focussed on learner experiences with problem solving set in the context of a technology-supported learning environment. It examined ways in which information related to the assigned problem(s) was accessed and interpreted, what use learners made of their designated support framework and whether the use of the support framework had an impact on the quality of the argument presented.

### 1.2.3 Research Strategies and Data Sources

Several strategies were employed to promote the qualitative nature of the study in the gathering of data to support the research. Qualitative data collection techniques included computer assisted data collection of supporting evidence (via the software-based Personal Digital Assistant, or PDA), participants' hand-written notes, verbalisation of individual participants' explanations and problem-solving processes, participant observation supplemented with field notes and student questionnaires. The strategies used were:

- ❑ a review of the literature - this covers the associated issues relevant to this study;
- ❑ use of information – this was defined as the most appropriate choice of evidence, using supporting details (primary data) selected from a range of embedded resources, to support the argument presented;
- ❑ transcripts of verbalisation of participants' individual 'theories and actions';
- ❑ written observations by researcher – a record of 'actions' by each of the participants during each attempt at problem solving;
- ❑ student questionnaires – responses of participants after completion of both problem-solving sessions.

Each of these strategies will be addressed in more detail in Chapter two.

### 1.2.4 The Participants

This study involved a sample of thirty-two undergraduates (27 female, 5 male) from the University of Wollongong. The participants, all volunteers, were drawn from an introductory information technology class that is a core subject for both the Bachelor of Education and Bachelor of Teaching courses offered by the Faculty of Education. The female/male ratio of the participants in this study is a reflection of the student enrolment in these courses.

Once the rationale for the study had been explained to the participants they were assigned to one of four tutorial groups for training in both their allocated support framework and use of the CD-ROM. For the problem-solving phase of the study the participants were then asked to work individually on the

specific problems chosen for the study. The problems, together with the context in which they are set, are outlined in Chapter three.

### 1.2.5 Limitations

The following points need to be made about the limitations of the study:

- ❑ the study was limited to subjects who were in the first year of pre-service teacher training. The research strategies developed may be applicable to other contexts, and the findings may support and extend the work of previous researchers in the field, but specific findings may be unique to the population studied;
- ❑ the role of the qualitative researcher was as the main research instrument in observing and interacting with participants as well as collecting and analysing data. This raises issues of subjectivity in data collection and interpretation in relation to the evidence collected and the conclusions drawn. It is acknowledged that care needs to be taken to avoid bias in observing and recording participant actions or reflections and later in how the patterns of data are interpreted. To address these concerns the assistance of a colleague was used to review coding protocol, to verify the authenticity of audio transcripts and in the interpretation of the data. Further verification of the audio-tape transcripts was obtained through 'member checking' from participants;
- ❑ This research used think-aloud protocols as part of the data collection process. (Ericsson & Simon, 1992). Verbalisation is extrinsic to the problem solving process and somewhat unnatural in the context of everyday behaviour. Within this sample there would be some variation between individuals in their ability to articulate their problem-solving processes as they explored the problem space.

## 1.3 Structure of Thesis

This research report is organised in five chapters that provide the theoretical framework on how one sample of learners solve complex problems set within a technology-supported learning environment. These chapters include a discussion of the background to the study, an identification of supporting educational theory with respect to problem solving, metacognition and learning, an evaluation of the methods used to study learners' outcomes, an analysis of the data from the study and finally an overview outlining the findings and conclusions of the project. The structure of each of the chapters is as follows:

### □ Chapter 2 – Review of Supporting Literature

The purpose of this chapter is to provide a theoretical basis that supports the rationale for the study. The chapter contains four parts. Part one discusses problem solving and associated concepts. In particular it examines the contribution of problem solving theory to our understanding of how learners process information when investigating problems that may be regarded as ill-structured. Part two examines the theoretical approaches to learning in relation to constructivism, situated learning and metacognition. It focuses on research that is relevant to the study. In Part three the theoretical basis for the design of cognitive tools that assist learners to process and construct meaning from information presented in a multimedia format is discussed. Finally, in Part four a review of research appropriate to the study is undertaken. It was important to examine previous studies about problem-solving issues that were relevant to the context of this research as, not only are they a source of appropriate research techniques, but they also represent a source of data that may help in the development of suitable cognitive tools.

### □ Chapter 3 – Methodology

The focus of this discussion is on the methods used to gather and analyse data. Initially a summary of the research design and mode of inquiry is presented. This is followed with a description of the site, the participants, and the artefacts and methods used for data collection. The Chapter concludes with an outline of the data collection process.



□ Chapter 4 – Analysis of Data

Chapter four reports on the analysis of the results of the study. It provides a rich description of the strategies used by participants as they investigated the assigned problem(s) in an attempt to develop appropriate outcomes.

□ Chapter 5 - Findings/Conclusions

This chapter provides an overview of the study outcomes, together with a summary of each of the results of the sub-questions used to guide the research. The implications of the study are then reviewed, with limitations noted and suggestions for further research provided.

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# Chapter 2

## Review of Literature

# Chapter Two

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Chapter one portrayed the way in which this study would determine how the cognitive strategies of learners could be supported when problem solving in technology-supported learning environments. The purpose of this review of research literature is to provide theoretical guidance for the design and development of a supportive framework based on cognitive tools that will assist learners engaged in this process.

The concept of problem solving through a student inquiry approach has strong association to the related developments in the ideas of constructivism and it is this philosophy of learning that forms the basis of this review. The constructivist view of learning asserts that knowledge is a constructed entity made by each and every learner. Such knowledge is internal and individually constructed through interpreting personal experiences of the external world (Jonassen, 1991). A constructivist approach emphasises learners' ability to solve real-life, practical problems that involve identifying issues, researching the problem, planning the investigation and choosing a solution. By their very nature, real-life, practical problems are often unclear or ill-structured tasks that require reflective thinking and consideration of multiple perspectives.

Research into the development and design of frameworks that support learners' metacognitive processes may help identify how learners use cognitive support tools for problem solving in ill-structured domains. This review develops an understanding of how learners can be supported when confronted with such problems in technology-supported learning environments. The key areas of this literature review are:

- ❑ problem-solving theory;
- ❑ theoretical approaches to learning that relate to problem solving;
- ❑ problem-solving activities within technology-supported learning environments;
- ❑ similar research studies related to current work.

## 2.1 Problem Solving and Related Concepts

The term 'problem' implies that the learner is being confronted by a situation s(he) does not recognise. The manner in which the learner goes about the process of dealing with this situation is a measure of his/her 'problem-solving' ability and may be regarded as a reflection on the previously acquired knowledge, skills and understanding that the learner has available to apply to the demands of the problem.

Theories of problem solving are dominated by the work of Newell and Simon (1972) in establishing the information-processing paradigm for the study of problem solving. This model represented a general problem-solving (GPS) approach that was applicable to a wide variety of problem types in a wide variety of scenarios. According to the GPS framework, problem solving involves the identification of sub-goals and the use of methods, usually heuristics, to achieve the goals of the task. In so doing, the learner may form a mental representation of the 'problem space' (Newell & Simon, 1972). A problem space includes the 'initial state' (the problem context), a 'goal state' (the problem solution), and a set of 'operators' (the steps that allow moving from one state to the other). When no relevant relationship is established with existing schemata no solution is found and the quality of the solution often depends on the search strategy used in information gathering.

Problem-solving skills appear to be related to many other aspects of cognition (Frederiksen, 1984) such as schema (the ability to remember similar problems), pattern recognition (recognising familiar problem elements), creativity (developing new solutions) and transfer (applying what has been learned to other situations). Green (1988, p.133) defines problem solving as: '...a process of moving through a problem-space in which an initial state of ignorance is transformed into a goal state where the solution of the problem is known. These states are really states of knowledge or belief about states of affairs in some real or imagined world'.

For successful problem solving to occur the problem has to be initially identified and some mental or internal representation of the problem constructed. Such interpretations by Green draw from the concepts associated with mental schemata (Piaget, 1978), information processing (Greeno, 1978; Simon, 1978), and constructivism (von Glasersfeld, 1989).

Problem solving involves the development of skills, which enable the learner to recognise and identify the problem, form hypotheses, search for and collate information through observation and measurement, and to interpret and analyse the data in proposing a solution(s) to the problem. The concept of problem solving has been addressed by a number of theorists in a range of domain-specific areas. For each of these, many of the steps in the problem-solving process are quite simple manipulative skills but others involve complex thinking ability. These skills, both manipulative and cognitive, can be placed into several broad categories that the learner needs to engage to enable achievement of a successful outcome. In general, competent problem solving requires the mastery of three categories of skills:

- ❑ flexible application of a well-organised knowledge base;
- ❑ systematic search strategies for information and problem clarification;
- ❑ ability for self-monitoring and self-regulation of cognitive processes (De Corte, 1990; Perkins & Salomon, 1989).

Several models have been reported on in research literature dealing with successful problem solving. The basic strategies proposed for three of these are outlined in the following table:

Model	Sequence of actions
Hayes’s problem-solving model (Hayes, J. R. (1989))	<ul style="list-style-type: none"> <li>❑ finding the problem</li> <li>❑ representing the problem</li> <li>❑ planning the solution</li> <li>❑ carrying out the plan</li> <li>❑ evaluating the solution</li> <li>❑ consolidating gains</li> </ul>
Bransford & Stein’s problem-solving model (Bransford, J. D. & Stein, B. S. (1992))	<ul style="list-style-type: none"> <li>❑ identify the problem</li> <li>❑ define the problem goals</li> <li>❑ explore alternative strategies</li> <li>❑ anticipate outcomes and act</li> <li>❑ look back and redefine</li> </ul>
Jonassen’s Problem-solving model (Jonassen, D. (1997))	<ul style="list-style-type: none"> <li>❑ learners articulate problem space</li> <li>❑ identify and clarify alternatives</li> <li>❑ generate possible solutions</li> <li>❑ assess viability of each solution through argument construction</li> <li>❑ monitor the problem space</li> <li>❑ implement and monitor the solution</li> <li>❑ adapt the solution</li> </ul>

Table 2.1 - Comparison of Problem Solving Models

The related theme in each of these proposals suggests that successful problem solving involves the development of flexible cognitive strategies that help analyse

unanticipated situations to produce acceptable solutions. It involves a multistage process including the clarification and investigation of the problem, an adaptation of strategies for solving the problem, formulating and proposing possible solutions supported by evidence and the generalisation of strategies for similar problems. The sequence of actions indicated by these proposed models may be interpreted as:

- ❑ clarifying the problem;
- ❑ data collection;
- ❑ data analysis;
- ❑ checking ideas;
- ❑ developing an argument.

Synthesis of the common elements in these models could be represented through the six components illustrated in Fig.2.1. This model illustrates the recursive nature of this approach, thus allowing the learner to retrace and reflect on the process as the need arises:

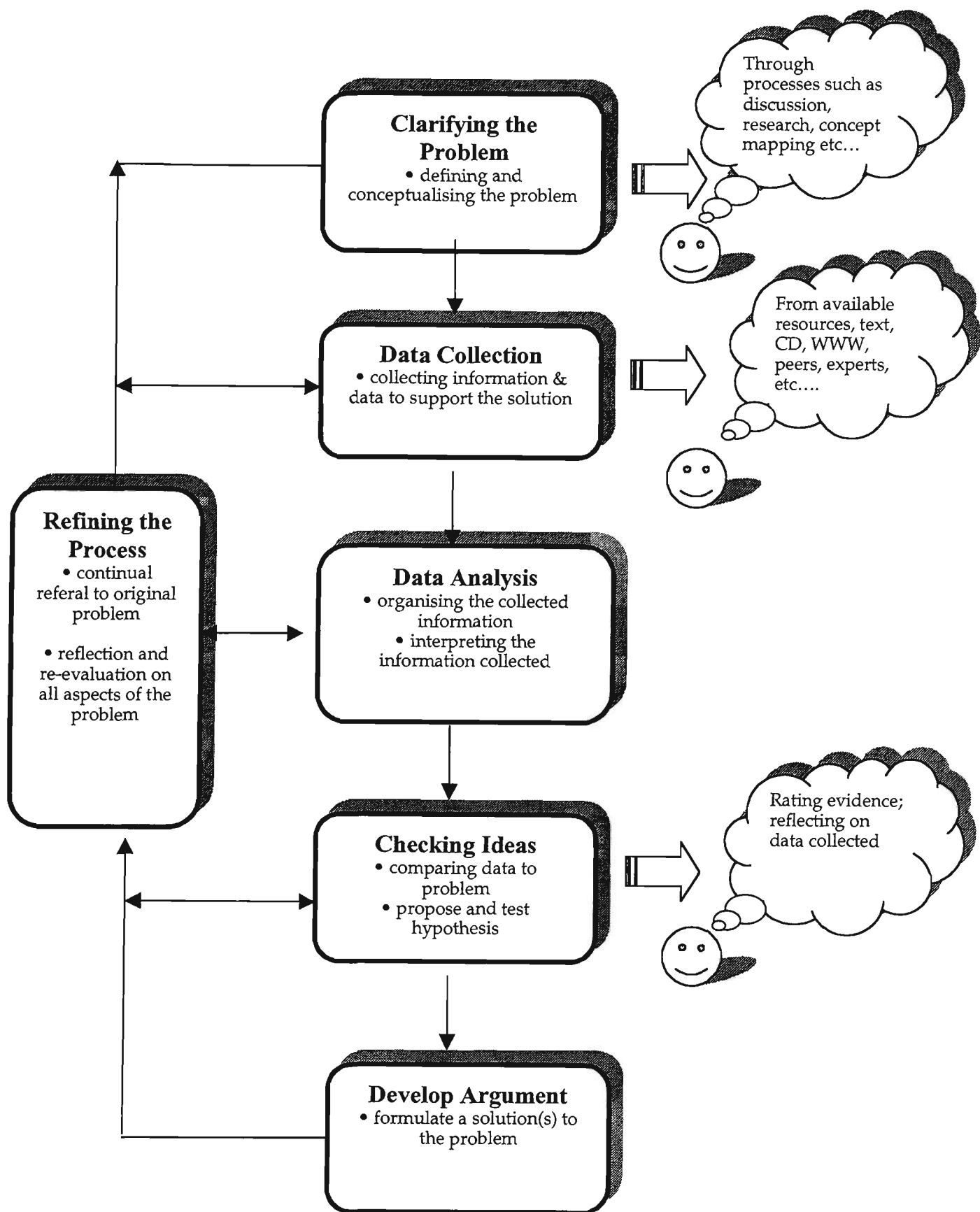


Figure 2.1 Suggested Problem-solving Model

2.1.1 Well-structured and Ill-structured Problems

A review of the problem-solving literature reveals that there is a long history of investigation of learner processes in this domain. Problems posed can be thought of as a continuum of problem types ranging from ‘well-structured’ to ‘ill-structured’. In the terminology of Newell and Simon (1972) a well-structured problem may be regarded as one in which the initial state, the goal state and the operators are known. This is in direct contrast to ill-structured problems where the learner may be uncertain of the characteristics of the problem space. Many of the well-structured problems can be found in the school environment because they have been developed to illustrate a particular principle. The current debate in educational circles is whether the skills developed solving such problems in a classroom setting are being transferred successfully to problems in the ‘real world’ where the complexities of problems are not as easily solved. Gallagher and Gallagher (1994, p.285) present a comparison of characteristics exhibited by these problem types:

Well-structured Problems	Ill-structured Problems
Problem definition is clearly defined	Problem lacks clear definition
All information to solve problem is provided	Additional information is needed to solve problem
The focus is on problem solution	Focus is on the nature of the problem
A single correct solution can be identified	Many different solutions are possible
Problem is presented in an abstract context	Problem is presented in a social context
Low motivation to find solution	High motivation to find solution(s)

Table 2.2      Characteristics of Well-structured and Ill-structured Problems

Hayes (1989) draws an analogy between problem solving and being on the wrong side of a river without appropriate means to cross. Solving this problem means finding an appropriate way across the ‘gap’. When applying this analogy to ill-structured problems he states:

‘ Since each problem solver may make different ‘gap-filling’ decisions in solving the same ill-defined problem, each may, as a result, arrive at a different solution. These solutions may differ considerably in quality depending on the decisions the problem solver has made. Our skill in solving



ill-defined problems, then, depends in an important way on our ability to make good gap-filling decisions' (p.30).

This initial phase of problem solving has support from other researchers, (Gick, 1986; Green, 1988), which involves the construction of internal mental representations of the 'problem space' (Newell & Simon, 1972) using existing schemata.

Jonassen (1996) also maintains that exposure to '... well structured problems in the classroom have limited relevance and transferability to solving problems that are situated in everyday contexts' (p.67). While supporting the view that many learners have difficulty in transferring the knowledge gained from structured problems within the classroom to ill-structured problems in everyday life, it has been my experience as a classroom teacher that learners still need to establish a background knowledge stemming from the development of basic concepts/facts to enable them to begin to attempt a solution of an ill-structured problem. The degree of understanding the learner has 'constructed' in the development of a solution to the well-structured problem does appear to have an influence in the ability of the learner to determine a 'successful' solution of the ill-structured problem. It has also been my experience that learners who have had some experience at classroom problem solving based on the methods of constructivism are better able to develop a solution to ill-structured problems than those learners who are used to a textbook-based approach to learning. However, this hypothesis is based on classroom observation and experience alone rather than any definite scientific evidence. As a member of the design team of *Exploring the Nardoo* (and a practising Science teacher) I have a personal interest in and commitment to researching the effectiveness of the software in supporting problem-solving skills and the ways in which learners interact with and learn from such an interactive learning environments.

According to Jonassen (1996, p.68) ill-structured problems:

- ❑ appear ill-defined because one or more of the problem elements are unknown or not known with any degree of confidence;
- ❑ possess multiple solutions, solution pathways or no solution at all; that is, no consensual agreement on the appropriate solution;
- ❑ present uncertainty about which concepts, rules and principles that are inconsistent between cases;
- ❑ have no explicit means for determining appropriate actions;
- ❑ require learners to express personal opinions or beliefs about the problem; and

- require learners to make judgements about the problem and defend them.

Support for the views expressed by Jonassen can be found from other researchers (Lajoie, 1995; Land & Hannafin, 1996). These studies have confirmed the lack of understanding of the problem-solving process that learners undertake in such settings. Land and Hannafin have proposed that learners need to apply a theory-action model as they engage 'open-ended problems'. Open-ended problems are those where the individual determines what is to be learned, how it is to be learned, what learning goals need to be met and what subsequent steps need to be taken (Land & Hannafin, 1996). In essence they have similar characteristics to the ill-structured problems previously described.

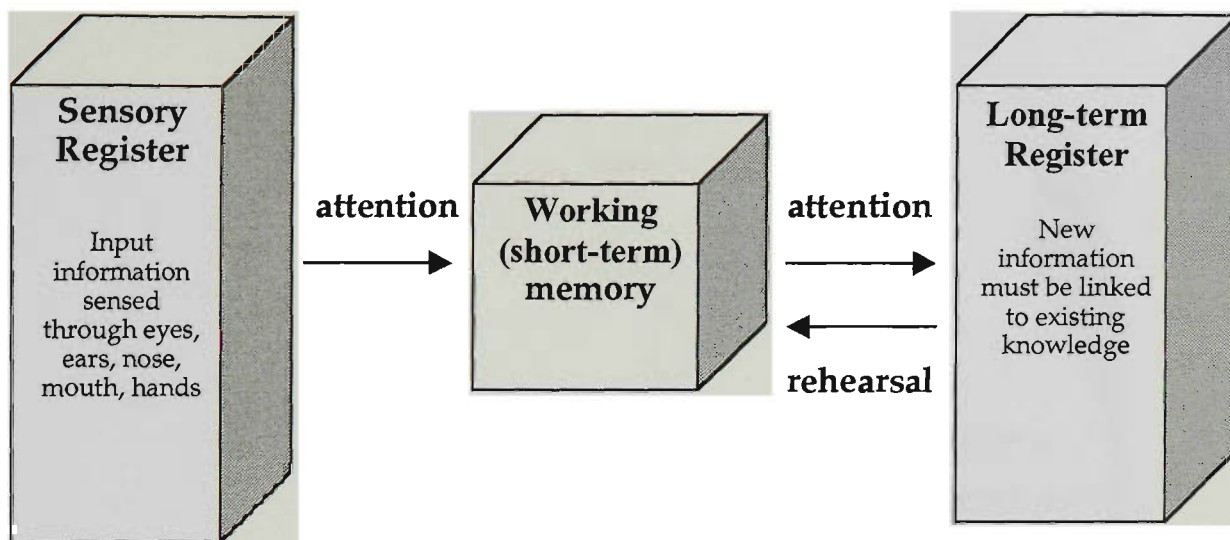
In recent work, Jonassen (2000) has organised the ideas of several researchers into a classification framework based on the different types of cognitive demands that different problem tasks place on learners. His framework schema identifies the type of problem and the degree of structure and abstractness in the problem. The conceptual approach taken in the development of *Exploring the Nardoo* was to design challenges for learners that include many of these characteristics. The problems are typically situated in and emergent from a specific context that encourages active learning and requires the learner to define the problem and construct ideas from a range of resources within the package. If placed on a continuum from well-structured to ill-structured, the problems presented in *Exploring the Nardoo* could be characterised as being 'design' problems that exhibit ill-structure, are problem situated, have a real world context and a learning activity requiring learners to act on goals to articulate and produce possible solutions.

In general, well-structured and ill-structured problem solving involves the same basic approach as illustrated from the models presented earlier. The difference between the two approaches lies in the interpretation of the problem itself and in the implementation of the problem-solving process. Difficulties experienced by learners with ill-structured problems stem from two essential areas. First, due to the complexity of the problem, the formation of a suitable mental problem representation is often difficult (Voss & Post, 1988). Second, since ill-structured problems involve a number of constraints, learners often form different mental representations of the same problem (Wiley & Voss, 1999). According to Jonassen and Grabinger (1990), both the representation phase and the actual problem-solving

phase can be supported in the development of technology-supported learning environments. This study sought to investigate a theory-action model by observing how participants initially developed their ideas about a solution to a problem and the actions taken to construct a solution that was supported by evidence.

### **2.1.2 Learning Strategies and Information Processing Theory**

Research over many years has shown that the learning strategies used in problem solving approaches vary with age, knowledge and ability of the learner (Stanton & Barber, 1992; Black et al, 1994). While the study of strategies is an effective way of describing individual differences it has also been found that learners will often use different strategies on different occasions for similar problems (Jonassen, 1996). Derry and Murphy (1986) define learning strategies as the cognitive processes used by a learner to facilitate the acquisition of knowledge or skills in problem solving and related tasks. Early research into learning strategies has tended to be explained in terms of information-processing theory. These models of learning make use of a computer metaphor to replicate human processing of information and have proved to provide an important approach for research into cognition especially in the areas of memory acquisition and problem solving. Bruning (1983, p.93) defines learning strategies as “any internally or externally mediated cognitive process that will facilitate transfer of information to be learned from short-term memory into long-term memory”. Information-processing theory holds that short-term memory has a limited processing capacity such that learners are forced to select from all possible information presented for processing. Short-term memory holds information for only seconds before it is lost or encoded for storage in long-term memory. Learning strategies are generally called into use at this point to facilitate the transfer of information (Bruning, 1983). One model (Fig. 2.2) that illustrates how information may flow in short-term and long-term memory registers is that proposed by Ormrod (2000).



- ❑ Information that is not immediately acknowledged may be lost before entering short-term memory.
- ❑ If acknowledged, information may enter short-term memory for up to 20 seconds or may be lost.
- ❑ If processed further, information may enter long-term memory or again be lost.

Figure 2.2 Model of the Human Memory System (after Ormrod, 2000)

In terms of the computer-based metaphor input information is available through the senses and, if acknowledged, may transfer to working or short-term memory. Stored information in long-term memory is compared to incoming information in the short-term register through an 'attention' and 'rehearsal' cycle. This aspect of the model represents the concept of matching new information with an organised set of existing knowledge or schema.

Several models of information processing have been proposed (Bransford, 1984; Greeno, 1978; Simon, 1978; Newell & Simon, 1972). A common theme throughout is the emphasis on two important processes: the construction of a mental representation of the problem space; and a solution process that investigates the problem space. Gick (1986) synthesised these ideas into a simplified schema (Fig.2.3) for the solution of well-structured problems. In this automated view, the learner searches for and generates a possible solution that may be tested. Until a solution is found the process continues through forming alternative mental representations of the problem and generating other hypotheses. The process is repeated until a possible solution is successfully tested.

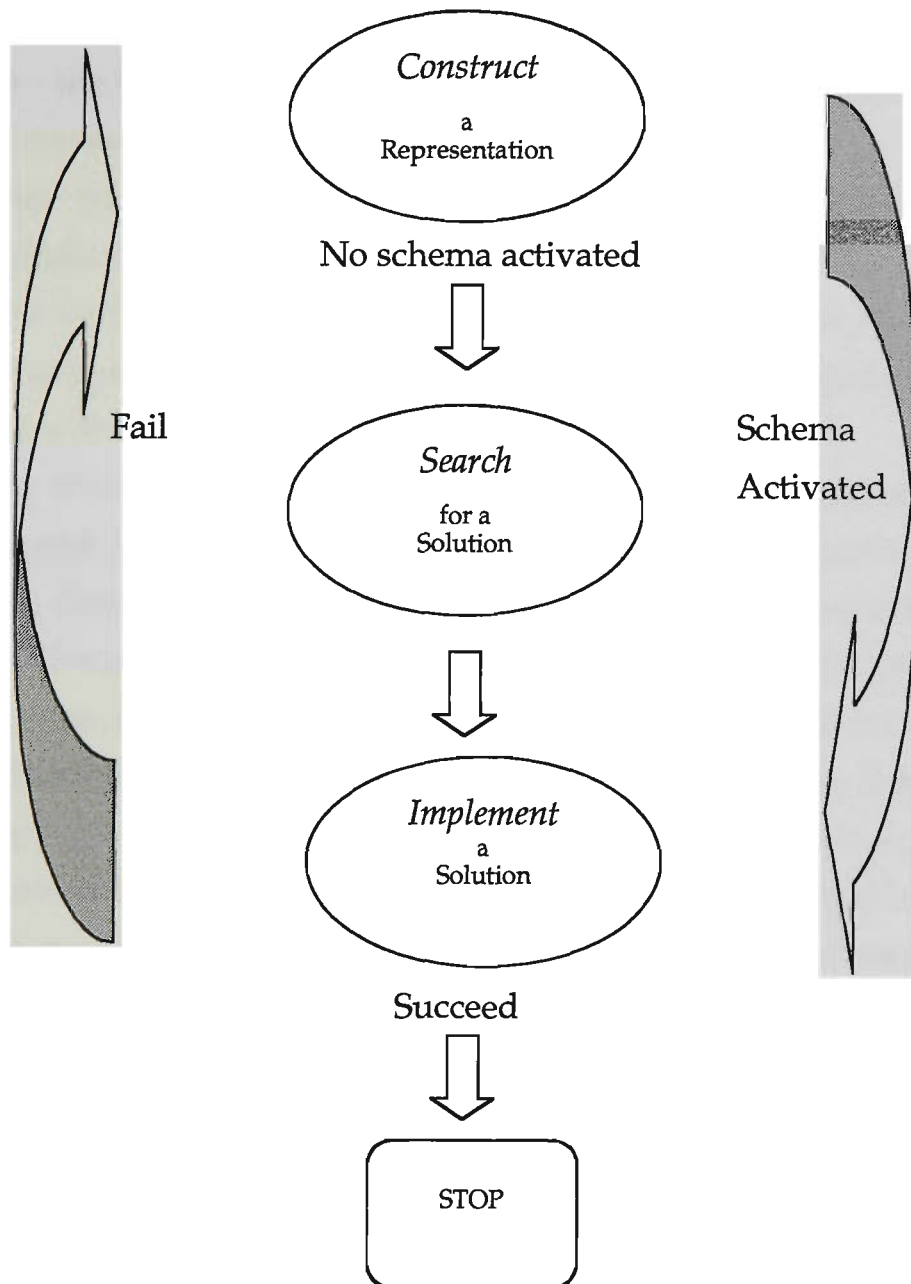


Figure 2.3 Information Processing Model (after Gick, 1986)

However, this view of problem solving based on information processing theory is limited due to its overly simplistic approach and does not support the solving of the more complex well-structured problems let alone the ill-structured variety.

Other studies have shown that learners acquire individual strategies in the processing of information in order to facilitate cognitive development. Weinstein and Mayer (1986) suggest four stages in the information processing strategies used in problem solving:

- ❑ selection – the learner actively pays attention to some of the information impinging on sense receptors and transfers it to working memory;
- ❑ acquisition – the learner actively transfers information between working and long-term memory for reinforcement;
- ❑ construction – the learner actively builds internal connections between ideas in the information that reaches working memory;
- ❑ integration – the learner actively searches long-term memory for prior knowledge and transfers it to working memory to construct external connections with the new information.

These strategies are used to rehearse, organise and elaborate information to make it more meaningful. Strategies include underlining, outlining, categorising, mental imaging, forming analogies, paraphrasing, analysing key points for elaboration and the planning of the approach for a solution strategy. Rehearsal strategies help focus attention on important information and encode it in short-term memory (selection and acquisition), while organising strategies help in selection of appropriate information and constructing connections among the ideas (construction). Elaboration strategies help transform information by making more it meaningful and building connections among new ideas and prior knowledge. Learners may benefit from strategies that help them encode the information they encounter in technology-supported learning environments - strategies such as paraphrasing, generating questions, outlining, creating images through cognitive mapping and summarising. These activities could be supplied and supported by the instructional system or generated by the learner.

More recent researchers have continued to move further away from behaviourist models of learning to constructivist models. Perkins (1991) links constructivism with information processing theory by noting:

'... information-processing models have spawned the computer model of the mind as an information processor. Constructivism has added that this information processor must be seen as not just shuffling data, but wielding it flexibly during learning – making hypotheses, testing tentative interpretations, and so on' (p.21).

In this manner, Perkins ties together contemporary cognitive theory and constructivist theory.

Cognitive psychology assumes that any observable differences between learners can be largely explained in terms of differences in their knowledge.

Consistent with information processing views of problem solving, Gagne (1980) proposes that learners require the fundamental capabilities of intellectual skills, verbal knowledge and cognitive strategies to be successful as independent learners. He suggests that all (or nearly all) of these capabilities are learned and hence will vary among a population of problem solvers, but are amenable to instruction. Others (Jonassen, 1985; Duffy & Jonassen, 1992) have expressed similar ideas in addressing the goals of education. Further research has suggested that these general skills do not transfer well when applied to situations involving the solving of ill-structured problems (Land & Hannafin, 1996; Jonassen, 1996; Brown & Duguid, 1993; Larkin, 1989; Perkins & Salomon, 1989).

Within the educational community little time is spent assisting learners in developing the cognitive strategies necessary to deal successfully with problem solving within ill-structured domains. Formal education often presents problem-solving scenarios that involve specific knowledge in decontextualised settings where solutions are based on a predetermined pattern of analysis. Knowledge development within such settings is often difficult to transfer to real-life situations or in settings such as those experienced in computer-based problem-solving simulations of real-life situations.

With the sophisticated technologies currently available the design of learning environments which engage learners in student-centred activities that require a range of learning strategies offer considerable promise. Recent studies (Lajoie et al., 2000; Gordon, 1998; Ferry, 1997; Guzdial, 1994) into the effectiveness of learner-support strategies within computer-based learning environments have demonstrated the need for additional built-in support tools for learners. These studies have indicated that there is a need for further investigation into the development of additional assistance to improve problem clarification and the reflection and assessment of responses with problem solving when in ill-structured domains. This study will concentrate on the clarification of the problem through investigation of mechanisms that help learners in defining and conceptualising the problem space. Being an independent learner involves not only solving but also identifying the problems to be solved (Bransford & Stein, 1992). With the aid of strategies such as concept mapping (Novak, 1990), venn diagrams (Gunstone & White, 1986), six thinking hats (De Bono, 1992) and critical thinking (Ennis, 1991), participants will be

assisted in clarifying the questions that will guide their search for pertinent and reliable information to support and construct solutions to the assigned problem(s).

2.1.3 Mental representations of the problem.

From observation and interaction with their surroundings learners develop an internal representation of objects, events, and the structural relationships between them. These experiences and interpretations of the 'real-world' form a mental model which learners draw upon when new situations are encountered or when new problems arise.

Barker and colleagues (1998) have suggested a conceptual model of how information may be processed within a problem-solving scenario (Fig. 2.4). The model illustrates the relationship between the problem setting (the environment), the learner’s existing experiences and the mental stimulus in integrating new material into existing schemata. The environments in which learners find themselves generate new experiences. The environments in which learners find themselves generate new experiences.

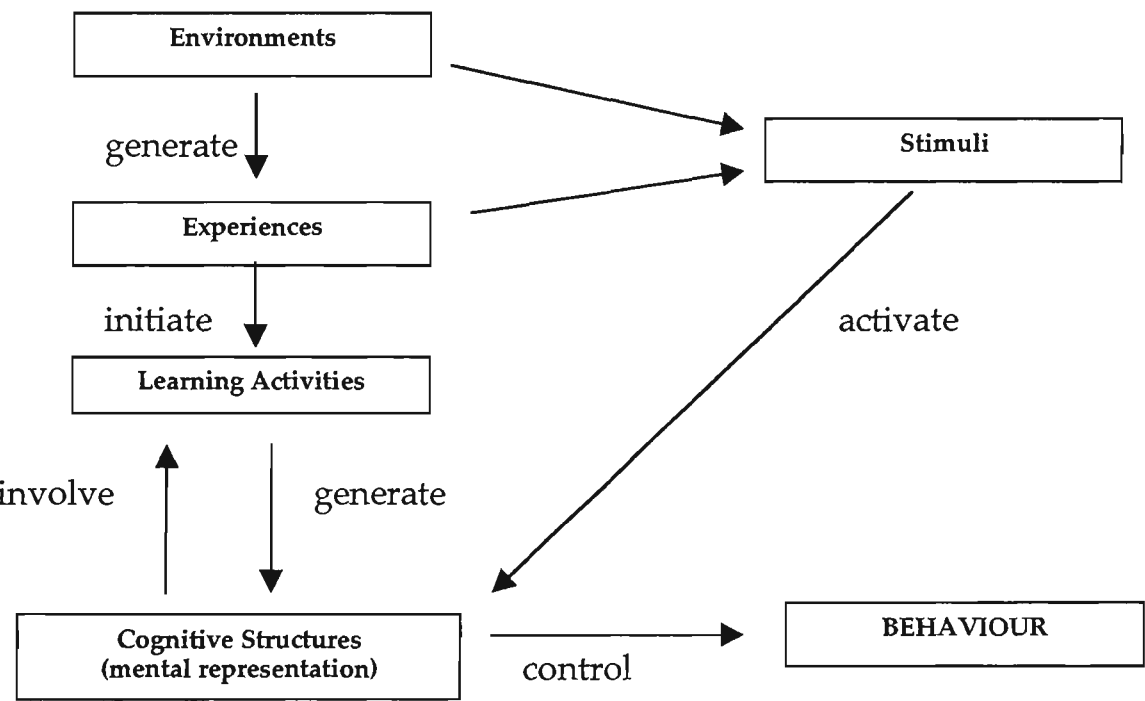


Figure 2.4 Overview of the Learning Process (after Barker et al, 1998)



Both situations may provide the stimulus necessary to activate the learners' existing mental model and/or help evolve new ones. Modification of the learner's behaviour may or may not take place depending on how the learner generalises his/her existing model to the new situation.

As a learner engages a problem-solving task mental representations are created or enhanced and the knowledge transfer that emerges is driven by the representation formed in the mind of the learner. The nature and quality of the actions that then take place in proceeding to solve the problem will depend upon the richness of the mental representations that the learner has formed. According to this view, mental models are cognitive structures that learners activate when attempting to solve problems. Learners seek new information in ways that depend on and are limited by their current mental model and learning goals (Tweney, 1987).

In this study participants will be assessed using think-aloud protocol analysis while solving the problem provided. They will be asked to articulate their plan for solving the problem and observed on how well they adhere to the plan, what strategies they use for dealing with the embedded information that supports the problem, and what generalisable conclusions they draw from suggested solutions.

#### **2.1.4 Scaffolding**

Technology-supported learning environments provide enriched learning opportunities by presenting information in a variety of forms usually incorporating high quality visual materials in the form of text, images, sound, graphics and video. A variety of pathways to access the information provides a different perspective on not only the information being presented but also on the interrelationships developed through the different metaphors used. Well-designed technology-supported learning environments support effective learning through reducing the cognitive load on the user, thus increasing the opportunity for more effective engagement and learning. In attempting ill-structured problems within such an environment many learners need guidance that can lead them to a satisfactory solution(s). Such guidance may be in the form of cognitive tools such as scaffolds that support and direct learners to manage the learning environment, provide a stimulus for an ongoing action or thought, or further develop the learner's cognitive processes.

Traditionally teachers have scaffolded learners to develop enhanced cognitive structures that assist them to solve problems. By building on the learner's experiences, providing challenging authentic activities requiring reflective thinking and working in collaborative groups, teachers can provide the scaffolding needed to bridge the 'zone of proximal development' (Vygotsky, 1978). Scaffolding is generally regarded as support for learners while they are engaged in activities just beyond their capabilities. It ranges from assisting with an entire task to providing occasional support. As the learners' capabilities improve, the teacher gradually reduces the support until the learner becomes self-sufficient with the assigned problem.

Depending on the degree and type of scaffolding offered within technology-supported learning environments, the learner may use the support system to assist with the planning process or as part of their ongoing development of higher-order thinking skills. Guzdial (1993) suggests the goal of scaffolding is twofold. Initially scaffolding enables learners to achieve a level of success that would not be possible without the support. Secondly, as the learner's ability level increases the level of scaffolding decreases until learning is facilitated without the supporting framework. For different problem-solving scenarios the type and level of scaffold available should vary to cater for not only the different activities but also for the variation in the learner's knowledge.

In an effort to identify the lack of understanding of the problem-solving and data-exploration processes of learners, Land and Hannafin (1996) propose one such framework to support problem solving in open-ended learning environments (OELE). This 'theory-action' model allows the learner to engage the problem context and then interpret and elaborate on the system goals based on personal knowledge and experience. Through investigation the learner then explores and refines his/her 'theory' using the cognitive tools and resources or 'affordances' of the system. These tools and resources work toward providing a bridge between the learner's existing cognitive processes and the additional cognitive demands required in resolving a complex task through a scaffolding mechanism that facilitates knowledge construction. The learner's knowledge and new experiences are cross-referenced with the problem context for 'action' that may range from simple browsing to a greater use of cognitive processes.

The model, presented in Fig.2.5, is one structure that suggests how learners could be assisted in the problem-solving process through a scaffolding

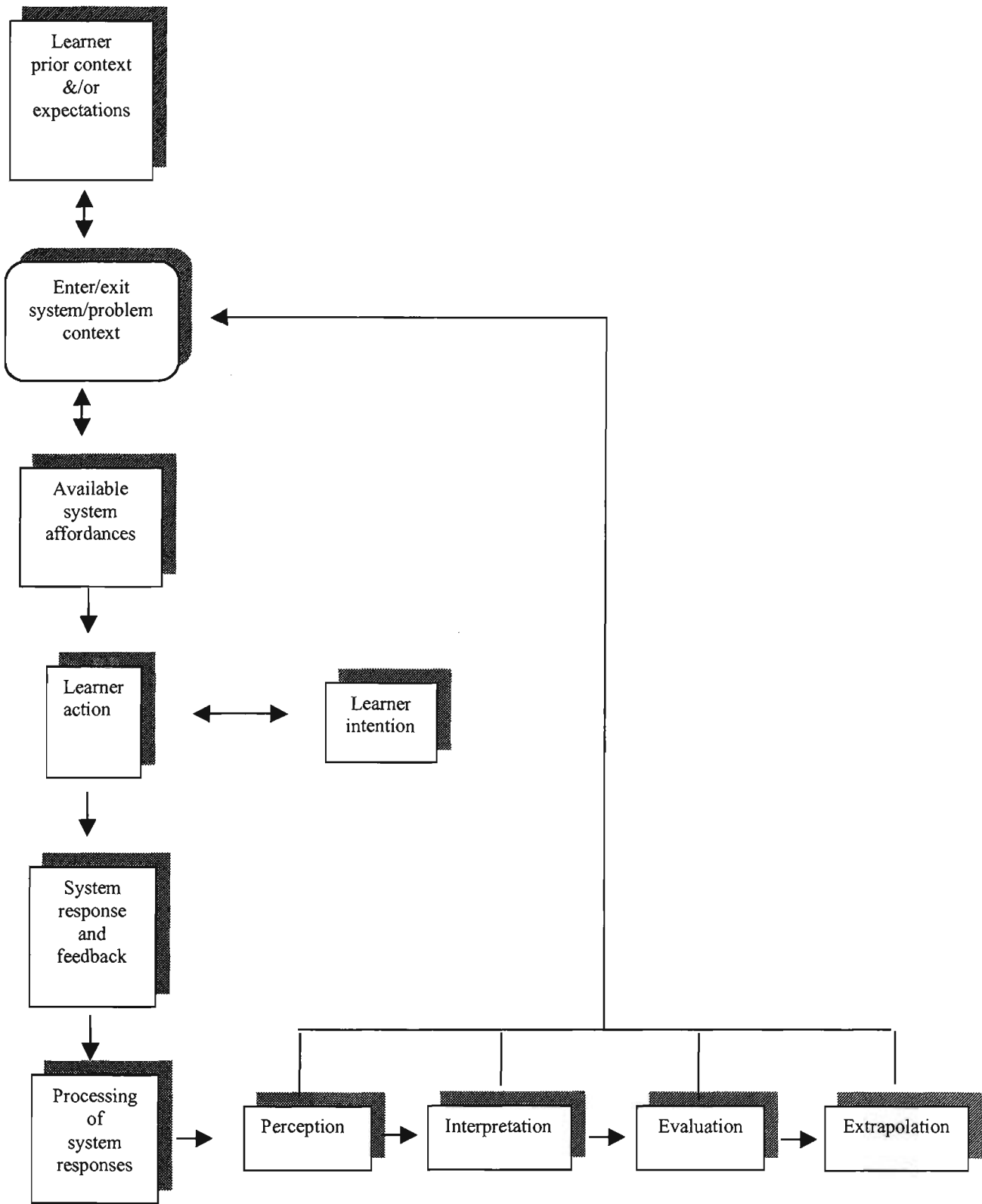


Figure 2.5     Solution Framework (after Land & Hannafin, 1996)

framework that has been built into an open-ended learning environment. Through the use of a variety of cognitive tools, resources and scaffolding support, learners are assisted in developing, testing and modifying individual theories of understanding. The result is a complex interaction between prior knowledge, perception of events, intents, actions observations and reflections that lead to ongoing thoughts and actions by the learner. This highlights the processes being investigated in this study because it demonstrates a series of sequential steps relating to learner strategies. The scaffolding framework also recognises the importance of interaction and reflection in the investigating process.

### **2.1.5 Transfer**

The ability of learners to transfer existing knowledge to the solution of real-world problems is the expected goal of education. Transfer is the application of acquired knowledge and skills to dissimilar tasks, problems or circumstances (Hedberg, Harper & Brown, 1993). Over a period of years research literature has demonstrated that the learning of general concepts, based on abstract knowledge from one situation, does not transfer well to real-world problems where the goals of the problem are not clear. Studies by Salomon and Perkins (1989) describe the effectiveness of transfer as 'near' or 'far'. Near transfer refers to situations where the knowledge and skills acquired through initial training are similar to those required in solving the problem. Far transfer refers to situations where the creative use of the acquired learning skills is successfully applied to more complex tasks where the connections are not as clear. While some researchers argue that only very near transfer is possible, other researchers have found that a moderate level of transfer can reasonably be expected (Detterman, 1993).

One focus of research into ways to optimise transfer, is that of teaching strategic knowledge (Larkin, 1989). Strategic knowledge includes procedural steps, strategies for identifying and meeting sub-goals, and metacognitive strategies for directing, monitoring and evaluating one's own learning. While this research has shown some positive results, it appears limited to transfer in situations requiring domain-specific knowledge.

Authentic problem solving situated in real-world settings, where the instructional context and task are designed to mirror everyday experiences, appears to be one strategy that would be beneficial in promoting transfer. When learners are presented with complex, ill-structured problems, they must engage in strategic thinking in order to define the problem and any sub-problems that may be identified before development of an action plan. By engaging in ill-structured problems learners are often required to monitor and manage their own thinking. Support for the development of these metacognitive strategies may be provided through the use of cognitive tools that stimulate the self-monitoring process. Such tools may serve as 'metacognitive coaches' providing hints, scaffolds, feedback, models and expert opinion to assist the learner to develop skills that allow better transfer across domains.

### **2.1.6 Reasoning**

Reasoning is a broad term that is usually applied to a statement in justification or explanation of a thought or action that has transpired. In its application to problem solving, reasoning may be considered to be the cognitive processes concerned with the drawing of conclusions or inferences that support a particular plan of action undertaken by the learner. For a number of years researchers have conducted studies into formal reasoning skills in domain-specific areas (mathematics, science, language) where problems have been set in a particular context. These problems tend to be well-structured and the reasoning demonstrated by the learner is based on the application of concepts and rules that converge in a probable solution. More recently attention has been directed towards studies involving informal reasoning that takes place in real world situations (Zimmerman, 2000; Patronis et al, 1999; Wiley & Voss, 1999; Means & Voss, 1996). The common thread of these studies relates to how the learner is expected to arrive at a decision, justify his/her position based on the evidence available and state possible counter-arguments when presenting a solution.

Keys (1995) obtained evidence which demonstrated that learners were actively engaged in analysing the meaning of data, observations and text during an investigation based on writing in science. During the course of her study learners used reasoning skills as they generated new ideas, assessed and related

their personal knowledge with the new ideas, and transferred their modified ideas to new situations. The reasoning skills identified in this study were: posing questions; evaluating and justifying predictions; evaluating observations; identifying patterns; drawing conclusions; formulating models; inferring; identifying relevant information; comparing and contrasting evidence; and discussing concept meaning (Appendix 2). As the investigative problems used for this current research required the use of similar strategies in achieving a final solution, this study has adopted the reasoning skills identified by Keys (1995) as a framework on which to base the data analysis procedures.

Nickerson (1986) argues that a learner's ability to reason includes the capacity to analyse, evaluate and construct arguments. Effective reasoning requires the ability to develop arguments, assess the validity of the argument in generating and testing hypotheses, judge the credibility of assertions made during the problem solving process, identify possible directions for action, and think through the consequences of choosing a particular direction of action.

### **2.1.7 Argumentation**

The term *argument* may be used in at least two ways. Firstly, to present reasons supporting or opposing a particular idea or belief and secondly, as a dispute or 'verbal disagreement' (Nickerson, 1986) between two or more people centred on a common theme. It is the first interpretation that is the basis for this discussion. The resulting manner in which reasons are presented and evaluated, together with the conclusions drawn from them, is the basis for the construction of an argumentation to support those ideas generated by participants in the study. In support of this view, Nickerson (1986) states: '... an argument ... is used to connote any set of assertions that is intended to support some conclusion or influence a person's beliefs' (p.68).

A number of recent studies have demonstrated positive learning outcomes between problem solving, argumentation and informal reasoning (Patronis, Potari, & Spiliotopoulou, 1999; Bliss, 1994; Voss & Means, 1991). Wiley and Voss (1999) demonstrated that learners performed better in the development of both causal models and conceptual understanding when engaged in problem-solving tasks that involved the development of written arguments. These arguments

were evaluated on the acceptability of the supporting reason(s) and the degree of relevance demonstrated by the reason(s) in supporting the conclusion(s). According to Patronis and colleagues (1999), learners engaged in ill-structured tasks involving elements of argumentation, (discussion, explanation, justification, using analogies, reasoning), are better able to meet the demands of decision- and policy-making in today's world. From this study two key aspects were identified from the analysis of the arguments presented by the participants. The first concerned the category of argument generated, the second relates to the nature of the argument presented. These common characteristics synthesised from the arguments generated in this study are categorised in the following framework.

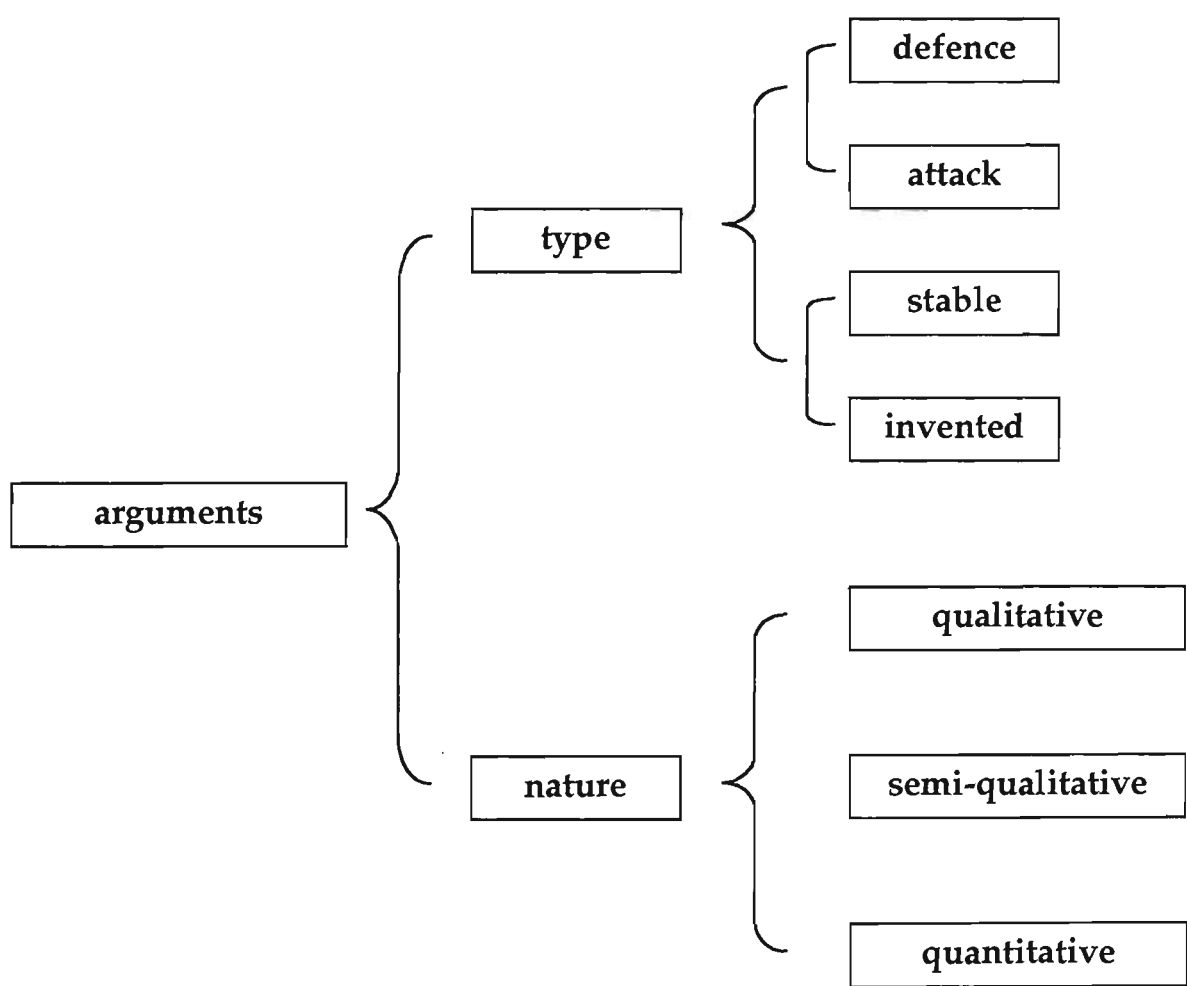


Figure 2.6 A Systemic Framework for Arguments (after Palonis et al, 1999)

Qualitative arguments are generated from community and moral values; for example, commercial development versus conservation of the natural

environment or euthanasia versus right-to-life issues. Quantitative and semi-qualitative arguments refer to the arguments stemming from expert opinion based on domain knowledge or common sense reasoning in the real world. These interpretations will be referred to in later discussions involving analysis of participant actions in the current study.

## **2.2 Learning Theory and Problem Solving**

Design guidelines, based on contemporary theories of learning (Savery & Duffy, 1995; Duffy & Cunningham, 1996; Jonassen & Tessmer, 1996) are being used to underpin the construction of learner-centered software products. Researchers experimenting with these learning environments are attempting to scaffold learners in the process of a cognitive task, usually presented in the form of a problem (Land & Hannafin, 1997; Lajoie, 1995). The following discussion focuses on the theoretical foundations for this current viewpoint.

### **2.2.1 Constructivism**

‘Constructivism is a philosophical view on how we come to understand and know’ (Savery & Duffy, 1995, p.31). The driving force of this philosophy is the idea that learning involves individual construction of knowledge through assimilation and accommodation from interaction with one’s environment (Savery & Duffy, 1995; Rieber, 1992). According to this approach to learning, learners enter problem-solving situations with prior knowledge and experiences and this influences the way they construct their own understanding of new concepts presented to them. The understanding that the learner develops within the problem-solving scenario is influenced by their prior knowledge and experience or belief structure. The learner has the responsibility for her/his own learning and the acquisition of knowledge involves construction of meaning from the stimulus material presented. As part of a continuous active process the knowledge, once constructed, is evaluated and either accepted or rejected by the learner thus becoming part of their belief structure. The process of learning involves the construction of meaning by the learner from what is



Constructivists de-emphasise instruction and performance and place far more responsibility for deciding what and how to learn on the learner (Hedberg, Harper & Brown, 1993). The instruction process is one of supporting the learner in the construction of knowledge rather than communicating knowledge from the instructor to the student. Rieber (1992) sites the work of Bruner (1986) in reinforcing the view that constructivists encourage discovery learning. By engaging in the set task '...learners induce, or construct, their own concepts and rules based on their interpretations of the instances encountered' (p.963). In a discussion on problem solving and its links with constructivism, Duffy and Cunningham (1996, p.190) suggest: 'The problem becomes a vehicle for training thinking skills ... the goal is to develop thinking skills, not only to solve the problem ...' and '... the focus is on developing skills related to solving the problem as well as other problems like it ... the skills are developed through working on the problem ie. authentic activity'.

Authentic tasks are coherent, meaningful, and purposeful activities that represent the ordinary practices of the culture (Brown, Collins & Duguid, 1989). This suggests that problems developed within technology-supported learning environments that utilise real world metaphors - scenarios that arouse learner interest and involve genuine interactivity with meaningful challenges - stimulate knowledge construction. The learner who is more actively involved in a learning process that draws on their cognitive ability is more likely to transfer knowledge from the virtual world of the technology-supported learning environment to that of the real world. In this particular study the 'virtual world' can be considered to be authentic because it encourages participation in realistic scenarios of environmental processes within the wider community. Information anchored in relevant contexts enables learners to take on a role and establish why, when and how knowledge is used (Cognition & Technology Group, 1990). In this study the problem space is the context that has been generated as part of an information landscape (Florin, 1990). This information landscape provides the learner with a variety of problem-solving opportunities that require different problem-solving strategies.

## 2.2.2 Constructivism: Association with Learning Theories

Constructivist strategies are based on principles of learning derived from branches of cognitive science. The fundamental premises of these strategies have developed in response to perceived deficiencies in behaviourist and information processing theories and the teaching methods drawn from them (Roblyer & Edwards, 2000). These strategies are based on the ideas of theorists such as Jean Piaget (1971), Jerome Bruner (1973), Lev Vygotsky (1978), and Howard Gardner (1983).

Piaget is generally regarded as a major contributor of theoretical principles in constructivist thinking, specifically related to the stages of cognitive development and the processes of cognitive functioning (Roblyer & Edwards, 2000). For Piaget (1971), the cognitive development of each learner is a progression through four stages, with the learner developing higher reasoning abilities through each successive stage. Through a gradual process of interaction with the environment, the learner matures through the two processes of adaptation. The first, assimilation, involves the transformation or integration of new knowledge into the learner's existing view of the world; the second, accommodation, involves some modification between the existing schemata and the new information to construct new schemata.

While some researchers support Piaget's views, 'Piaget's contribution to our knowledge of cognitive development have been nothing short of stupendous ...' (Flavell, 1987, p.4), others (Osborne & Wittrock, 1985; Vygotsky, 1978, Novak, 1977) do not always agree on the implications of Piaget's theories. This disagreement stems from the claim that Piaget failed to adequately recognise the functions of language in the conceptual pattern of development in reasoning and problem-solving skills. While this debate may still continue Piaget's suggested processes of assimilation and accommodation are acknowledged in this study as they may indicate a process for determining how learners form a mental representation of the task and for developing an understanding of how learning occurs.

Bruner (1986) believed that education could be made more relevant to learners through active participation in the learning process. By self-exploration of discovery-learning environments the learner is seen to explore alternatives and recognise relationships between ideas. Discovery learning is '... an approach to instruction through which students interact with their environment by exploring and manipulating

objects, wrestling with questions and controversies, or performing experiments' (Ormrod, 2000, p.442). However, research findings with ill-structured problems have yielded mixed results (Frederiksen, 1984; Gagne, 1985) indicating that discovery learning is best achieved when learners have some prerequisite knowledge and undergo some guided, structured experiences. This re-emphasises the issue of transfer of knowledge and skills from well-structured to less-structured learning environments and the effectiveness of learners in achieving satisfactory outcomes when investigating such problems through a discovery approach. The contributions of Bruner have relevance to this study in the design and application of a cognitive tool to support problem solving. Ferry (1997) outlines several aspects of learning, based on Bruner's work, that reinforce the learner's ability to solve real-life practical problems. Such learning through problem solving should:

- ❑ optimise experiences that encourage learners to learn;  
 ' Learning and problem solving require the exploration of alternatives. Instruction that is geared to promote this function should minimise the risk involved in exploration: it should maximise the informative nature of error, and should seek to weaken the effects of previously established constraints on exploration and curiosity...' (Bruner, 1966, p.198).
- ❑ structure knowledge for maximum comprehension;  
 Bruner states that ' ... grasping the structure of a subject is understanding that it in a way permits many other things to be meaningfully related to it ... ' (p.7). Hence learners should code knowledge experiences in such ways that are useable in present and future learning situations.
- ❑ provide organization of content into optimal sequences of presentation;  
 Bruner argues that the task of the instructor is to convert knowledge into structures that are within the grasp of the learner at different stages of development. Hence structures need to be provided in an optimum sequence of materials to be learnt. Constructivist approaches suggest we provide the learner with tools that allow her/him to arrange learning material into meaningful knowledge structures that are relevant to the individual.
- ❑ acknowledge the role of success and failure and the nature of reward and punishment;  
 Rewards and punishments associated with learning are seen as motivators that affect the degree of success in problem solving. Such successes and failures in

learning may lead to a greater awareness and understanding, a feeling of confidence associated with mastery of one's own metacognitive capability, a sense of achievement and the development of 'reciprocity' (the human need to respond to others and to operate jointly with them).

- ❑ encourage procedures for stimulating thought in an educational setting; Bruner believed that '... if information is to be used effectively, it must be translated into the learner's way of solving a problem ... ' (p.53). Therefore instruction should '... make the learner or problem-solver self-sufficient' (p.53). Later researchers, operating from a constructivist perspective, support this view in advocating the design of cognitive tools to support learners in knowledge construction and providing the means for learners to become self-sufficient.

Bruner's work supported learning through discovery, where learners interacted with their environment, explored and manipulated objects, developed questions about their learning and performed experiments. He felt that learners were more likely to understand and remember concepts they had discovered in the course of their own exploration. However, research has yielded mixed results based on this unstructured approach to learning and has advocated strategies based on a guided discovery approach such as that of 'cognitive apprenticeship' (Brown et al, 1989).

While Piaget considered adaptation and learning to be independent processes with adaptation being the basic element in a learner's development, Vygotsky (1978) advanced a different view. He proposed that all learning takes place in the 'zone of proximal development'. This zone is the difference between what a learner can do alone and what s(he) can do with assistance from a peer or teacher. By building on the learner's experiences and providing challenging problems teachers can provide the 'intellectual scaffolding' to help learners progress through different stages of development.

These twin concepts of 'scaffolding' and 'zone of proximal development' are important to constructivists as many constructivist models of teaching and learning use these concepts in developing each individual's potential (Roblyer & Edward, 2000). The views of Vygotsky are in accord with constructivist views of instruction, as they are based on the construction of knowledge through the interaction of the learner's personal experiences with participation in collaborative, social activities. With meaningful support, problem solving can help learners expand their own zone of proximal

development, clarifying their interpretations of the problem and allowing for the development of better analysis and reasoning skills.

One of the more popular contemporary psychological conceptions of cognitive ability is that proposed by Gardner (1989). This theory maintains that there are a number of different intelligences exhibited by individuals, each with its own characteristics:

- spatial – perceives the world in spatial terms; notices and remembers visual details;
- logical-mathematical – recognises patterns; uses logical and deductive reasoning;
- linguistic – sensitive to the use of language; writes clearly & persuasively;
- musical – sense of rhythm, pitch and melody;
- bodily-kinaesthetic – good manipulating skills; uses tools skilfully;
- interpersonal – understanding of moods in others; relates well with others;
- intrapersonal – understanding of one's self; has heightened metacognitive skills.

It is suggested that learners use most or all of these types of thinking, with varying degrees of success. However, Gardner suggests that these intelligences seldom work in isolation and are best utilised in holistic learning experiences. Such opportunities may be experienced when actively engaged in problem solving within technology-supported learning environments. When engaged in complex learning tasks, such as those experienced when problem solving in ill-structured domains, learners use a combination of different kinds of thinking (Jonassen, 1995).

### **2.2.3 Constructivism: Associations with Problem-solving**

Constructivism supports current trends in western education towards more inclusive and innovative approaches to teaching and learning. Constructivism focuses on learners' ability to solve real-life problems, and its methods call for learners to be knowledge constructors as opposed to knowledge receptors.

In the early 1990's various researchers (Choi & Hannafin, 1995; Cognition & Technology Group, 1991; Perkins, 1991; Spiro et al, 1991; Brown et al, 1989) identified strategies for the development of computer-based instructional environments based on constructivist models. Problems set within highly visual formats, such as those experienced on CD-ROM and the World Wide Web (WWW), allow learners to build rich mental models of problems to be solved. Most of these focus on learners solving problems in specific content areas, such as mathematics or science, or using an interdisciplinary approach across a range of curriculum areas. Many of these problems

are presented as open-ended questions which are usually more complex than those associated with direct instructional methods and require learners to devote more time and more diverse skills to solving them. Such open-ended problems are designed to support higher-order cognitive skills such as identifying and manipulating variables, interpreting data, hypothesizing, experimenting and reasoning (Roth & Roychoudhury, 1993).

The learning environment associated with *Exploring the Nardoo* is one example of this format. Problems are presented that enable learners to actively manipulate a complex environment, seek information and conduct investigations in order to construct knowledge about environmental issues. The two problems used in this study are examples of how such problems have the potential to engage the learner in utilising their higher-order thinking skills.

Constructivists tend to favour problem-solving activities that are linked to learners' interests and are characterised by some of the attributes of real-world scenarios. Such activities promote learning that manifests itself through experience in which '... understanding is developed through continued and situated use ...' (Brown et al, 1989). In spite of the fact that constructivism is not a model of learning, it does provide a set of principles that can serve as a guide in the design of technology-supported learning environments. A number of projects (*Investigating Lake Iluka*, 1993; *Exploring the Nardoo*, 1996; and *Stagestruck*, 1999) serve as specific examples of successful attempts at developing and implementing constructivist learning environments. These projects exhibit common traits such as authentic context for learning and emphasis on problem solving. The environments all rely on technology to facilitate the process indicating that technology-supported learning environments can have an essential role to play in the realisation of constructivist learning.

### *Situated Cognition.*

From a constructivist view, learning is a process of constructing knowledge within social environments. The theory of situation cognition, consistent with this view, asserts that what we come to know and understand is fundamentally a product of the learning situation and the nature of the learning activity. Learning tasks should, as far as possible, be embedded in the target context and require the kind of thinking that would be done in real life (Lave & Wenger, 1991; Brown et al, 1989). According to Brown,

Collins and Duguid (1989), knowledge is situated as part of the context or culture from which it is acquired. This forms the basis of situated cognition. Situated cognition emphasises higher-order thinking skills and has grown out of research that explored the way that people reason and solve problems in everyday life. Choi and Hannafin further support this view, (1995, p.54) suggesting that 'Situated cognition emphasises the importance of context in establishing meaningful linkages with learner experience and in promoting connections among knowledge, skill and experience'. The application of knowledge to everyday problems requires the consideration of the context in which the problem arises since a suitable response takes much of its meaning from the situation being confronted. Technology-supported problem solving embodies many of the elements of situated cognition through emphasis on solving authentic problems in authentic contexts that enhance the development of higher-order thinking skills.

Situated cognition, as a general theory of knowledge acquisition, has particular relevance to this study where the problems used for learning arise as a function of the activity, context and culture in which they occur or are situated (Lave & Wenger, 1991). These environmental problems are situated in the context of technology-based learning activities where the focus is on the development of problem-solving skills. By providing complex, open-ended problems and authentic tasks, such technology-based learning environments attempt to cultivate awareness of the issues, provide the opportunity to retrieve relevant information when required, promote development of metacognitive skills, and facilitate the evolution of reasoning expertise for real-world problems. When problem solving scenarios are situated in real-world settings, the learners have the opportunity to develop their understanding of the concepts involved and to internalise information through meaningful semantic networks (Gick, 1988). This objective is consistent with the ideas expressed by Whitehead (1929) that education should be aimed at '... the production of active wisdom ...' rather than the '... aimless accumulation of precise knowledge, inert and unutilised ...' (p.58) in isolation from real-world experiences. One approach taken in the development of *Exploring the Nardoo* was to develop problems that situate the learning experience by inviting the learner to adopt a specific role within the context of the problem. By placing learners in the role of professionals who are actually confronted by such problems, they are challenged to develop the knowledge base and strategies that are normally required to solve the problem.

Other researchers have extended the concepts of situated learning through an instructional approach that emphasises 'cognitive apprenticeship' (Brown et al, 1989) and 'anchoring instruction' (Cognition & Technology Group, 1993). Modelled on the traditional ideas of apprenticeship between an 'expert' and a 'novice', cognitive apprenticeship is a mechanism for building and reinforcing cognitive understanding through expert modelling of appropriate strategies. It provides a framework for analysing and sequencing content to support the development of appropriate strategies for learning in technology-based learning environments. 'Cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity' (Brown et al, 1989, p.39). Collins, Brown and Holum (1991) provide a framework for the design of learning environments based on research from the traditional domains of reading, writing and mathematics when applied to problem-solving. They suggest that:

'In order to translate the model of traditional apprenticeship to cognitive apprenticeship, teachers need to:

- ❑ identify the processes of the task and make them visible to students;
- ❑ situate abstract tasks in authentic contexts, so that students understand the relevance of the work;
- ❑ vary the diversity of situations and articulate the common aspects so that students can transfer what they learn' (p.9).

Apprentices acquire skills through a combination of observation, coaching, and practice, which promoted mental models, scaffolding and self-guidance (Winn, 1993). In a link with the ideas of Vygotsky, this suggests that it is the job of the technology-supported learning environment to scaffold learners in their 'zone of proximal development' by providing a degree of help and guidance for reasoning and metacognitive processes. In this study, the researcher used think-aloud routines to model the cognitive processes involved in both the assigned support framework tutorial and the CD-ROM problem-solving tutorial.

Anchored instruction is a major paradigm for technology supported learning environments that '...provides a way to recreate some of the advantages of apprenticeship training in formal educational settings...' (CTG, 1990, p.2). The initial focus of the work undertaken by the CTG group (the Jasper Series) was on the development of interactive videodisc tools that encourage learners to pose and solve complex, realistic problems and provide opportunities for the learner to contribute to



his/her own learning. The video materials serve as 'anchors' (macro-contexts), that are sufficiently rich and complex to be viewed from several different perspectives, for all subsequent learning. As explained by Cognition and Technology Group (1993, p.52) '...our goal was to create interesting, realistic contexts that encouraged the active construction of knowledge by learners'. Anchors help to create problem-solving environments that '...permit sustained exploration by learners and enable them to understand the kinds of problems and opportunities that experts encounter' (CTG, 1990, p.3). In discussing the design of situated learning environments, Choi and Hannafin (1995) propose that the anchoring of tasks within such settings should be structured around the 'authenticity of objects and data in the setting' and 'authenticity of the problem situation' (p.60). In *Exploring the Nardoo* (1996), learners are invited to solve authentic problems using authentic data. The 'problem space' has been designed to engage learners in a meaningful context for learning. On selecting a problem the learner is immersed in the problem situation where the information is 'situated' or 'anchored' in a realistic, rich setting. This approach is reinforced through inviting the learner to adopt a specific role in assisting to solve the problem. One example of the anchoring of tasks in authentic settings that require use of authentic data is illustrated in the following problem from the CD-ROM.

### *Zone 3, Blackridge Region*

#### *Coal Mining*

*The residents of Pilliga Crossing have been complaining to the Pilliga Shire Council about the colour and clarity of the river making it unsafe for their children to swim. The problems appear to first occur in the Black Ridge Region of the catchment.*

#### *Your task:*

*Determine the cause of the problem and write an explanation for Pilliga Shire Council. Your report should include the results of chemical and biological tests that you have carried out as well as any relevant information reported in the media.*

These scenarios provide authentic anchors for analysis and reasoning. The problems themselves are realistic and vary in complexity. All data needed to generate an answer to

the problem are distributed throughout the problem setting. Learners must identify or generate additional problems they need to address and discriminate between relevant and irrelevant data, and test and revise possible solutions.

### *Metacognition*

This study sought to identify how learners construct knowledge and to clarify and describe specific strategies (metacognitive processes) used when solving problems in ill-structured domains. Metacognition refers to the self-awareness of one's own cognitive processes (Brown, 1987; Flavell, 1987; Paris & Winograd, 1990). It has been described as '...cognitions about cognitions or the executive decision-making process in which the individual must both carry out cognitive operations and oversee his/her progress' (Jo, 1993, p.416). Metacognition is concerned with the active monitoring and regulation of one's own cognitive processes and is central to the planning, analysis and evaluation required in problem-solving. Metacognitive skills refer to the steps that learners take to regulate and modify the progress of their cognitive activity. These skills include taking self-control of the learning process, planning and selecting appropriate strategies, monitoring the progress of learning, evaluating evidence and analysing the effectiveness of the learning strategies used in reaching an outcome. In completing a problem-solving task a learner's ability to analyse and reflect on their progress may influence the strategies used to develop a solution. 'Metacognitively aware persons tend to formulate a plan of action, monitor their progress along a plan, recognise restrictions and personal limits, detect and recover from error, reflect upon and evaluate their own processes' (Rowe, 1988, p.227). If learners are conscious of the processes they utilise when solving problems they have an opportunity to more easily improve on their strategies and become more effective problem-solvers. Self-regulation is one way in which the practice of metacognition helps to facilitate the cognitive aspects of problem solving. Learners with metacognitive skills make a conscious effort in initial planning, use a variety of search strategies and monitor and revise ongoing progress, correcting errors and modifying their strategies when necessary. In an earlier study, (Brickell, 1998) it was evident from direct observation that many learners, from a sample of year nine students, did not demonstrate these metacognitive strategies.

Several authors, (Flavell, 1987; Rowe, 1988; Jo, 1993, Lin, 1994) have concentrated on the importance of metacognitive development in promoting successful

learning. These studies support the view that learners can control and direct their mental processes with cognitive and metacognitive support. When problem solving within technology-supported learning environments learners need to adopt a learning strategy that is suitable for them. A metacognitively aware learner is able '... to apply, adapt and/or modify what and how they have learnt, to new tasks and across different situations' (Rowe, p.228).

Flavell (1987) proposes three variables in the development of metacognitive strategies that may influence a learner's performance: person variables, task variables and strategy variables. Personal variables refer to knowing about one's personality and cognitive characteristics. In technology-supported learning environments this knowledge will encompass one's ability to interact with the environment and the degree of motivation, curiosity and anxiety that arises during the interaction. The realisation of the amount of confusion and frustration experienced by some learners (Lin, 1994) is a further example of this variable. Task variables relate to how the nature of the information encountered by the learner affects and constrains the ways they deal with this information. The knowledge gained from previous experience in problem solving may help the learner to recognise that different types of tasks impose different kinds of information processing demands (Rowe, 1988). Strategy variables are used to achieve more than just reaching the cognitive goal or sub-goal. Lin (1994, p.490) suggests that 'Strategy variables include knowledge of how to use a strategy, or what strategies are available, or how well a strategy works'. From previous experience some learners may be aware of the most effective strategies for best results and these may include initial planning, monitoring of progress and self-evaluation.

Thus metacognitive strategies are self-regulated, conscious experiences that are cognitive and affective; any kind of conscious affective or cognitive experience that is pertinent to the regulation of cognition is a metacognitive experience. Person, task and strategy variables interact and learners need to understand these interactions (Flavell, 1987). Based on previous experiences some learners may believe that certain tasks are difficult or easy. This may influence the strategy selection for the task in the given environment (Lin, 1994). Furthermore, personal growth in the development of metacognitive strategies is often related to previous experiences and it needs to be recognised that learners need time and practice to better regulate their cognitive processes (Flavell, 1987).

When problem solving within technology-supported learning environments learners need to be aware of the metacognitive processes they possess. In recognising this awareness they will have a greater insight into the use of cognitive support tools to aid their problem-solving strategies through active monitoring and regulation of their cognitive processes. For researchers there is need for a greater awareness and a better understanding of the learning process and a need to '... shift the focus of learning from getting the right answers in learning, to obtaining the right processes of learning' (McInerney, 1995. p.22). Within such environments the non-linear nature of the information structures and the variety of media formats requires the learner to make decisions about where to find supporting information, what kind of information should be selected to support the task, how much information is needed to justify an argument and what strategic approach is best suited to the problem under investigation. It becomes apparent then that knowledge of one's metacognitive processes, through independent decision making and regulation of learning processes, is necessary for a learner to successfully manage the learning environment.

Lin (1994), a researcher with the Cognition and Technology Group at Vanderbilt, conducted a study based on the role of metacognition in the problem-solving strategies of first semester university students. The study was designed to investigate whether self-regulative learning strategies can be communicated to learners through a scenario that involves reflective and problem-solving practices in a technology-supported learning environment. Participants in the study were found to generate a series of questions in the process of solving the problem in an attempt to provoke thought and inspire reflection. These responses centred on the prime questions of why? how? and when? in developing the personal strategies used in the process. Findings from the study suggest that learners' metacognitive strategies are further stimulated when they are able to monitor, revisit and evaluate the problem-solving process '...from the why, how and when perspectives' (p.486).

Existing research suggests that a major difference between expert and novice learners is that the former exhibit greater metacognitive sophistication in learning and memory processes. If we are to provide novice learners with complex problems, of an ill-structured nature, within technology-supported learning environments, then we also need to consider the provision of additional support strategies to coach and scaffold the learner through these metacognitive processes. This study took the

view that in order to support learners in solving problems it was necessary to provide them with a support framework to assist with the enhancement of these metacognitive strategies. It was assumed that one or more of these frameworks would help to generate questions that promote profitable search strategies and better-structured arguments.

## **2.3 Technology-Supported Learning Environments**

In changing the focus of education, the development and application of technology-supported learning environments, using CD-ROM or WWW-based information systems, has become more common in recent years in an educational setting as a stimulus for both teaching and learning. This technology has the potential to provide a learning environment that allows the user to explore, collect, organise and interpret information in association with their individual pattern of learning. Development of such products, based on sound educational theory, has the potential to enhance the improvement in higher-order thinking skills in the user of the technology in problem-based learning. Many of these resources have been developed using a constructivist approach to learning and have endeavoured to provide the user(s) with a number of problems to solve, using the technology to provide the stimulus material, in a context that encourages the development of problem-solving skills. Within such an interactive environment, the ability to locate, evaluate and use information effectively is essential in developing a successful strategy for the problem-solving process.

Used as tools for learning environments, these technology-supported learning systems have the power to stimulate more than one sense at a time. These systems present information that utilises the learner's senses of seeing, hearing, movement and touch. Such multiple presentations of information are said to provide more opportunities for knowledge construction than from a single presentation of material. Advocates of these learning environments would argue that this multisensory approach helps to reinforce the learning process through exploration of the metaphor(s) used through stimulation of the various cognitive processes in the learner. For effective learning to take place in multimedia learning environments the learner must interact with the elements of the surroundings s(he) is exploring by

manipulating the available cognitive tools. In providing suitable learning experiences, both the content and the media resources within the program must be geared to the learner's interests, ability and motivational readiness to become involved in the investigation and exploration of the medium. In this exploration of the metaphor(s) used to represent everyday surroundings the learner is provided with the opportunity for knowledge acquisition and possible reconstruction based on their prior experiences. Land and Hannafin (1997), suggest that '... student-centred learning environments emphasise constructing personal meaning by relating new knowledge to existing conceptions and understandings; technology promotes access to resources and tools that facilitate construction' (p.170). Further support for this view is provided by Wilson (1996) in defining a constructivist learning environment as '...a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities' (p.5). By emphasising learning environments as opposed to instructional environments Wilson is supporting a more flexible approach to learning through 'meaningful, authentic activities that help the learner to construct understanding and develop skills relevant to problem solving' (p.3).

Research into the effectiveness of interactive learning environments in developing specific learning outcomes has turned towards an analysis of instruction and learning within well-structured and ill-structured problem-solving domains. In a study into developing problem-solving skills of graduate students, Fitzgerald, Wilson and Semrau (1996) suggest:

'Instruction in ill-structure domains is different from instruction in well-structured domains where knowledge may be taught in compartmentalised units and later integrated. In ill-structured domains, construction must focus on general principles and knowledge interconnectedness across a wide scope of cases or examples' (p.27).

When learners engaged in solving ill-structured problems draw upon pre-existing knowledge, that in itself may not be sufficient to satisfy the requirements of a solution to the problem. If learners are supported in their ability to restructure knowledge through the development of their 'cognitive flexibility' (Spiro et al, 1991), they may be better able to accommodate new information to the problem solution.

Further discussion on instructional design models (Jonassen, 1997; Land & Hannafin, 1997) suggests that solutions to well-structured problems require defined principles whereas solutions to ill-structured problem require the application of constructivist and situated learning approaches. Within such complex learning environments, tools that can assist learners to accomplish cognitive tasks have been termed in the literature as 'cognitive technologies' (Pea, 1985), 'technologies of the mind' (Salomon, Perkins & Globerson, 1991) and 'mindtools' (Jonassen, 1996). Regardless of the terminology, the commonalities in the concept of a cognitive tool are in supporting learners during thinking, problem solving and learning. Jonassen and Reeves (1996) refer to cognitive tools as '... technologies, tangible or intangible, that enhance the cognitive powers of humans during thinking, problem solving, and learning' (p.1).

Based on the differences suggested, problems presented within *Exploring the Nardoo* - being representations of real world scenarios that have occurred in river catchment systems - are examples of the ill-structured category. They are designed to raise awareness of the associated environmental issues and promote the development of higher-order thinking skills through problem solving. Each problem is unique and has no 'right' or 'wrong' answer. Learners need to make value judgements based on the information collected to support their argument(s) for the solution(s) to their problem.

### **2.3.1 Cognitive Tools for Problem Solving.**

Robert Taylor (1980) described the paradigm in which computers could be used in educational settings, introducing the terms, 'tutor', 'tool' and 'tutee'. The term 'tutor' referred to the use of the computer as a teaching machine, while 'tool' referred to specific applications such as spreadsheets and databases. The term 'tutee' referred to instances where the learning is achieved through the user 'teaching' the computer. In the two decades since, advances in computer speed, processing capability, data storage and image handling have provided the basis for imaginative use of the technology in both pedagogical and cognitive settings, further promoting the concepts of 'tutor' and 'tool'. It is in this context that the following discussion is based.

The concept of a computer in the role of 'tutor' has been modified in recent years as emerging technologies have attempted to address ways in which independent learning systems can promote the learner's role in regulating his/her own learning (Schwier, 1994). Such emerging technologies, often described as 'interactive multimedia systems', focus on the ability to manage, deliver and support a wide range of educational activities including information seeking, knowledge acquisition and problem solving (Jonassen & Grabinger, 1990). The term 'multimedia' is used here to describe systems in which a variety of media, text, figures, images, sounds and movies, are displayed and integrated through a computer system. It incorporates the additional terms of 'hypertext', a system for presenting active text that allows learners opportunities to determine their own pathway through the associated nodes and links available, and 'hypermedia', a combination of both approaches. Typical examples of such systems are usually delivered through CD-ROM technology and the Internet via the WWW where learners can interact with a system that allows them to determine their own learning path through well-integrated combination of different media. Research has recognised that learners bring a range of knowledge, skills, experiences and cognitive awareness to tasks set within these systems (Land & Hannafin, 1997; Jonassen, 1996; Guzdial, 1994). This body of knowledge about human-system interaction has demonstrated the need for designers to consider computer-based help, support and feedback to enable the learner to effectively explore the learning system to full advantage. Such concerns are currently being addressed with the development of a range of 'tools' designed to provide cognitive support for the learner when engaged in solving complex problems. These 'cognitive tools' (Pea, 1985; Perkins, 1985; Salomon, Perkins & Globerson, 1991) or 'mindtools' (Kommers, Jonassen & Mayes, 1992) share the common attributes of having a variety of flexible outcomes (open-ended) and placing control of the learning in the hands of the user (learner-centred). They are knowledge-construction and facilitation tools that can be applied to a variety of subject-matter domains and engage the learner in more effective metacognitive processes.

Jonassen (1992) describes cognitive tools as '... generalisable tools that can facilitate cognitive processing' (p.2). Design of such tools is based upon a constructivist philosophy that supports thinking and favours knowledge construction : '...cognitive tools are constructivistic because they actively engage



learners in the creation of knowledge that reflects their comprehension and conception of information rather than focussing on the presentation of objective knowledge' (p.5). Cognitive tools engage generative learning processes that occur when learners construct meaning from relating new information to prior knowledge structures. Ferry (1997) contends that this results in deeper information processing because the learner activates appropriate schemata, uses the tools to interpret new information, accommodates new information into their individual schemata and uses the revised schemata to explain, interpret and infer in new situations. These computer-based tools not only extend the mind, they have the potential to reorganise mental functioning (Pea, 1985) and engage learners in high level generative processing of information (Wittrock, 1974). In generative processing, deeper information processing results from activating appropriate mental representations, using these to interpret and assimilate new information, reflect and reorganise the existing representation and use the newly extended mental representation to transfer to new situations. When using cognitive tools, learners engage in knowledge construction rather than knowledge reproduction.

In discussing the role of cognitive tools in constructivist learning environments Jonassen (1998) maintains that a range of tools need to be considered, each with its own function, that facilitate different kinds of cognitive processing. These tools fall into the following categories:

- ❑ problem/task representation tools;

These visualisation tools assist learners in developing a mental representation of the problem. Because they are designed to help the learner form a clearer framework of the problem they are task- or domain-specific.

- ❑ static and dynamic knowledge modelling tools;

Many technology-supported learning environments contain interactive and interdependent components. As learners attempt problems within such settings, it is important that they articulate their understanding throughout the process. Modelling tools provide a mechanism that helps learners encode their understanding as they analyse and organise information.

- ❑ performance support tools;

As learners explore these learning environments tools should be provided to facilitate repetitive tasks - for example note taking - that may occupy some of the cognitive processes of the learner. This 'cognitive load' may distract the learner

from higher-order cognitive tasks associated with the problem under investigation.

□ information gathering tools;

The process of seeking information may distract learners from the primary goal of problem solving. Providing search tools to facilitate this process may help learners in gathering and filtering information, thus reducing any cognitive load the learner may experience when developing individual search strategies.

When designing tools to engage and facilitate learner performance in complex and authentic problem-solving tasks consideration needs to be given to the types of activity structures that are required to solve the problem. Many cognitive tools, such as those used to stimulate metacognitive strategies (Derry, 1990; Tessmer, & Jonassen, 1988), are internal to the learner. Others are computer-based tools that have been adapted and/or developed to support the learning process. In this study both types of cognitive tools were used to support and extend the thinking ability of the participants. In supporting learners' metacognitive strategies four frameworks (concept mapping, venn diagram, six thinking hats, critical thinking) were introduced to assist participants with their cognitive processing. Within the software, *Exploring the Nardoo*, a range of tools are provided to support the data collection relevant to individual problems, and also to support the development of the learners' argument structures when presenting possible solutions. However, research has demonstrated that while learners have little difficulty in using the data collection tools effectively, learners are still experiencing difficulties in developing well-supported arguments or solutions to problems (Brickell, 1998; Gordon, 1998). The purpose of this study was to further investigate the development of individual reasoning and argument skills during the course of the problem-solving activities.

## 2.4 Research that relates to current study

Technology-supported learning environments show promise in assisting learners to process new information and construct knowledge when engaged in the solving of complex problems in authentic settings. Researchers experimenting with these learning environments are attempting to scaffold learners in the process of

resolving a cognitive task, usually presented in the form of a problem (Land & Hannafin, 1997). In particular, such environments that make use of cognitive tools can assist learners to form associative links with existing semantic networks already held in long-term memory. Such tools support learners in processing and reorganising new information in depth so that it can be more easily absorbed into long-term memory (Jonassen et al, 1999). The current study sought to explore ways in which learners developed their problem-solving strategies when provided with a scaffold that aided their metacognitive development. The aim of the scaffold was to help learners improve their self-organisation, not only in the gathering of information, but also with the assimilation and accommodation (Piaget, 1971) of new knowledge into existing schema to help reduce the gap between 'expert' and 'novice'.

### **2.4.1 Expert versus Novice**

Technology-supported problem solving provides an opportunity for learners to encounter scenarios with ill-defined problems, incomplete information and unasked questions in an effort to extend their knowledge domains through a constructivist approach. As novices they are apprentices in the development of a series of skills that are intended to equip them for ill-structured problems in real life. Although a number of studies have been conducted into learning strategies in interactive learning environments, few resemble the research study proposed. Some authors believe (Jones, 1990; Kozma, 1991) that within technology-based learning environments, if learners are provided with a body of knowledge from many different perspectives, they will develop greater understanding of the concepts involved.

Many studies have considered the differences in problem solving between 'expert' and 'novice' learners in an undergraduate setting. In several subject-specific areas - physics (Chi et al, 1981, Ross & Loftin, 1994), chemistry (Comacho & Good, 1989, Altwater & Alick, 1990), and genetics (Smith & Good, 1984) - studies were confined to observed differences in cognitive structures between experts and novices in well-structured problem domains. The general theme throughout these studies is summarised by Smith and Good who suggest that differences in the approach to problem solving arise from the following:

- ❑ experts within a given domain tend to apply principles from their existing knowledge as part of a well-defined method of approach. Novices have a less defined and fragmentary approach;
- ❑ experts and novices have different perceptions of the same problem;
- ❑ experts tend to spend some initial time analysing and defining the problem - novices are less inclined to do so;
- ❑ experts use more specific strategies that lead to an appropriate solution. Novices use strategies that are more general across a range of problems.

Hyerle (1996) distinguishes apparent differences between expert and novice problem solvers through the concept of 'habituated metacognition' (p.9). Thinking and the discussion of thinking processes promote the development of further thinking. In this way the process of problem solving is further developed when learners think aloud and discuss or communicate their thought processes to others. As novices engage in such strategies, over time they more readily assume the mantle of expert.

As western educational curricula continue to be transformed the emphasis is on developing a curriculum that is relevant in a culture that is being changed by technology and focussing on strategies that are learner-centered. This approach is based on the belief that the learner constructs knowledge through having meaningful experiences, making personally significant connections, developing mental models and collaborating with others in a teacher-facilitated social setting. There is an expectation that learners develop improved skills in creativity, critical thinking and problem-solving skills. Problem solvers become 'expert' by spending substantial time experiencing a variety of problems and searching various solutions paths. If educational systems require 'novice' learners to develop strategies that reflect the problem-solving behaviour of 'experts', through the development of better analytical reasoning and representational skills, then there is a need for technology-based tools that support this objective. Such 'cognitive tools' may help learners interpret and manipulate the technology, to analyse and construct meaning from the task presented, to better utilise the available information that may or may not support the problem, and to develop problem schemata that more closely represents those of 'experts'.

## 2.4.2 Technology-supported Learning Environments

With the extensive use of CD-ROM- and World Wide Web-based teaching and learning resources there has been increased awareness of the need to scaffold learners in their search for and evaluation of the diverse range of available information. Knowledge of the manner in which learners access and interpret computer-based learning materials has lagged behind the rapid technological development of the past decade. In recent years, research has focussed on understanding how learners can benefit from tools that can assist in the development of informal reasoning skills when constructing arguments in support of problem solving. Examples of such interactive learning environments include *BioWorld* (Lajoie, 1993), *Belvedere* (Suthers, 1998), and *SenseMaker*, (Bell, 1996).

*BioWorld* was designed as an interactive learning environment to support the acquisition of scientific reasoning skills in high school students and integrates a variety of cognitive tools to assist in scaffolding scientific reasoning activity. Lajoie and Greer (1995), in outlining the purpose of these tools, suggest that they are designed to support metacognitive processes, help reduce cognitive load (Sweller, 1988), allow the learner to engage in cognitive activities that would otherwise be out of their reach (Pea, 1985) and allow learners to generate and test hypotheses in the context of problem-solving. Users of this package are engaged in explicitly justifying hypotheses with evidence: organising, categorising, and rating evidence; and constructing a final summary argument on the topic. In determining the effectiveness of the tools researchers studied the responses and approaches of high school students. The problem scenario presents the patient and patient symptoms to the student in a simulated hospital setting. Further research (Lajoie et al, 2000) indicated that although the majority learners were competent in the use of the computer-based support tools, the search strategies used by learners varied considerably. This study was of interest to this researcher because users of this package are engaged in the problem-solving process through hypothesising, organising, categorising and rating evidence and construction of an argument to support the diagnosis. Learners who used the tools to assist their reasoning skills were more efficient, took less time in solving the problem, and needed fewer actions than their less successful counterparts. In addition, the study recognised that

difference in the level of success between learners was related to their initial mental representation of the problem.

*Belvedere* is a web-based online environment supporting collaborative learning while engaged in developing arguments for solutions to ill-structured problems. Learners use this reasoning-based strategy to record hypotheses, gather information and develop the evidential relationships between them (Suthers, 1998). Using a series of visual representational tools (Jonassen, 1998) that bear similarities to concept mapping tools, learners are aided in visually organising knowledge of the problem space and this appears to be one of its strengths. Learners are able to develop visual representations that demonstrate evidential relationships between hypothesis, data or evidence in support of a solution. Initial research involving high school students (ages 12-16) has indicated that the tools help some learners in knowledge building through allowing them the capacity to develop patterns and to express abstract concepts in concrete form. However other learners became confused through making choices that were irrelevant to their specific inquiry and tried to develop arguments outside the context of the representational tool. It may be more appropriate then to gain a better understanding of how learners develop their reasoning skills in the process of argumentation. While it is recognised that the interaction of the cognitive processes of several individuals, working collaboratively, is different to the cognitive strategies of an individual, this software is of relevance to the current work due to its focus on the development of representational tools to promote the development of 'higher-order' thinking skills.

*SenseMaker* uses a range of knowledge-representational tools to assist learners when collecting evidence from the Web to support an investigation. Learners are able to access the various components that form the learning environment as required. Using conceptual categories (or claim frames) students can assign each piece of evidence linked to a theory or hypothesis a rating for use in construction of their arguments. Using a selection of tools, the software assists the development of mental representations of the problem. This is accomplished through a modelling process that has close associations with the concept of cognitive apprenticeship (Collins, Brown, Holum, 1991).

Research into the effectiveness of the software has shown positive development in learners' general thinking strategies. This research also demonstrated the differences in individual learning strategies used and called for

designing learning environments that can be flexibly used by learners with different preferences. This study sought to support this view through investigating the different preferences learners use in the investigation of similar complex problems.

A common feature of these systems, and one that is of interest to the current study is the use of support mechanisms (scaffolding) to facilitate learning. Learners are encouraged to make notes on the evidence and claims associated with the specified task. Support mechanisms are provided to enable learners to rate the evidence on the relative strengths and weaknesses of the evidence in supporting the claim. When the learner has investigated the task to a satisfactory level an argument can be put forward to support her/his theoretical opinion.

### **2.4.3 Specific Studies similar to current study**

The studies cited are of interest to this study because they investigate differences in the way(s) individuals gather and interpret information within the context of problem solving in technology-supported learning environments. Because the researchers have focussed mainly on the problem-solving ability of individuals many of the methodological concerns are similar.

In a study designed to explore ways in which cognitive tools may be used, Ferry (1997) investigated the cognitive strategies of a group of pre-service teachers while engaged in the interpretation of graphs and tables. These concept-mapping tools were designed to assist learners to interpret information presented in the form of text, graphs and tables that related to the destruction of rainforests. Findings from the study suggest that a strength of this tool was that it helps learners to visually organise knowledge information in a variety of ways.

Gordon (1998) found that learners who used a genre template had a framework to use in their decisions about the presentation of the data/information they had gathered as they constructed a supporting argument to their assigned problem. The templates were designed to scaffold the construction of solutions to problems through the genres of reviewing, reporting, narrative, exposition, explanation, discussion and procedure. Most learners who had access to templates, made use of them and found them helpful in carrying out reporting tasks. Learners also believed that the templates allowed them to construct better solutions to their investigation. However, the research found that there was no significant difference between those learners who used the

genre templates and those who did not on either the effective use of evidence collected or the quality of the argument presented as a solution.

Land and Hannafin (1997) have identified the lack of understanding of the problem-solving and data-exploration processes that learners undertake in technology-supported learning environments. Findings from the study involving year seven students indicate that learners need to apply a theory-action model as they investigate the problem context. As they go about the data-collection process they need to develop a theory about the solution(s) to the problem and take action to test the theory. In this study, during the investigation of the problem, participants showed little evidence of integration of data and little reflection on previous observations. While this approach may show some promise in providing a structure for learners to become more aware of their ideas while problem solving it may be more appropriate to investigate the specific ways in which learners investigate the problem space and the strategies they use in this process.

Fernandes and Simon (1999), using a methodology involving verbal protocol analysis and non-parametric statistical comparison, carried out a study on the differences in problem-solving strategies used in solving an ill-structured problem. Participants had a range of backgrounds and were regarded as professionals, having completed degrees in architecture, engineering, law and medicine. The research found significant differences in the general problem-solving strategies adopted by the participants. Variations in mental representations of the problem may be attributed to differences in knowledge domains of the individuals. This may indicate that the evolution of individual problem-solving strategies is more closely aligned with the knowledge domain in which they are developed. If we are to design cognitive tools that support the problem-solving process then sufficient flexibility in the tool(s) should be provided to cater for this domain specific development.

This study was of use to the current research in that it identified several qualitative approaches that may be used in data collection when identifying strategies used by individuals solving ill-structured problems.



## 2.5 Summary

Technology-supported learning environments show potential in assisting learners in the development of reasoning and argumentation skills when engaged in solving complex problems in the context of real world scenarios. In particular, learning environments that make use of cognitive tools can assist learners in constructing knowledge that represents their comprehension and conceptualisation of information and ideas.

A review of the literature has provided a wealth of information to guide the development of this study in two focus areas: problem-solving theory and theoretical approaches to learning. The underlying theme of these areas is in the use of cognitive tools to support each process. Synthesising the literature on problem-solving theory has led to the identification of a number of important attributes of this focus area: well-structured and ill-structured problems; information processing theory; mental representations; scaffolding; transfer; reasoning; and argumentation. The focus on the theoretical approaches to learning has drawn upon literature relating to constructivism, situated cognition and metacognition.

Further research needs to be carried out on the development of more context-sensitive assistance to improve strategies for targeting and storing of relevant information as well as reflective assessment of the quality of the arguments generated through the problem-solving approach. This study will provide additional support for the further development of a specific cognitive tool, or tools, to aid this process within technology-supported learning environments.

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# Chapter 3

## Methodology

# Chapter Three

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This study set out to investigate the problem-solving strategies used by novice learners in a technology-supported learning environment. The problems were of an ill-structured or complex nature and were set in the context of real-world scenarios situated in an imaginary river catchment system. The purpose of the study was two-fold:

- To review a range of theoretical support frameworks which could help learners organise ideas and focus problem-solving strategies;
- To understand how learners clarify, analyse and organise information when developing solutions to complex problems in technology-supported learning environments.

To address these issues the following research questions were posed:

- What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?
- What strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task with a technology-supported learning environment?

The Chapter begins with an outline of the rationale behind the research method chosen for the study and follows with a description of the study itself and the data-collection processes used.

### 3.1 Introduction

In deciding on an appropriate method for this study, a review of appropriate literature was undertaken. In selecting a methodology the researcher should choose a model appropriate to the '... phenomenon being investigated' (Guba, 1981, p.76) and the '... assumptions underlying the nature of the research' (Merriam & Simpson, 1989, p.9). Analysis of studies related to cognition, computer-based instruction, problem solving, and informal reasoning reveals a variety of methodologies have been used. After reviewing these studies it was decided that an appropriate methodology to use for this study would be a qualitative one as the aim of the researcher was to understand the thoughts and actions of the participants as they engaged the assigned problem(s). The abilities of learners to process information in a meaningful way, to construct their own knowledge, to situate their learning in their own context, and to use the acquired knowledge to solve problems, are of paramount importance.

After consideration of research methods a case study approach was deemed to be the most appropriate for this study. The case study has been defined as '... an empirical inquiry that investigates a contemporary phenomenon within its real-life context ...' (Yin, 1994, p.13) and '... a bounded context in which one is studying events, processes and outcomes' (Miles & Huberman, 1984, p.28). The advantage of the case study approach is that the collected data are strongly based in 'reality', reflecting the richness and complexity inherent in the activities of the individual unit being studied (Cohen & Manion, 1992). Within this framework the researcher is able to concentrate on a specific context and identify the interactive processes utilised by the participants (Bell, 1987). A case study is a triangulated research strategy (Tellis, 1997) in which triangulation occurs with data, investigator, theories and methodologies. It is a multi-perspective analysis that is likely to answer questions of "how" and "why". The single most defining characteristic of case study, according to Merriam and Simpson (1989), lies in delimiting the object of study - the case - as a thing, a single entity or bounded system such as an individual, program, event, group, intervention, or community. Other characteristics of case study include:

- ❑ the key concern is understanding the phenomenon of interest from the participants' perspective, not the researcher's;
- ❑ the researcher is the primary instrument for data collection and analysis;
- ❑ a case study usually involves fieldwork in order to observe behaviour in its natural setting;
- ❑ a case study primarily employs an inductive research strategy, which builds abstractions, concepts, hypotheses or theories rather than tests existing theory;
- ❑ a case study focuses on process, meaning, and understanding and the product are richly descriptive (Merriam & Simpson, 1989).

The role of the qualitative researcher as the main research instrument in observing and interacting with participants, as well as collecting and analysing data, contrasts with the objectivity and impartiality valued in the quantitative approach. This feature of qualitative research raises issues of subjectivity in data collection and interpretation in that the evidence collected and the conclusions drawn come from a single perspective. Peshkin (1988) argues that all researchers should systematically identify the ways in which their subjectivity shapes their inquiry and its outcomes. In the current setting the researcher's ability to interpret experiences within the environment is of central importance in the focus of the study. It is important to recognise those personal values and attitudes that ultimately affect the researcher's subjective responses and interpretation. These factors are not necessarily negative and Peshkin (1988) believes that researchers should actively seek out their feelings and emotions during their enquiry so as not only to acknowledge them but also to be aware of how subjectivity can affect their work and thus act accordingly. For this study it is argued that the researcher is a legitimate member of the group setting, being a member of the original design team for the software and a science teacher with twenty years experience as a classroom practitioner. It is acknowledged that care should be taken to avoid bias in observing and recording participant actions or reflections and later in how the patterns in data are interpreted.

To support the reliability of the data an outside reader – an experienced science teacher with a Masters degree in Environmental Education – was approached to review the criteria used in assessing participants' responses. The

researcher and reader discussed the categories suggested in reviewing one example from each of the four frameworks. The reader independently reviewed one further example from each framework for comparison with the researcher's evaluation before finalising the criteria used in the study.

## 3.2 Research Protocols

Prior to data collection a protocol was developed to examine and record the interactions of participants through their problem-solving approaches. The criteria included in the protocol were based on reviews of related studies (Fernandes & Simon, 1999; Stratford, Krajcik, & Soloway, 1998; Land & Hannafin, 1997; Keys, 1995). The research followed two stages of operation (or events) as indicated in Table 3.1. Actions refer to the proposed steps and protocol suggested for the research procedures mentioned in Table 3.2.

The first stage of the research, the training phase, entailed making all participants familiar with their designated support framework and with the operation of the CD-ROM, *Exploring the Nardoo*. The second stage, the problem-solving phase, involved the researcher as a participant observer with each member of the study group. Each participant was allocated the same problem to solve and asked to investigate the problem using the support of the paper-based support framework. Minimum guidance from the researcher was provided during this phase.

During the problem-solving process, observational field notes were taken on learner activity and resource interaction. Notes were recorded in an observations booklet designed by the researcher. This booklet contained a series of visual indicators (iconic representations) to each of the embedded media elements that related to the problem under investigation (Appendix 3). This allowed the researcher to accurately record a chronological sequence of events during the individual problem-solving approaches. To verify observations, the assistance of a colleague was sought and observational notes taken by the researcher were compared with her observations.

Participant artefacts, transcriptions of audio-recorded think-aloud comments of participants, researcher observations and a post-experience

questionnaire were the primary sources of data collection. Participant artefacts comprised notes collected in a computer-based notebook, (the PDA, a tool within the software environment), and handwritten workbook notes. Notes in the PDA consisted of extracts that had been highlighted and copied from the various media articles, typed notes reflecting development of ideas and measurements related to the problem under investigation. These were analysed using a protocol adapted from a review of related studies (Fernandes & Simon, 1999; Stratford, Krajcik, & Soloway, 1998; Keys, 1995). In collecting think-aloud data, participants were asked to recount the methods they employed in ‘solving’ the problem.

Event	Action
<b>Stage 1 – Training</b>  Introduction & Experience	<input type="checkbox"/> instruction in framework & use <input type="checkbox"/> instruction on CD - ROM <ul style="list-style-type: none"> <li>• navigation</li> <li>• use of measurement tools</li> <li>• use of PDA</li> <li>• access to support articles</li> </ul> <input type="checkbox"/> participants to solve an example problem and reflect on process <input type="checkbox"/> check data collection procedures and validity of instruments to be used
<b>Stage 2 - Problem Solving</b>  Data Collection (Research Questions 1 & 2)	<input type="checkbox"/> assign participants a problem to solve <input type="checkbox"/> audiotape recordings - verbalisation of actions <input type="checkbox"/> examine PDA contents <input type="checkbox"/> examine workbook <input type="checkbox"/> examine researcher’s notes <input type="checkbox"/> participants' recount of actions - interview <input type="checkbox"/> completion of questionnaire by participants <input type="checkbox"/> analyse written responses

Table 3.1      Data Collection Procedures

Table 3.2 indicates the data sources, techniques and proposed analysis methods for each of the research questions. For research questions 1 and 2, the study focussed on the strategies employed by learners as they explored the problem space to develop their understanding of the problem. Based on previous research, it was assumed that learners would present a wide range of responses. The study examined ways in which information related to the assigned

problem(s) was accessed and whether the designated strategy used by each participant had an impact on clarification of the problem, the development of informal reasoning skills and the quality of the argument presented in supporting the problem’s possible solution.

Focus Question	Research Questions	Data Sources	Techniques	Analysis Method
How can learners be supported in problem-solving processes within technology-supported learning environments?	1. What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems?	<input type="checkbox"/> Verbalisation of reflections or meaning of the results of an action	<input type="checkbox"/> think aloud protocols  <input type="checkbox"/> interviews  <input type="checkbox"/> individual written work	<input type="checkbox"/> identification and categorisation of learner approaches.  <input type="checkbox"/> comparison of themes and patterns between learners
	2. What strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?	<input type="checkbox"/> verbalisation of a reason or intention for acting in the environment  <input type="checkbox"/> verbalisation of decision making process  <input type="checkbox"/> verbalisation of strategies for taking action	<input type="checkbox"/> think aloud protocols  <input type="checkbox"/> interviews  <input type="checkbox"/> individual written work  <input type="checkbox"/> analysis of PDA records	<input type="checkbox"/> comparison of problem interpretation and solution design  <input type="checkbox"/> analysis of themes and patterns in framework use

Table 3.2      Research Protocols



### 3.3 The Study

#### 3.3.1 Site and Participants

Volunteers were called for this study from a cohort of 250 students (200 female, 50 male) enrolled in *Information Technology for Learning*, a first year undergraduate information technology class in the Faculty of Education at the University of Wollongong. Of this group of students a sample of 32 participants (27 female, 5 male) agreed to participate in the study. The study was conducted in the Interactive Multimedia Learning Laboratory of the Faculty of Education. The ages of participants ranged from twenty to forty-five years.

Following compliance with the ethical procedures required for the study the rationale for the research was explained to the participants. They were then randomly assigned to one of four groups for initial tutorial sessions in the two components of the training phase. Subsequent to the completion of the training phase participants were assigned, by mutual agreement, to individual sessions on the problem-solving phase of the study. The study took place over a twelve-week period during the Spring Session of 2000 as indicated in the following schedule (Table 3.3). The time-line for each phase of the study has been shaded.

Week	1	2	3	4	5	6	7	8	9	10	11	12
Introduction & Planning												
Strategy Tutorial												
CD-ROM Tutorial												
Problem Solving Problem 1												
Preliminary Analysis												
Problem Solving Problem 2												

Table 3.3 Weekly Schedule for Study

### 3.3.2 Research Materials and Strategies Used.

#### *Problem-solving Support Framework*

Structural knowledge is knowledge of how the relationships within a domain are integrated and interrelated (Diekhoff, 1983; Beissner et al, 1993). In an attempt to support the structural knowledge of each participant during the problem-solving process four specific support frameworks were identified for use in this study. Each of these support frameworks, Concept Mapping (Novak, 1990), Venn Diagrams (Gunstone & White, 1986), Critical Thinking (Ennis, 1991) and Six Thinking Hats (De Bono, 1992) have been identified as alternative learning strategies that assist learners in processing and analysing information. It was thought that the support framework would provide cognitive support for problem solving and the development of higher-order thinking skills that would facilitate more efficient problem clarification, together with better reasoning and argumentation outcomes. The researcher prepared a paper-based tutorial booklet for each framework (Appendix 1) containing an overview of the theoretical aspects of the strategy together with examples on which the participants could practise their assigned framework.

*Concept Mapping* (Novak, 1990) was developed as a spatial knowledge representation technique to link specific relationships between concepts. A concept map illustrates the sequencing of ideas in the form of '... hierarchies of ideas that suggest psychologically valid sequences' (Novak & Gowan, 1984, p.82). Critics of concept mapping claim that it describes only declarative knowledge and therefore can only benefit memory processing, but research by Gordon and Gill (1989) has shown the central role of these knowledge structures in problem solving. Jonassen (1996) shares this view, recognising the support of concept mapping for problem solving in the development of structural knowledge.

Research has shown that concept mapping can be taught in a relatively short time: three to four class periods for eighth grade science students (Novak, Gowin & Johansen, 1983); three twenty-minute sessions with practice (Arnaudín, Mintzes, Dunn & Shafer, 1984); and three seventy-five minute sessions for elementary education majors (Wallace & Mintzes, 1990). In this study one two-hour tutorial session was utilised together with practice assignments. This use of

the strategy was reinforced in the second tutorial session involving the CD-ROM. For consistency in the tutorials the same time allocations were made for the three remaining support frameworks.

*Venn Diagrams* (Gunstone & White, 1986) are another graphic technique that assists with the development of structural knowledge. Using a spatial representation of interlocking circles learners are able to reorganise information into related conceptual arrangements. Each circle contains a subset of the whole set of information or classes of concepts. Items common to each subset of information are placed in the circles' intersection. These pictorial representations may act as visual roadmaps which indicate pathway connections between related pieces of information that assist learners in perceiving relationships among concepts.

A review of literature indicates the use of Venn diagrams in a variety of contexts: as illustrations of the partitioning of overlapping variance in texts on research methodology (Burroughs, 1975); as a tool to enable greater precision in specifications for on-line computer literature searches (Smith, 1976); as an approach to the study of dinosaurs (Dudley, 1977); and as a method for analysis and clarification of language used in writing about curriculum innovations (Rice, 1978). It was thought that this approach may also be useful in assisting learners in this study by providing a model to restructure and group ideas that support hypotheses about the problems under investigation.

*Critical Thinking* (Ennis, 1991) is a philosophical approach that tries to challenge learners through the development of their thinking skills – reasoning, inquiry, concept formulation and reflection. A review of the literature yields a range of definitions for the concept that are encompassed in the ideas expressed by Halpern (1996) which are relevant to this study.

“ Critical thinking is the use of those cognitive skills or strategies that increase the probability of a desired outcome. It is used to describe thinking that is purposeful, reasoned and goal directed – the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions when the thinker is using skills that are

thoughtful and effective for the particular context and type of thinking task. Critical thinking also involves evaluating the thinking process – the reasoning that went into the conclusion we’ve arrived at, the kinds of factors considered in making a decision.”

The term ‘critical’ does not mean thinking that is negative or finds fault, but rather thinking which evaluates reasons and brings thought and action in line with our evaluations. The essential differences between a critical thinker and a non-critical thinker may be illustrated in the following table:

Critical Thinking	Non-critical Thinking
<ul style="list-style-type: none"> <li>❑ Distinguishes between poor &amp; strong reasoning</li> <li>❑ Uses a number of identifiable learning skills</li> <li>❑ Analyses and evaluates reasons &amp; evidence</li> <li>❑ Makes assumptions &amp; evaluates them</li> <li>❑ Uses the best &amp; most complete evidence available</li> <li>❑ Avoids inconsistency &amp; contradiction</li> </ul>	<ul style="list-style-type: none"> <li>❑ Doesn’t reflect on or evaluate reasons for a set of beliefs</li> <li>❑ Simply agrees or disagrees, accepts or rejects conclusions</li> <li>❑ Lacks skills to analyse &amp; evaluate</li> <li>❑ Doesn’t notice assumptions &amp; fails to evaluate them</li> <li>❑ Has difficulty sorting out ideas</li> <li>❑ Is oblivious to contradictions</li> </ul>

Table 3.4      Comparison of Critical/Non-critical Thinking.

*Six Thinking Hats* (De Bono, 1992) is a strategy designed to enhance learners’ thinking ability. Using the metaphor of coloured hats, learners may ‘put on’ or ‘take off’ a hat to indicate the type of thinking being used in helping to make decisions and solve problems. By mentally wearing and switching ‘hats’ a learner can focus or redirect thoughts in a proactive way rather than a reactive one.

- ❑ The White Hat is the metaphor associated with information gathering. It is used to help learners generate questions such as: How can I get the information? What information do I have? What information is missing?
- ❑ The Yellow Hat is the hat for the deliberate logical, positive view of the situation. Questions generated could include: What are the benefits of this point of view? Why is this proposal preferred?

- The Black Hat encourages a critical judgement of the evidence at hand. It allows the learner to critically and logically evaluate the information collected and to reflect on the validity of any suggestions, or collected information to fit the facts.
- The Red Hat promotes feelings, hunches and intuition. Wearing the red hat allows the individual to put forward her/his feelings and intuitions without the need for justification or explanation.
- The Green Hat focuses on creative thinking. It encourages thinking leading towards development of new ideas, alternative proposals, and additional hypotheses to support an investigation. Questions generated could include: What additional alternatives are possible? Could there be another reason for this situation?
- The Blue Hat is used to stimulate the metacognitive processes in the learner. Its purpose is in organising and controlling the thinking processes with the aim of being more productive and developing an overview of the process. In associating the coloured hats with key words and questions that direct, re-direct and sequence their thinking, learners are able to focus on separate thinking skills and then combine them to gain a complete perspective.

During the tutorial process for the strategy the researcher modelled each of the hats as required for the type of thinking being used, physically 'putting on' and 'switching' the hats as required. Each of the group members was supplied with a set of paper-based coloured hats and was asked to attach the appropriate hat to the front of his/her clothing throughout the tutorial session. When these participants completed the problem-solving phase of the study a set of appropriately coloured hats was positioned in an observable position adjacent to the computer used for the study to act as a visual cue through the process.

It was anticipated that each of these four frameworks would provide direct support for participants in clarification of the problem space, and in the development of clearer reasoning and argument skills. A copy of the support framework was made available for reference by each of the participants if required. This was to remind the participants to view the problem from a variety of perspectives. The decision for the researcher was to ascertain whether one

framework was better than any other in achieving this outcome. A related issue was how a framework, or combination of frameworks, might be implemented as a structure for the later development of a software-based support scaffold to assist novice learners in developing better solutions to complex problems.

### *Think-aloud Protocol*

Audio recordings were used as the main technique for verbal protocol collection. In this study the analysis of the think-aloud protocols was carried out with the procedures outlined by Ericsson and Simon (1992) in mind. The authors suggest that think-aloud approaches require a minimum set of assumptions about the nature of the processing, mainly that it occurs in an information-processing framework. By encouraging learners to articulate what they know, to define how they intend to map out their strategies, or to explain why they utilised a particular approach in their development of ideas, an observer can develop a sense of the cognitive skills used in the problem-solving process (Collins, Brown & Newman, 1988).

The purpose of the audio-tape recordings was to document the thinking processes of the participants as they engaged the problem under investigation. The problem was presented in written format and participants were asked to keep talking about their thoughts as they worked through the problem space. At the completion of the assigned problem the researcher asked some participants questions to clarify particular actions that were observed during the process. This provided additional verification of the researcher's observations on the action pathway taken by each participant through the problem-solving process. This collection of both verbal and retrospective data provided a nearly complete record of the sequence of data collection needed during the problem solving process (Ericsson & Simon, 1992).

In one study on aging, involving the solution of ill-structured problems by adults (age range 26 to 89 years), Sinnott (1989) used a similar approach to collect verbal data. When the problem was introduced to the participants they were instructed to:

'Think aloud as you work on the problem. Say whatever comes to mind, even though it doesn't seem important. When you have finished with the

problem, I'll ask you about anything you said that seems unclear to me' (p.78).

This approach was adopted for the current study. Other studies into the development of informal reasoning and argumentation skills have used verbalisation techniques for data collection (Lajoie, 2000; Fernandes, 1999; Patronis, Potari, & Spiliotopoulou, 1999; Stratford, Krajcik, & Soloway, 1998; Land & Hannafin, 1997; Hill & Hannafin, 1996; Keys, 1995). These studies have demonstrated the usefulness of this technique in gathering data and support the view that verbally-reported data seem as regular and valid as other types of data (Ericsson & Simon, 1992). For this aspect of data collection the researcher needed to have good listening skills and be able to interpret visual cues such as changes in the participants' facial expressions, voice and body language.

Following the completion of each of the problems the individual participant's audio-tape recordings were transcribed verbatim, coded appropriately and set aside for later analysis. A selection of these transcribed audio-tape recordings (five) was checked by the participants to verify the authenticity of the transcriptions. This analysis will be discussed in detail in Chapter Four.

### *Note taking with the PDA*

Research related to learning strategies that make use of spatial representations of text-based material showed that learners assimilate more from text when one or more of the following strategies are utilised (Kiewra, 1988; Kiewra et al, 1991):

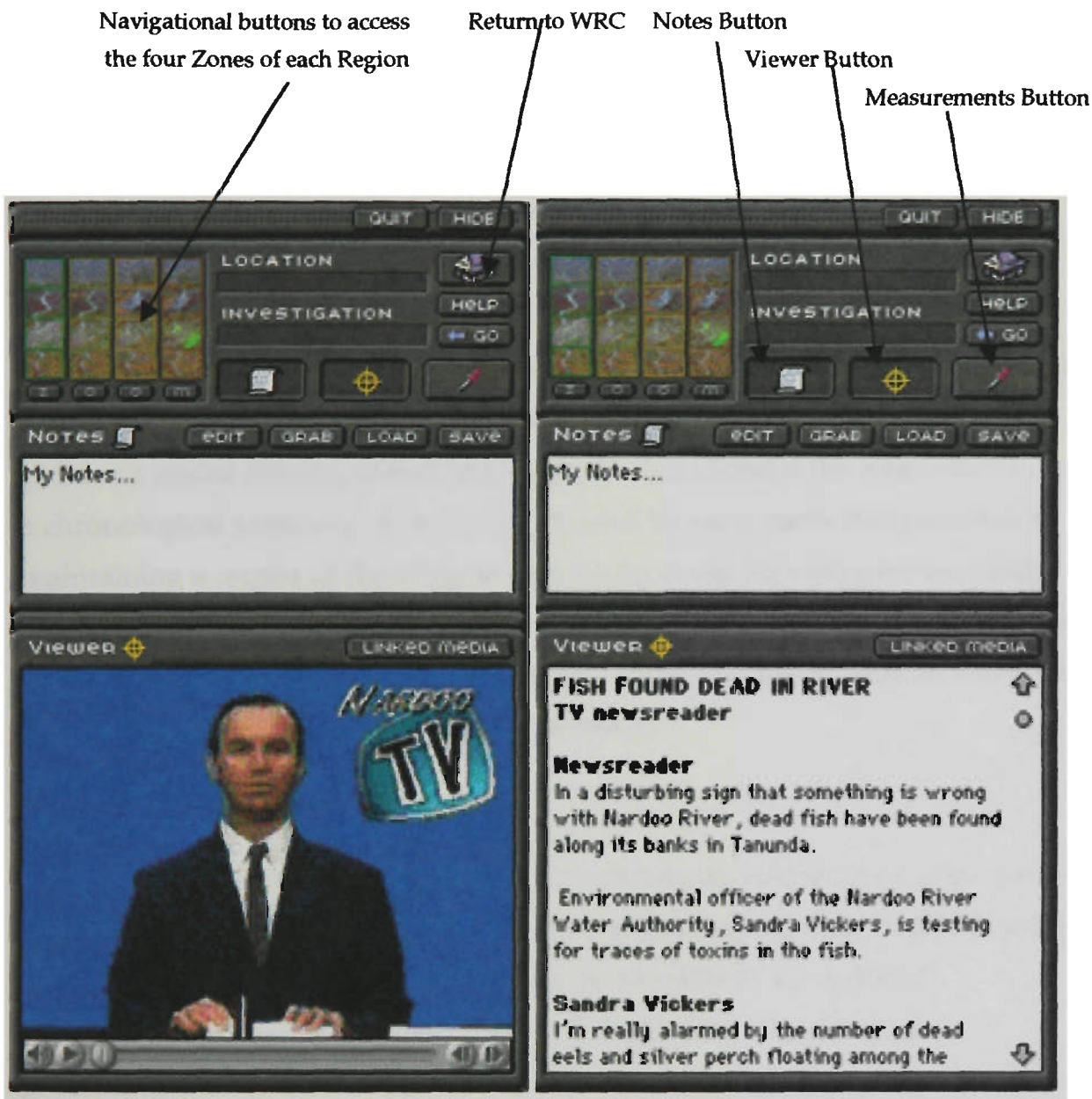
- ❑ study the text in deep and meaningful fashion;
- ❑ form mental images of the textual material;
- ❑ construct an organised interrelated representation of concepts expresses within the text.

Being able to store and report thoughts and impressions derived from media experiences by using the media itself (actual video/audio and images and not just text) provides a more powerful means of 'reformulating' learners' ideas (Kenny & Schroeder, 1994). However, the authors also offer a word of caution in suggesting learners not accustomed to this form of note-taking utilising

multimedia tools, will require clear instruction in its use to reduce cognitive load. Other studies have investigated the effectiveness of information location and use between computer-based and print-based resources (MacKnight & Baroni, 1993; Schneiderman, 1987). Each of these studies demonstrated that learners using either of these two resource formats to complete a research task did not differ in their ability to recognise or extract important information. The studies also illustrated that there was little difference in the number of times learners bypassed or overlooked important information between the two presentation formats. Mynatt and colleagues (1992) found that subjects using a hypertext, non-linear book, even with minimal training, are as successful in information seeking as those using a conventional book. Based on these studies the tutorial time allocated for training on the CD-ROM was considered suitable for development of the participant's skills in information retrieval.

As outlined in Chapter Two, one of the features of the PDA is its use as a sophisticated multimedia notebook. Not only do learners have the choice of viewing or listening to media elements (video, text, sound, graphics), they also have the option of manipulating or editing the text through copying, cutting and pasting, or composing their own text in constructing personal representations of the media information. The combination of media viewer and notebook (Fig.3.1 (a) & (b)) was designed to allow learners to view and then critically evaluate or compare different representations of similar information. By collecting and reflecting on the various media elements that may be related to the problem solution, the learner has the opportunity to document any emerging ideas that help establish cognitive links among the various elements that support the problem space.





(a) Extended view of PDA showing viewer (containing video footage) and note-taking facility.

(b) Same extended view showing viewer (containing related text of video)

Fig. 3.1 (a) & (b) PDA viewer and notebook

### ***Researcher's Observational Workbook.***

Observation involves recording the actions and events that occur within the research setting. Not only should the researcher look for those specific actions and events that have been previously identified for study, but s/he should also be prepared to sense those incidental and unforeseen factors that may have a bearing on the research questions. The disadvantage in the researcher being the main instrument in participant observation is the difficulty associated with observing and recording everything that takes place during the observation period.

To facilitate the recording process here the researcher prepared a booklet containing markers for all the supporting media elements for each of the problems under investigation (Appendix 4). This allowed the researcher to record a chronological sequence of events performed by each participant, as well as maintaining a record of the support articles accessed for each problem under investigation. Additional notes on off-task behaviour, any observed confusion or frustration on behalf of the participant, and any instances of reflective behaviour were also noted as the investigation proceeded.

### ***Participant Workbook***

Prior to commencing each of the experiments, participants were provided with a paper-based workbook (and pen) to assist them in their problem-solving strategies. They were encouraged to use the workbook to construct representations that would help them with both with their information processing and with the support framework presented during the tutorials. Earlier research has shown (Gordon, 1999; Brickell, 1998) that some learners have a preference for developing paper-based strategies that support the development of their ideas. These learners have shown a preference to using paper-based outlining of their ideas, in contrast to those learners who are comfortable in using a computer-based notebook approach. As a learning strategy these learners note different aspects of their investigations and try to identify relationships among the ideas and concepts generated.

### *Post Questionnaire*

A post questionnaire was completed and collected after participants had finished the second problem of the problem-solving phase of the study. They were asked to attempt all relevant questions. The questionnaire (Appendix 5) consisted of a combination of both open-ended questions (participants were required to generate their own responses) and closed questions (participants were restricted to a choice of specified alternatives). Asking open-ended questions allowed the researcher to gain further insight into how and why the participants approached the problem-solving process from their own frame of reference rather than from one structured by pre-arranged questions.

## **3.4 Data Collection Process**

### **3.4.1 Ethics**

The qualitative research conducted in this study required the establishment of ethical guidelines at the outset of the project. This study was conducted using the ethical guidelines implemented by the University of Wollongong (<http://www.uow.edu.au/research/current/guidelines>) with every effort being made to protect the rights of the participants. The participants were all volunteers; there was no coercion to participate and no reward for participation. Closely related to the notion of voluntary participation was informed consent. Participants were all required to read and sign a consent form (Appendix 6) informing them of their rights whilst participating in this study. They were informed of any potential risk or harm which could result from their participation (in this case none or negligible), told that their participation was not compulsory and alerted to the fact that they could withdraw at any time without penalty. Anonymity was maintained at all times and confidentiality was guaranteed to all participants.

### 3.4.2 Orientation Phase

Initially all participants were given an overview of the research and its relevance to classroom practice and to the undergraduate course they were currently studying. Any questions raised by participants regarding ethical issues and freedom to withdraw without penalty were addressed. An indication of the data-collection procedures and associated timeline were also discussed, together with details of the site where the study would take place. The role of the researcher as participant observer was also explained at this time. Participants were then assigned to one of four groups based on prior indications of availability and provided with an initial timetable for the tutorial sessions associated with the study. To facilitate effective data collection and later analysis, each of the four problem-solving support frameworks was assigned a colour code for the duration of the study. Each of the participants was also allocated a code based on her/his assigned support framework (critical thinking, CT1, CT2 etc; concept map CM1, CM2 etc; venn diagram VD1, VD2 etc; six thinking hats, SH1, SH2 etc.), which was used for identification of the participants during the study.

### 3.4.3 Training Phase.

Participants were asked to participate in the following sessions as part of the data collection process:

- Support Framework tutorial – Four tutorial sessions were conducted for this phase of the study, one for each group. After an initial introduction participants were each issued with a copy of their support framework outline in paper-based format. Each group was instructed on the basic principles of their designated support framework through modelling by the researcher. This was followed by individual practice of the framework ideas on a selection of problems across a range of domains. Participants were encouraged to present their ideas to the remaining group members for discussion, allowing reinforcement of the framework concepts. On completion of this two-hour session participants were provided an opportunity to ask questions and address any concerns prior to leaving the tutorial session;

- CD – ROM tutorial – Four tutorials were also conducted for this phase of the study. Each group was independently instructed on the use of the investigating tool and given an opportunity to develop their skills, with both the software and their assigned strategy, using alternative problems to those used in the study. Making a selection from the 'River Investigations' board within the Water Research Centre of *Exploring the Nardoo* accesses the problems (Fig. 3.2). When selected, the problem is introduced by one of three Research officers (guides) who invites the learner to assist in solving the problem. This guide may be activated during the course of the investigation for further assistance and hints to help with the process. The session provided participants with an overview of how to navigate through the software, use of the PDA, accessing and manipulating media elements (copying, cutting, and pasting), use of the measurement tools, and use of the 'guides' for additional support.



Fig. 3.2. The Water Research Centre.



This orientation phase was also delivered in the form of a verbal protocol, together with use of video segments from the CD-ROM that provide 'help' support for learners when in difficulty. These walk-through movies are immediately available to users through the CD-ROM help system, providing guidance as required. Participants were then allowed a period of one and a half hours to explore, investigate an assigned problem and use those parts of the software package in which they had received instruction. Any questions raised by participants at this time were related to their individual skill development and were resolved. As each group completed their allocated tutorial session each participant was provided with a timetable indicating their allocated time for the problem investigation. Participants were again given an opportunity to ask questions and address any concerns prior to leaving the tutorial session.

#### **3.4.4 Problem-solving Phase**

Each participant was again given an overview of the research and allowed a few minutes to reacquaint himself or herself with the software. The role of the researcher was again explained and the purpose of the audio-recorder outlined. The focus of this initial introduction to the problem-solving phase was to minimise any discomfort the participant may have experienced at this time with the research setting. Participants were given the opportunity to familiarise themselves with the software and to ask any questions regarding their assigned framework. Once s/he had acknowledged her/his comfort with both the setting and the research tools, each participant was asked to attempt the first problem. The problem outline and the context in which it is set are presented in Figure 3.3.

Each participant was allocated the same problem to solve from the 'River Investigations' board in the Water Resources Centre on the CD-ROM and asked to prepare her/his solution using the resources of the software package and their specific problem-solving support strategy. Participants were given an indication of how long they had to work on the problem and told that the purpose was to complete the task as required and verbalise their thoughts and actions as they proceeded to investigate the problem.

**Problem 1:   *Zone 3, Tanunda Region***

**Chemical Pollution of River**

Many of the children of Pilliga Crossing enjoyed fishing from the banks of the Nardoo River during their spare time. They noticed an increasing number of dead fish floating around their favourite fishing holes. Local media carried news reports dealing with this and other incidents which may be related.

**Your task:**

Find possible reasons for the fish kill. Prepare a report that details your findings as well as any procedures that the community might adopt to fix the problem.



Figure. 3.3   Setting for Problem 1 showing the Township and the PDA with measurement tools module

When a problem is selected the context is explained by one of the 'Research Officers' and this outline, together with a description of the actual task, is displayed in the PDA for future reference.

During this problem-solving phase observational field notes on participant activity and interaction were taken. The time allocation for each session is indicated in Table 3.5.

Tutorial Group	Number of Participant	Assigned Framework	Template Tutorial	CD – ROM Tutorial	Problem Investigation
1	8	Concept Mapping	2 Hours	2 Hours	1 Hour each
2	8	Venn Diagram	2 Hours	2 Hours	1 Hour each
3	8	Critical Thinking	2 Hours	2 Hours	1 Hour each
4	8	Six Thinking Hats	2 Hours	2 Hours	1 Hour each

Table 3.5 Time Allocation

At the completion of each problem solving session the process notes of each participant that were recorded in the PDA were saved on the desktop of the computer used in the study and then copied to a removable storage disc for backup and later processing. Throughout the duration of the problem-solving phase each PDA file was numerically coded, placed in a colour-coded computer folder to indicate the appropriate strategy and crosschecked by the researcher using a spreadsheet. All participants had completed the first problem prior to the mid-session break. During this two-week period the researcher analysed the data collected to date, noting any patterns of behaviour, events and phenomena that may have needed to be investigated further. The current protocols were checked with the assistance of a colleague to see if any variation to the existing structure was required. It was decided to proceed with the second problem using the established protocol. The second problem outline and the context in which it is set are presented in Figure 3.4.



## Problem 2: *Zone 2, Merringurra Region*

### Water Plants and Weeds

Hugh Smythe captains a riverboat that ferries passengers up and down the Nardoo River. As the river is the key to his livelihood, he has become concerned about the rampant growth of weeds and willows that have begun to obstruct parts of the river in recent months.

### Your task:

Identify, with supporting evidence, the main cause(s) of the problem and suggest actions that could be taken to reduce the weed growth with minimum impact on the river.



Figure 3.4 Setting for Problem 2 showing the Logging Camp and the PDA with measurement tools module

### 3.4.5 Triangulation of Data

The main purpose of triangulation is to enhance the trustworthiness of the research. This practice involves the incorporation of multiple data sources, methods, investigators and theoretical perspectives in the study (Lincoln & Guba,

990). This concept of triangulation is based on the assumption that any bias associated with the data sources, the researcher and the research method will be cancelled out when supported by other data sources, researcher(s), and method(s).

In this study the opportunities for triangulation were limited. Even though a number of data sources were used in the data collection, the methodology was restricted to a qualitative paradigm and carried out by one researcher. Miles and Huberman (1984, p.235) suggest:

'... triangulation is a state of mind. If you self-consciously set out to collect and double-check findings, using multiple sources and modes of evidence, the verification process will largely be built into the data-gathering process, and little more need be done than to report on one's procedures'.

To verify the trustworthiness of the participants' action plans throughout each of the problem-solving investigations a process of member checking (Miles & Huberman, 1984; Stake, 1995) was undertaken. One participant from each of the four targeted groups was asked to listen to his/her individual audiotape recordings and review the researcher's interpretation of the data collected pertaining to his/her individual problem-solving strategies. Each of these participants had completed both assigned problems. In each case the researcher's interpretation was based on data collected from the audio transcripts, the participant's notes in the PDA and/or workbook, and the researcher's observational notes. The purpose of the member checking procedure was to ensure the accuracy of the findings generated by the researcher. On completion of the review of the researcher's interpretation each of the four participants provided a written acknowledgment of this process confirming the accuracy of the original analysis.

### 3.5 Data Analysis

Preliminary analysis of the data was carried out during the initial data-collection phase to provide an opportunity for changes in focus and to address unanticipated issues. The collection of evidence from multiple sources, documenting the chain of evidence and seeking cooperation from participants in reviewing interview transcripts and the researcher’s interpretations were used to support the analysis of the data collected.

Participants’ written work, audiotape recordings and think-aloud transcripts were coded and analysed to identify emerging categories and themes that help address the research questions for each phase of the process. Coding for assessment work was centred on assessment criteria and evaluation protocols from appropriate literature.

This analysis and subsequent discussion of these results will be undertaken in greater detail in Chapter four.

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# Chapter 4

## Analysis

# Chapter Four

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## 4.1 Introduction

This chapter describes how participants used their designated strategy to solve two problems set within a virtual environment represented through the CD-ROM, *Exploring the Nardoo*. The qualitative data collected and the subsequent analysis is described in order to address the main research question:

*How can learners be scaffolded in problem-solving processes within technology-supported learning environments?*

The focus of the data collection process was directed towards addressing the research sub-questions:

*What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?*

*What possible strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?*

The analysis was developed in three phases. In phase one, preliminary examination of the artefacts was undertaken to obtain a general overview of the main approaches used by participants in solving the two assigned problems. Phase two involved evaluation of the transcripts to identify patterns or strategies used to address the first of the sub-questions. Analysis of the artefacts for evidence related to the second of the sub-questions was carried out in phase three.

## 4.2 Method of Analysis

### 4.2.1 Phase 1 - Preliminary Analysis

Analysis of the first stage of data was undertaken to verify the focus of inquiry. The various artefacts used in the data-collection process were reviewed for any emerging patterns or themes prior to conducting the data collection associated with the second problem.

The data was reviewed to address the question:

*What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?*

The purpose of this study was to gain some understanding of the cognitive approaches used by learners in developing solutions to problems of an ill-structured nature. As learners explore the problem space a degree of informal reasoning takes place where each learner, after locating and analysing the information available, arrives at a conclusion based on developing inferences generated from the evidence that has been accessed (Voss & Means, 1991). Such informal reasoning is usually experienced in real-life scenarios where multiple solution paths exist and not all premises are stated.

#### 4.2.1.1 Participant access to Data

Initial examination of the artefacts focussed on participant use of the evidence available on the CD-ROM that related to the specific problem. The researcher's data-collection notes on the strategies used by each participant were examined to develop an evidence profile of the media articles that were accessed. Access to these articles within the CD-ROM may be made either through random exploration of the region in which the problem is occurring or within the Water Research Centre. Some of the media articles have more relevance than others do in directing the focus of inquiry leading to the development of one or more possible solutions to the problem. They help strengthen a particular line of

reasoning when developing a logical argument to support one or more possible solutions. It is apparent from the following table(s) that many of the participants failed to access all of the relevant information available. In some cases the participant missed detecting the critical piece(s) of evidence that would assist in focussing their reasoning towards a strong argument in support of a specific set of solutions. The results of this initial examination appear in tables 4.1 and 4.2.

With problem one (Table 4.1), three reports - 'Industry suspected of dumping acid (newspaper)', 'Tip chemicals killed fish' (radio), and 'Chemical dumping to be fined' (television) - point to the main causes of the fish kill associated with chemical pollution. More than half the participants did not access one or more of these reports. Of these three media articles, the radio report provides information regarding the illegal dumping of empty agricultural containers containing residual insecticide waste. Participants CT1, CT4, CT6, SH2, SH8, VD3, VD4, VD7, and CM5 did not access this report. Participant SH2 did not access all three reports. Participants CT1, CT5, CT6, SH2, SH3, SH4, SH5, SH7, VD2, VD6, VD7, CM1 and CM6 did not access articles contained within the folder in the filing cabinet. These articles provide additional information to support the main media reports and provide possible solutions to remedy some of the problems occurring for the residents within the context of problem one.

Research into the information that supports the development of possible solutions to problem two (Table 4.2) followed a similar trend. Many of the participants did not access media articles that are pertinent to this particular problem. Participants CT3 and CT5, SH2, SH4, SH5 and SH6, and VD7 did not access the newspaper article 'Logging linked to weed growth'. Similarly, participants CT3 and CT4, SH1, SH4, SH5 and SH7, VD5 and VD7 did not access the radio report of the same title. Both these articles provide a clear indication of the link between the pollution problem, the logging camp, and the growth of weeds. Participants CT2, CT3 and CT7, SH4, VD1, VD5 and VD6, and CM3 did not access the radio report "Expert warns against weed invasion" which provides a link between the weed problem, the ways in which it is spread and the association of the problem with excessive nutrients in the river.

Critical Thinking							Six Thinking Hats						Venn Diagram					
Participant	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8			
EVIDENCE																		
(1)Newspaper Keep out of River		Y					Y		Y		Y		Y			Y	Y	
(2)Newspaper Acid burns School Boys		Y	Y		Y	Y	Y	Y			Y	Y		Y		Y	Y	Y
(3)Newspaper Industry Suspected		Y		Y				Y		Y	Y			Y	Y	Y	Y	Y
(4)Newspaper Industry killed fish		Y		Y		Y	Y			Y	Y	Y			Y	Y	Y	Y
(5)Radio Chemical disposal	Y	Y	Y		Y	Y	Y	Y			Y	Y			Y	Y	Y	Y
(6)Radio Chemical dumping ad.	Y	Y	Y		Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y
(7)Radio Tip poisons river		Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
(8)Radio Tip chemicals kill fish		Y	Y		Y		Y	Y	Y			Y	Y		Y	Y	Y	Y
(9)TV Fish found dead in river		Y					Y	Y	Y	Y	Y	Y	Y	Y	Y			
(10)TV Chem dump. fined	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
(11)TV Resident's call			Y	Y	Y			Y		Y	Y	Y				Y	Y	Y
(12)TV Chem dump. witnessed	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		Y	Y	Y	Y	Y	Y
(13)Filing Cabinet		Y	Y	Y			Y	Y		Y	Y	Y			Y	Y	Y	Y
(14)Measurements	Y		Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = participant accessed article                      x2 = second referral to article

Table 4.1              Access and Use of Evidence to support Problem 1



Critical Thinking										Six Thinking Hats						Venn Diagram					
Participant	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	1	2	3	4	5	6
EVIDENCE																					
Newspaper Weed effort fails		Y		Y	Y	Y			Y		Y		Y	Y		Y		Y		Y	
Newspaper Weed Erad. Program	Y				Y			Y								Y			Y		
Newspaper Logging linked	Y	Y		Y		Y	Y	Y			Y	Y	Y	X2	Y	Y	X2	Y	Y		
Newspaper Farmer doubts beetle		Y	Y	Y	Y		Y			Y		Y	X2					Y			
Radio Weeds cover river	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y			Y		
Radio Logging linked	Y	Y			Y	Y	Y	Y		Y	Y		Y	X2		Y	X2	Y	Y		
Radio Expert warns	Y		Y		Y	Y		Y			Y	Y		Y	Y	Y			Y		
TV Weed Distresses resid.	Y		Y	Y	Y	Y			Y	Y	Y	Y	Y		Y				Y		
TV Cause found	Y	Y	Y	Y	Y	Y		Y			Y	Y	Y	Y	Y			Y	Y		
TV River choked by willow	Y		Y		Y	Y	Y	Y			Y	Y			Y	Y			Y		
Filing Cabinet	Y	Y	Y	Y			Y				Y	Y	Y		Y	Y	X2		Y		
Measurements	Y		Y	Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	X2	Y	Y		

Y = participant accessed article

x2 = second referral to article


 = no data (participant withdrew)

Table 4.2 Access and Use of Evidence to support Problem 2

A number of participants (CT5, CT6, SH1, SH5, SH7, VD5, VD7, and CM3) did not check the filing cabinet for related information. Some of these participants had not listened to advice (hints) from the Water Research Officer supporting this problem guiding them in this direction. Others had ignored the advice. Articles within these files provided information that indicated possible ways to reduce or eliminate the excessive weed growth.

#### **4.2.1.2 Participant Strategies**

Initial interpretation of the data was based on a constant comparative method of analysis (Glaser & Strauss, 1967) in an effort to identify common categories that could be used in the dissection of the participants' cognitive strategies used in problem solving. Cognitive strategies or learning skills are demonstrated through the learner comprehending information, organising ideas, analysing and synthesising data, choosing between alternatives and evaluating ideas or actions. Bloom (1956) identified six levels of classification within the cognitive domain - knowledge, comprehension, application, analysis, synthesis, and evaluation - which indicate the intellectual behaviour demonstrated by the learner. Essentially the classification is a taxonomy arranged in a hierarchy from less to more complex cognitive thinking. The demonstrated cognitive strategies (learning skills) that were chosen for the initial analysis in this study were:

- ❑ clarification - initial planning & defining problem. Regular referral to problem outline and task. Participant translates, comprehends or interprets information.
- ❑ application - researching & gathering of evidence. Participant selects, transfers and uses data to address the problem.
- ❑ analysis - highlight evidence to support problem resolution; compare and contrast information; makes inferences. Participant classifies and relates evidence, statements or assumptions.
- ❑ synthesis - planning through linking of or between evidence. Participant integrates and combines ideas into a plan or development of a strategy.
- ❑ evaluation - informal reasoning to support argument. Participant appraises, assesses and judges on the basis of personal criteria.

The transcripts of each participant's 'think-aloud' protocol were examined for statements that indicated the thought processes used as they investigated the problem. Each of these transcripts was cross-referenced with the researcher's observational notes to develop a summary profile for every participant in each of the four strategy groups. The results of this initial examination are presented in Table 4.3 and Table 4.4.

Table 4.3 represents an overview of each participant's approach to this problem. Initial inspection indicated that many participants spent little time in clarification of the problem. Most restricted this commencement of the problem to reading the task and then proceeded to collect information. However it became apparent with some participants that clarification of the task came from regular referral to it while undertaking the task. Others (CT2, CT6, SH6, CM1) read the initial outline to the problem and made no further reference to it. While all participants (except CT1) engaged in some analysis of the evidence available to support the resolution of the problem, initial indications were that the degree of analysis and the interpretation of related issues varied considerably. Framework use was more apparent with those participants using the Critical Thinking and Six Thinking Hats frameworks than with the Venn Diagram and Concept Map frameworks.

Table 4.4 presents a summary of the learning skills associated with problem 2. Initial analysis of the strategies used in developing a solution to the assigned problem appeared to indicate similarities in the approaches used. Little time was spent in the initial definition of the problem or apparent planning of an overall strategy. For the majority of participants the next stage in their strategy was to begin to locate information, usually through a random exploration of the region in which the problem is set. Again those participants using the Critical Thinking and Six Thinking Hats frameworks made greater use of their support framework than their counterparts.

Critical Thinking										Six Thinking Hats										Venn Diagram										Concept Map									
Participant	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6		
Learning Skills																																							
Initial planning & defining problem (clarification)			Y				Y	Y		Y	Y	Y	Y		Y	Y			Y	Y		Y								Y									
Researching and gathering of evidence (13 articles) (application)	4	12	9	7	8	7	10												8	8	8	5	7	9	9	10	10	12	10	8									
Highlighting of evidence to support problem (Analysis)		Y	Y	Y*	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y												
Linking of/between evidence (synthesis)	Y	Y	Y		Y		Y	Y	Y	Y		Y				Y			Y	Y			Y	Y	Y	Y	Y	Y	Y								W		
Regular referral to task outline				Y	Y			Y	Y	Y		Y			Y	Y				Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Referral to strategy outline		Y	Y	Y	Y	Y		Y	Y	Y	Y	Y						Y	Y				Y	Y															
Inference/assumptions																									Y								W		W				

Y = evidence of action      w = weak evidence      s = strong evidence  
 • = missed important articles (final conclusions generalised)

Table 4.3      Identifiable Learning Skills - Problem 1

Critical Thinking							Six Thinking Hats							Venn Diagram							Concept Map						
Participant		1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	1	2	3	4	5						
Learning Skills																											
Initial planning & defining problem (clarification)		Y			Y			Y			Y		Y		Y	Y				Y							
Researching and gathering of evidence (13 articles)		9	7	8	7	9	8	6	7	7	11	3*	8*	8	8•	9				9	3*	7	4*	8	8	5*	10
Analysis of evidence to support problem (highlighting)		Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	
Linking of/between evidence (synthesis)		Y	Y		Y	Y	Y		Y	Y	Y	Y	Y		Y	Y	Y		Y	Y		Y		Y	Y	Y	
Regular referral to task outline		Y			W	W	W	Y	W	W	Y	Y	Y			Y	Y				Y			W			
Referral to strategy outline (inference/assumptions)		Y	Y	Y	Y	Y	(2)		Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	(2)	(2)	Y	Y	Y	

Y = evidence of action

- missed articles on logging company (sewage)

w = weak evidence

s = strong evidence

- = no data (participant withdrew)

Table 4.4

Identifiable Learning Skills - Problem 2

### 4.2.1.3 Evidence of Framework Use

*What strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?*

The full range of data collection artefacts was examined for evidence that indicated use of the support framework.

Transcriptions of the audiotape recordings of each participant's think-aloud protocol were examined. As participants investigated and made decisions relating to solving the assigned problem(s), they verbalised their cognitive processes. The researcher's interpretation of these thoughts and actions forms the basis of this stage of the analysis.

Evidence from the researcher's observational records, the audiotape transcripts and informal questioning of the participants showed that many participants used alternative strategies that were not specific to their assigned support framework. Also, a number of participants used strategies that appeared to incorporate aspects of critical thinking. It was hypothesised that this was due to previous school experience, exposure to real life experiences, or a combination of both.

## 4.2.2 Phase 2 - Research Question 1

The data was reviewed to address the research question:

*What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?*

Each of the artefacts was examined and the data combined into one document to provide a comprehensive profile of the strategy(s) used by the individual participants in their problem solving process. The transcriptions from the audiotape recordings were combined with data from the participants'



workbooks, the computer-based PDA files, and the researcher's written observation notes. From this analysis a series of 'action steps' were identified in which the participants address the process of the problem-solving task. The criteria used in establishing these steps are outlined in Table 4.5, together with examples of the kinds of behaviour that were regarded as evidence for the 'action steps'. In brief, the action steps were clarification, seeking support, locating evidence, and developing a solution.

*Clarification* included statements or actions in which participants identify key points of the task. *Seeking Support* includes statements or actions where participants look for guidance in directing their line of inquiry. *Locating Evidence* includes statements or actions participants generate in finding information that may support a particular line of investigation. *Developing a Solution* includes statements or actions that are associated with viewing the process as a whole in establishing a final outcome. It includes making connections between supporting evidence or using cause-and-effect statements.

The purpose of this stage of the data analysis was to examine each of the participant's profiles to develop a better understanding of the strategies used by the participants in solving the two problems. An iterative approach was developed to organise and interpret the profiles for each participant, a process that involved writing, refining and evaluating the profiles in terms of the events allocated to each of the 'action steps'. Development of this process was carried out through consultation with a colleague as described in the previous chapter.

Action Steps	Criteria and Examples
<b>Clarification</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> reads problem outline - no reinforcement</li> <li><input type="checkbox"/> highlights key points while reading ... <i>I've got a weed problem ... find out why it grew quickly ... how to control it</i> (VD1)</li> <li><input type="checkbox"/> reads problem outline &amp; records key points in workbook ... <i>I'm making a note that I'm looking for a cause why the fish were killed.</i> (SH4)</li> <li><input type="checkbox"/> highlights key points and records points in PDA</li> <li><input type="checkbox"/> ongoing referral to problem outline</li> </ul>
<b>Seeking Support</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> views/listens to advice from guides ... <i>I'll just go back to this guy to help me.</i> (VD8)</li> <li><input type="checkbox"/> acts on advice from guides ... <i>he told me to go to the river, so I'm going there...</i> (SH7)</li> <li><input type="checkbox"/> reviews strategy outline</li> </ul>
<b>Locating Evidence</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> systematic exploration - exploring left to right or top to bottom in specific pattern within the Region where problem is set</li> <li><input type="checkbox"/> random exploration - haphazard exploration of Region</li> <li><input type="checkbox"/> reads, views or listens to media report (single access)</li> <li><input type="checkbox"/> views/listens and reads media report (multiple access)</li> <li><input type="checkbox"/> highlights key points while reading</li> <li><input type="checkbox"/> analyses and records key points in workbook</li> <li><input type="checkbox"/> analyses and records key points in PDA ... <i>I'm just taking out the points that are valid</i> (SH7)</li> <li><input type="checkbox"/> takes measurements in river ... <i>I'm testing in the river ... moving downstream from the dump ... results are pretty weird ... don't really understand ... now I'll try for something else.</i> (VD4)</li> <li><input type="checkbox"/> relates measurements to evidence ... <i>test around the logging site ... apparently the waste from their site is adding nutrients to the water</i> (SH1)</li> </ul>
<b>Developing a Solution</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> no apparent plan in developing solution ... <i>I've got no idea of what I'm to look for ...</i> (CM6)</li> <li><input type="checkbox"/> apparent plan of action to achieve solution ... <i>I'm switching to my blue hat ... thinking about what I need to do next</i> (SH3)</li> <li><input type="checkbox"/> relates evidence to problem ... <i>disposal of chemical containers ... that's one of the reasons they think the fish are dying.</i></li> <li><input type="checkbox"/> recognises relationships between evidence ... <i>a possible cause is chemicals leaking into the river from the local tip and it's supported by the boys being burnt by the acid</i> (VD 7)</li> <li><input type="checkbox"/> values/ranks evidence ... <i>apart from reading through the notes and taking out the information that I thought would be relevant in correct order would be the way to do it.</i> (CM3)</li> <li><input type="checkbox"/> exhibits causal reasoning ... <i>see if ... any relationship between pesticides and other pollutants to the fish kill</i> (SH7)</li> </ul>

Table 4.5 Action Steps for Problem Solving



An analysis procedure for one of the participant's profiles in each of the four assigned groups follows. Each of these cases provides a comprehensive description of the typical range of strategies employed by participants in each group. Each profile has been developed from the participant's 'think-aloud' conversation (presented in italics) and follows the researcher's observational notes made during problem solving.

#### **4.2.2.1 Critical Thinking Framework – Case 1**

Participant CT2 was female from the 31 - 35 age group. She first read through the critical thinking strategy outline before accessing the problem (Chemical Pollution) from the Investigations Board. After listening to the introduction from the guide (Peter) she followed the advice and recorded the problem outline and the associated task in the PDA. While reading and paraphrasing the task she highlighted sections of the text and wrote these into her workbook before revisiting the guide. Following the advice of the guide, this respondent proceeded to gather supporting evidence from within the Water Research Centre. This sequential process commenced with the newspaper reports, followed by the television and radio reports.

Examination of each of the media reports followed a similar pattern. The participant read through each article thoroughly, critically analysing the text in determining the essential ideas of the report. Even with the audio reports (television and radio) she chose to read the associated linked media support in preference to the audio/visual presentation. In the early stages of gathering evidence she indicates her preference for writing notes on paper ... *I'm actually writing all these notes on paper because I find it faster than typing* ... and employed this method continually, writing the key ideas from each article in the workbook and developing an extensive record of data from these. As each media report was accessed and read, she paraphrased key elements of the report, developing inferences from her understanding of the evidence presented and suggested possible solutions to the assigned task. This is demonstrated in the verbal record. Following examination of all media reports she sought assistance from the guide and acting on his advice began further evidence collection from articles in the filing cabinet. These articles were selectively chosen as they all related to issues

mentioned in the media reports. On completion of this overview of articles in the filing cabinet, CT2 consulted the critical thinking framework, followed by the problem outline, and began to prepare her solution to the task with regular referral to her hand written notes from her workbook.

In developing a solution to the second problem (Water-Plants and Weeds), this participant proceeded in a similar manner to the approach used in the first. The preference for processing the information was through reading and paraphrasing, followed by extensive hand notes in the workbook. In both problems it was apparent, both from the researcher's observations and the respondent's words and notes in the workbook, that CT2 worked out the essence of the problem, the expected goals, the criteria for selection of evidence to support the problem solution and drew inferential conclusions based on observations that yielded consistent but incomplete data.

This participant made no effort to use the electronic notebook (PDA) or take any measurements from the environment in which the problem was set. When asked about this later, she replied *...on the first day that we actually played with this I spent the whole hour taking measurements and I just didn't find it an effective use of my time ...I was hoping that I could find through reading ... if I didn't find what those nutrients were through the printed media then I would have to go back but I was avoiding doing that straight away because I knew I was wasting a lot of time doing that ... so I find I learn much better with written information...*

This outline is presented in the following 'Action Plan' for both problem 1 (Chemical Pollution) and problem 2 (Water-plants and Weeds). The steps taken by the participant in both action plans are in chronological order.

***Action Plan CT2 - Problem 1***

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Strategy Outline	brief review of critical thinking framework
Introduction	views/listens to guide – selects problem <i>Ok I'm opening up now... I'm going to go straight into the research centre ... Ok, I'm going to the little box called chemical pollution ...</i>
Problem selection	listens – grabs problem - reads - highlights key points - paraphrases - writes key points in workbook

*OK, I'm going to do as he said and grab and read what it has to say...I'm in the zone 3 Tanundra region...*

*OK, it says here there has been an increasing number of dead fish and I need to find why this is so ... I might see if they have any hints for me ...*

Hints

Peter(x2) (media reports) – acts on advice

*OK ... might go into the newspaper to see if there are any media reports ...*

Locate Evidence

Newspaper articles - Acid burns school boy at tip – reads, analyses article by highlighting key points - writes key points in workbook

*... Tanundra region zone 3... OK... its got here acid burns school boy at local tip ... indicates there is a problem with acid... and... by clicking on these articles you can read what it says...Acid is being dumped at the tip in some unmarked drums...*

Locate Evidence

Newspaper - Industry suspected of dumping acid - reads & paraphrases - (Participant made list of businesses in workbook while verbalising thoughts – ticked ones associated with acid) - outlines strategy for working towards solution.

*...I'm looking at all the articles here ... now I'm looking at the one which says industry suspected of dumping acid ... remains a mystery but they're thinking it's the nearby industrial estate ... So contractors are illegally dumping maybe...at the tip or into the sewerage system ....just writing a list of the businesses to get an idea of what could be the possible cause ... especially if it was acid related...I'm actually writing all these notes on paper because I find it faster than typing...just looking at that list I might put a tick against the ones that might have acid involved in their processes... where they would need to dump large amounts of acid...*

Locate Evidence

Newspaper - "Industry killed fish", says worker - reads - links sewage treatment to illegal dumping in notes (workbook) - suggests possible solution.

*... now looking at an article on sewerage treatment...reading ... O.K, it indicates here a problem with businesses being able to have opportunities to breach their conditions for dumping without being detected ... so a possible solution would be to increase the amount of time they come out and test their waste...*

Locate Evidence

Newspaper - Keep out of river - reads & paraphrases - expresses opinion

*... I'm just going to go back to the Tanundra page ... keep out of river article.... so, there's dead fish and even consuming the fish there is making people unwell... It seems in the article about the tip, the tip manager wants to put the blame on the industries whereas I guess he can be in control of what's coming in as well ... I might close out of there now and just have a look at some TV reports.*

Locate Evidence

TV report – Fish found dead in river – views/listens - paraphrases - linked media - reads - highlights sections - notes key points in workbook.

*OK, she suggested to look upstream to see what the problem is.... now going to read some of the linked media... OK, this is the written report of what's just been said*

*...environmental officer involved...people have been warned away... OK, just...going to the next article...*

Locate Evidence

TV report – Chemical dumping to be Fined – starts to view - stops, then linked media - reads/analyses - paraphrases - notes in workbook - expresses opinion  
*...I might just read it... OK, so there's going to be big fines if you're caught dumping ...it seems to be a problem with people being able to dump without being detected...OK, its got here the chemical substance may have entered the river during recent heavy rain... so its been washed away from somewhere... possible source of it actually being dumped in the river where its coming from somewhere during.....I'll see if I can find out where its coming from ...so, the water authority is looking at setting up regular patrols so that's a possible solution... OK, many people are not aware that chemical dumping affects both the community and environment so maybe there needs to be a bit more education for the local community...  
OK, so they're wanting people who saw anything unusual to come forward ... so another solution is for the community to be more aware and report anything suspicious ...OK, the river environment is going to take some time to recover and is there anything the community can do to help that recovery...*

Locate Evidence

TV report - Residents' call for Tip's closure - reads - paraphrases - notes in workbook - expresses opinion  
*I'm looking at the next...Going to read the linked media report...OK, it seems the dead fish are in the river near the tip, so it could be wash-off from the tip ... chemicals could be leaching from the soil in the tip...the residents want to close the tip but it may not necessarily be the ideal solution ...the leaching will still continue....OK, site needs to be regenerated... OK, a possible idea is to actually move the tip away from being so close to the river... that still does not mean that people don't have to dump things properly...*

Locate Evidence

TV report – Chemical Dumping witnessed – reads/analyses – suggests possible reason - paraphrases  
*... I'm now looking at the article 'chemical dumping witnessed' and reading that article now... gentleman is an observer of nocturnal wildlife...people are dumping at night by the sound of it... so, do they need to have staff at the tip at night? ... Once again asking for the community to come forward...*

Locate Evidence

Radio report – Chemical disposal policy outlined - reads - paraphrases - suggests possible remedies to problem  
*... now I might go into the radio tapes... in the Tanundra region... chemical disposal policy... might go into linked media for that also... there are storage pits at the tip but people have not been using them ... .reading ... .so local groups want council to review its waste policy and it's probably an idea if the community is involved as well...so large amounts of chemicals should be placed in pits for treatment ... so you have to wonder if these pits allow the chemical to be leached into the soil anyway... there an alternative there... interviewer is worried about the site of the tip being so close to the river ... so it is a problem with liquid waste being poured directly on to the tip with leaching and also*

*when there's rains with the hazardous waste going directly into the river...ok, so there's obviously a problem with paying for the waste removal ... um ...they're saying it's the responsibility of the local industry but obviously maybe the costs are too high so that's why they're dumping so the government.. should give them assistance which may mean they won't do it anymore ... what can the residents do... OK, if as individuals they put their dangerous chemicals there it could be a problem so there should be fines for individuals and some education as well.... individuals when they are coming to the tip there should be some control of them...*

Locate Evidence

Radio report – Chemical dumping radio campaign– linked media - paraphrases  
*Going to the next one... this is an advertisement ... OK ... so .this advertisement outlines that people believe that everything gets treated at the sewerage plan...so once again its education... and everyone believing their little bit of rubbish is not going to make any difference ... so that's a good promotion... .advertising through the radio... I'm just scribbling on my paper here...*

Locate Evidence

Radio report – Tip poisons nearby river – linked media - reads - paraphrases - forms opinions  
*... looking at next article... tip poisons nearby river...tests of the ground-water beneath the tip ... so they've done some tests and it does indicate chemicals that are being stored and disposed at the tip are making there way into the ground-water and then get into the river... its got here the tip has been positioned in an area that once was a wetland so it not a good spot to put it on in the first place ...so. perhaps they may need to look long term and actually move the area where the tip is.... it says the residents want to close it down but obviously they need to put it somewhere....*

Locate Evidence

Radio report – Tip chemicals kill fish– linked media – cross referencing with other articles – using reasoning skills to apply to problem  
*... another report... this one indicates that empty agricultural containers have also been left at the tip so it seems that a few people are dumping or not disposing of their waste properly.... See what this says...*  
*OK, so insecticides have seeped into the river ... so this is saying the fish kill would be a result of that...so obviously they have been taken to the tip without having being rinsed and sealed ... and so there needs to be some sort of processes at the tip being sure that has been done so some sort of stamp or seal put on them to show they have been properly rinsed first...*  
*So that's all the media ones... let's listen to what the people have to say ...*

Hints

Stephen - Wrong guide - reselects

Hints

Peter - (check media reports) ... recognises a repeat of info  
*... he's just repeating what he has already told me ...*

Hints

Tatiana - wrong guide - reselects

Hints	Peter - (filing cabinet - farming , disposal of waste) - acts on advice
Locate Evidence	<p>Filing cabinet – reads list of articles – made correct choice of related articles – reads &amp; paraphrases - evidence of reasoning /thinking about problem in verbal record - notes in workbook - recognises previous articles</p> <p><i>... haven't yet gone out of the research centre at all ...opening the filing cabinet... looking under farming ....just have a look at agricultural run-off and the use of pesticides...</i></p> <p><i>OK...so cotton farming are big earners ... so perhaps they should spend some money towards dumping problems ... lots of chemicals at all stages of the farming process ...so they discharge it to natural water policies....Surface run-off... just want to see if there is anything else under farming practises that I think might be of help to me...</i></p> <p><i>...that's the same thing I was just reading... OK, I might just go back to see what Peter was saying ...</i></p>
Hints	Peter - (preparing report/farming) - acts on advice
Problem Selection	<p>Reads problem outline - looks through own notes and support framework</p> <p><i>OK, I'm just going back now to have a look at the critical thinking strategy just to sort of ... quickly write out what I feel is going on here...</i></p>
Problem Solution	<p>Begins to prepare solution - reviews notes - periods of reflection -</p> <p><i>... what I believe to be the problem... um... so there's illegal dumping and there's problems with...</i></p>
Question	<p>What are you doing now?</p> <p><i>... I just sort of summarise what I've ... go through the strategy as I've just been writing lots of scribbly notes everywhere... I probably could investigate... go back and check zone 3...</i></p>

## ***Action Plan CT2 - Problem 2***

<b><u>STEPS</u></b>	<b><u>REFINEMENT PROCESS</u></b>
Strategy Outline	brief review of critical thinking framework
Introduction	views/listens to guide – selects problem
Problem selection:	<p>Tatiana - listens – grabs/reads - notes key points in workbook</p> <p><i>... just going to see if she has anything else to say ...</i></p>
Hints	<p>Tatiana (measurements/fisherman) - acts on advice - note in workbook</p> <p>Goes to Region - random exploration</p>
Locate Evidence	TV – Cause of algal growth found - Linked media – reads aloud – note in workbook.

*...got a media report ... fisherman has identified a possible cause of the problem...weeds are greener near the logging area...Waste water coming out...*

Locate Evidence

Newspaper – Weed effort Fails - reads & paraphrases

*...residents are trying to clear the weeds... that's one solution they've tried ....spent two days clearing it.. already growing back... Looks like there are a lot of them along the banking area... spreading elsewhere... they've actually been introduced.. not native... erosion...more problems...*

Locate Evidence

Radio – logging linked to weed growth - Linked media – analyses/notes in workbook - poses questions

*...just now reading the article logging leads to weed growth ... this logging operation is linked to the spread....So they're willing to help... so they've done some water quality tests... below camp contains more nutrients than above ....so they've put there main camp facilities near the river... got the sewerage draining directly ....question is whether they are the only cause ....they're not going to stop their logging.... going to be employing more people.... Does that mean there is going to be more facilities therefore they need to start thinking where they might put these facilities? ... alternative ways to deal with the sewerage so it is not going directly into the... if they are going to be there for fifty years...*

Locate Evidence

Newspaper – logging linked to weed growth – reads – note in workbook

*...reading another article logging linked to weed growth... scientists has got some findings ... samples of water and weeds from the worst effected areas... he believes the logging company has contributed to the growth...excess nutrients below the site...phosphorus and nitrogen ....present in higher than normal concentrations (note in workbook)... so his suggestion is that these chemicals have to be prevented from entering the river...he wasn't able to determine the actual source of the nutrients...so, in thinking of a solution that is one of the first things you have to do because that is what is going to determine a cause of action...*

Locate Evidence

Radio – Weeds cover river– linked – notes in workbook

*...reading another article...weeds cover the river killing the fish ... So up river it's thinning but the river is muddier... I don't know if that is significant at this stage...*

Locate Evidence

Newspaper – Farmer doubts beetle solution – reads

*. ..there is a suggestion of a solution here about the beetles...just eat all the weed... concerns about introducing something....Always related problems later... Initially solve the problem but create more in the long run... another person suggesting spraying.... While other methods of controlling the weed are available... the beetle is the choice favoured by the government... you have to question why... is it cost related?... spraying... there might be other problems with doing that... Back to the hut now...*

Returns to WRC

Hints

Tatiana (measurements/fisherman) - recognises prior access

*... I've spoken to the fisherman ...*

Hints	Tatiana (filing cabinet- animal/plants, archives) – acts on advice
Locate Evidence	Filing cabinet – reads articles on weeds - note in workbook - reads & paraphrases <i>... found along stationary and slow moving water...duck weed is an indicator of high nutrient waters....</i>
Locate Evidence	Checks TV reports – wrong region – recognises & corrects <i>...go back to ....I'm in the wrong region here ...Merrringurra....actually a variety of weed species... just going back to find out what weeds they were...</i>
Locate Evidence	Checks TV listings – rereads sections - paraphrases <i>Cause of algal growth found...river choked by wild willows.... Logging company planted those willows.....mistake to use those...logging company is going to be expanding over the next five years they definitely should not be planting any more of those and even be taking measures to remove those that they have already planted... just going to zone 2 to see what .... Reads ... Not relevant to what I want...cross into zone 2....no...</i>
Hints	Tatiana (journal/presentation) - not relevant, so ignores advice
Locate Evidence	Checks radio reports - reads <i>...got all of these... solution to the alligator weed... check machinery ... alligator weed and salvinia...controlled by weed ... no point attacking the weeds if you don't deal with the problem that's making them grow ...</i>
Hints	Tatiana (measurements/fisherman) - ignores advice (not relevant?)
Hints	Tatiana (filing cabinet - plant/animal book) - acts on advice
Locate Evidence	Filing cabinet – animal/plant book – checking information on weeds <i>...filing cabinet ....just ....the alligator weed to start with....so...biological control...chemical spraying... limiting nutrient flows....salvinia...growth in slow water... lots of nutrients...</i>
Possible Solution	Begins analysing evidence from personal notes in workbook - develops a solution <i>...solution... need to define extent of problem...possible causes... does it need intervention... possible control measures... cost... short and long term effects.... Harvesting the weeds...water level management ... so does that mean if they manage the water level it will be free flowing so the weeds won't grow there because they like stationary water ....before entering that area they might have to prohibit the area for a while....Biological control needs a lot of research...to attack the problem the water species... (notes in workbook) ....a control could be permanently biological....don't want any biological...we can manipulate the water and nutrient levels ...physically remove the weeds... improve the flow of the water ....associated with any of the solutions</i>



*you came up with... increasing the flow can cause erosion of exposed and weakened banks... use of herbicides could contaminate the ground water ... problem here with alligator weed and salvinia that's because of the nutrients especially ... that problem where the nutrients are coming from...the willows have been introduced by the logging site... machinery may have the weed... the logging site are prepared to help...so that's good...but they wont be cutting down on the logging and possibly expanding... so solution... relocate facilities so they are not pumping sewerage in the river and when they expand they should build them elsewhere... pumping system where sewerage gets taken away... look at the cost of moving the willows... investigate the use of native plants to stabilize the banks with no long term negative effects... now ... ( looking at notes) ....if they deal with getting rid of the nutrients then they can physically get rid of the weeds again...that should help...I'm not so sure about... they could set up a study to determine the effectiveness of the beetle... (reviews notes)....also just need to determine that its just actually the sewerage that's causing the phosphorus and nitrogen...is there anything else at the logging site that's causing it ...(checks notes) ....clean their equipment ....indicates completion.*

Question

What do you think the problem is?

*I think that obviously the problem is the weed and they are growing abundantly and choking the area and my feeling is that one the nutrients is much higher than normal and that seems to be related to the logging site.*

Question

*I noticed you never actually took any measurements, is there any reason for that? (Short laugh) ...yes, there is a very good reason for that...on the first day that we actually played with this I spent the whole hour taking measurements ...(short laugh)...and I just didn't find it an effective use of my time ...I was hoping that I could find through read ... if I didn't find what those nutrients were through the printed media then I would have to go back but I was avoiding doing that straight away because I knew I was wasting a lot of time doing that ...so I find I learn much better with written information...*

Question

Is this the way you normally go about solving problems?

*Yes, I think ...yes I don't think I would do anything differently...just gone with what I'd do anyway, even though I've read the critical thinking ... I've just reverted back to what I would normally do anyway.*

Question

Did the strategy help you focus your ideas better or clarify the problem better for you?

*...yes, I think that ...really the strategy just clarified how I should go about it and that's why I kept going back to sort of look at how I should start.*

## Summary of Group Profiles

A summary of the remainder of the participants' strategies from this group follows.

	Problem Solving Profile
CT 1	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task</li> <li><input type="checkbox"/> Seeks Support:- no</li> <li><input type="checkbox"/> Locate Evidence:- random exploration - little analysis of limited number of media reports - no checking - measurements taken with little relationship to problem</li> <li><input type="checkbox"/> Develop Solution:- no apparent plan - no evidence of goal setting - no revisiting or evaluating evidence - participant appeared nervous/uncertain throughout session</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task – copies to PDA – rereads &amp; paraphrases while highlighting key points</li> <li><input type="checkbox"/> Seeks Support:- no</li> <li><input type="checkbox"/> Locate Evidence:- random exploration of region – reads/ views/ listens to reports (5)– highlights/copies key points to PDA – returns to WRC for systematic check of TV/Radio reports – highlights/copies key points to PDA – checks related articles in filing cabinet - returns to region &amp; takes series of measurements above/below camp related to problem.</li> <li><input type="checkbox"/> Develop Solution:- relates evidence to problem - recognises relationships between evidence - strong causal reasoning - ranks evidence and applies to task – identifies main cause of problem and ways to reduce weed growth.</li> </ul>
CT 2	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task - highlights key points &amp; records - paraphrases</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide(x3) - reviews strategy outline(x2)</li> <li><input type="checkbox"/> Locate Evidence:- thorough systematic access from within WRC - analyses each media report and records key points in workbook - paraphrases - makes inferences ... <i>you have to wonder if the pits (storage) allow the chemicals to be leached into the river anyway ... maybe the costs are too high and that's why they're dumping ...</i></li> <li><input type="checkbox"/> Develop Solution:- demonstrated ability to develop detailed plan of action - relates evidence to problem - recognises relationships between evidence - strong causal reasoning - identifies main cause &amp; ways to control</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task - highlights key points &amp; records in workbook</li> <li><input type="checkbox"/> Seeks Support:- selectively acts on advice from guides (x4) - ignores measurements hint</li> <li><input type="checkbox"/> Locate Evidence:- random exploration of Region - analyses each media report and records key points in workbook - paraphrases - makes inferences - returns to WRC for systematic check of media reports - extensive notes in workbook</li> <li><input type="checkbox"/> Develop Solution:- relates evidence to problem - recognises relationships between evidence - strong causal reasoning - ranks evidence and applies to task - identifies main cause of problem and ways to reduce weed growth.</li> </ul>
CT 3	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task - highlights key points &amp; records in workbook - paraphrases</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide(x1) - reviews strategy outline(x1)</li> <li><input type="checkbox"/> Locate Evidence:- random access in environment - analyses reports from linked media - highlights key ideas &amp; records in PDA - paraphrases - makes inferences ... <i>I definitely think there's a problem starting about halfway down the river.</i> - relates measurements to supporting evidence - rechecks media reports in WRC.</li> <li><input type="checkbox"/> Develop Solution:- demonstrated ability to develop detailed plan of action - relates evidence to problem - recognises relationships between evidence - strong causal reasoning</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:-reads outline &amp; task – notes key points in workbook – rereads aloud.</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide (x2)</li> <li><input type="checkbox"/> Locate Evidence:- initial random exploration in region – reads /paraphrases reports (4) from linked media – returns to WRC for systematic check of TV/radio reports – reads/paraphrases main ideas – checks filing cabinet &amp; reads related articles – returns to region &amp; test range of measurements related to problem above/below camp – makes</li> </ul>

	<p>links with previous information</p> <ul style="list-style-type: none"> <li>❑ Develop Solution:- relates evidence to problem – identifies main causes but not clear on ways to reduce problem – reasoning based on memory – no notes recorded</li> </ul>
<b>CT 4</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task</li> <li>❑ Seeks Support:- acts on advice from guide (x2) - reviews strategy outline(x1)</li> <li>❑ Locate Evidence:- random exploration in environment ...<i>I'm not really gathering stuff at the moment, I just like to look at everything first</i> - brief notes in workbook - media then accessed (systematic) in WRC - analyses &amp; highlights key points - takes measurements (expresses uncertainty) ...<i>I'm not really sure what to look for</i> ... - missed some key media reports</li> <li>❑ Develop Solution:- :- demonstrated ability to develop detailed plan of action - relates evidence to problem - recognises relationships between evidence - limited causal reasoning</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task – notes key points in workbook – verbalises process .. <i>just identifying the problem and writing down what I need to find ... the main problem and the actions needed to reduce it.</i></li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- checks TV/Radio in WRC – viewed/listened to specific reports (2) on weeds – checks filing cabinet for related articles – random exploration in region – reads/views/listens to reports(4) – brief notes in workbook – tests above/below camp for confirmation of evidence from previously accessed articles – rechecks filing cabinet</li> <li>❑ Develop Solution:- identifies excess nutrients from camp as main problem – recognises relationships between evidence - weak causal reasoning – recognises possible options for control of weed but does not evaluate – process occurs from memory – limited support notes.</li> </ul>
<b>CT 5</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - refers back when developing solution</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- random exploration in environment - highlights sections &amp; records in PDA - returns to WRC - researches unrelated information in filing cabinet - then limited number of media reports - highlights &amp; records key points - limited causal reasoning</li> <li>❑ Develop Solution:- indication of plan of action - relates evidence to problem but narrow focus of ideas - limited causal reasoning</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task – copies to PDA – ongoing referral to notes &amp; task</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- checks Animal/Plant book for background information on weeds ... <i>just have a look through ... see how they reproduce ... what sort of things that can cause plants to grow quicker...</i> takes full range of measurements, (many unrelated to task) above/below camp – systematic comparison of readings – infers from data ... <i>so, the quality of the river as you go downstream gets worse ... I guess that's because of the development &amp; the growth of plants and weeds in the river...</i> - returns to WRC &amp; analyses TV/Radio reports from linked media – highlights sections &amp; copies to PDA – paraphrases &amp; cross references reports – recognises common characteristics of weeds – missed articles in filing cabinet.</li> <li>❑ Develop Solution:- identifies excess nutrients from camp as main problem – recognises relationships between evidence - weak causal reasoning – no specific actions to reduce weed growth or pollution from camp – reasoning based on generalisations ... <i>I'd look at the types of species ... try to kill them off, probably look at ways of changing that environment so eventually they die off.</i></li> </ul>
<b>CT 6</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task</li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- random exploration in environment - reads from written text (linked media) - records key idea in workbook - paraphrases - expresses personal opinion - missed key reports</li> <li>❑ Develop Solution:- no apparent plan - no evidence of goal setting or evaluation of evidence - solution based on generalisations ... <i>the evidence is all here in the media reports.</i></li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task – copies to PDA – ongoing referral</li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- random exploration in environment - reads from written text (linked media) - records key idea in workbook under 'problem' and 'solution' – takes measurements relating to problem above/below camp &amp; compares visually – returns to WRC &amp; checks newspaper/radio reports adding to notes in workbook – checks Animal/Plant book &amp; filing cabinet for additional information (misses article on weed</li> </ul>

	<p>control)</p> <ul style="list-style-type: none"> <li>❑ Develop Solution:- identifies excess nutrients from camp as main problem, together with the fishing boats – no specific actions to reduce weed growth or pollution from camp – reasoning based on generalisations ... <i>its really a big problem ... you need to look at everything and try to prevent it before it happens ...</i></li> </ul>
CT 7	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - verbalised key ideas</li> <li>❑ Seeks Support:- uses guide but does not act on advice (x3)</li> <li>❑ Locate Evidence:- read /viewed /listened - writes key idea in workbook - recognises main problem areas ...<i>so far there's problems with the tip and sewerage treatment.</i> - accessed reports in filing cabinet, many unrelated to task - takes measurements, some unrelated to task</li> <li>❑ Develop Solution:- no clear strategy - some attempt to prioritise notes in workbook - ideas based on generalisations without support from evidence</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task – copies to PDA – headings in workbook</li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- random exploration of region – accesses TV/newspaper reports (x3) &amp; records key points in workbook – measurements of phosphorus and nitrogen above/below camp – returns to WRC &amp; examines radio/newspaper reports – reads &amp; records key ideas in workbook – examines Animal/Plant book &amp; Filing cabinet – highlights sections relating to weed control &amp; copies to PDA</li> <li>❑ Develop Solution:- no clear strategy – recognises main problem lies with the logging camp ... <i>seems to be the logging company planting trees ... willows ... and the sewage from the camp ...</i> - little evidence of cause/effect relationships between reports – no specific actions to reduce weed growth or pollution from camp – suggestions based on generalisations.</li> </ul>

Table 4.6      Analysis of action steps in cognitive strategies used in individual problem-solving process (Critical Thinking).

In reviewing the strategies used by participants in this group several generalisations can be made. When clarifying the problem only two participants (CT2, CT3) engaged in in-depth analysis of what was required of the problem context and task. This was achieved through careful highlighting of key phrases in the text, paraphrasing of these ideas, and the recording of these ideas in either the PDA or the workbook. Initial clarification from the remainder of this group was considered to be low quality, being restricted to a single read through of the text with little or no reinforcement.

In terms of problem resolution, most participants engaged in some analysis of the media reports that were accessed. The degree of analysis varied from an initial reading (newspapers), listening (radio) and viewing (television), followed by the recording of a key point or idea that was considered important, through to secondary access of the linked media for more in-depth analysis. During these occasions, sections of text were highlighted and key ideas were paraphrased and recorded for later referral. With the exception of CT1 and CT5

all participants sought advice from the Water Research Officer (Peter) in guiding their search strategies.

Throughout the information-gathering process those participants who had spent additional time in clarification of the problem (CT2, CT3) engaged in quality strategies that included highlighting, paraphrasing, recording key points that linked to their original concepts of the task, made inferences and expressed a degree of causal reasoning between evidence. Other participants (CT4, CT5, CT6) exhibited similar strategies but to a lesser degree. The remainder of the group (CT1, CT7) appeared to have no clear strategy or exhibit any degree of goal setting throughout the problem solving process.

#### **4.2.2.2 Six Thinking Hats Framework – Case 2**

Participant SH 7 was female from the 21 - 25 age group. After listening to the introduction from the guide (Peter) she followed the advice and recorded the problem context and the associated task (Chemical Pollution) in the PDA. After reading and highlighting sections of the text she wrote the key ideas into her workbook before revisiting the guide. Following the advice of the guide, she proceeded to the environment where the problem is set and began a random search to gather supporting evidence.

Throughout the process of gathering evidence the participant demonstrated the ability to summarise information, giving a brief review of essential information that had been read, heard or observed from each of the media reports. She highlighted sections of reports that were considered relevant to her particular direction of inquiry and placed these in the electronic notebook (PDA) for later reference. Hand-written notes were also made in the workbook to support the original key points recorded from the task outline. Throughout the process she regularly outlined her focus ... *I'm highlighting sections that support the problem ... and ... finding bits of information that support reasons why the fish are dying.*

After accessing a range of reports she began to assess the data collected and from this analysis took a series of measurements along the river. These tests and the sampling points where the testing was carried out supported the key ideas from the media articles that had been previously analysed. Following this

testing process the participant returned to the Water Research Centre and checked all media reports, only spending time on the ones not previously accessed. When satisfied, she began revisiting the notes collected in both the PDA and her workbook and prepared a 'solution' based on the main ideas initially outlined.

Problem two was treated in a similar fashion to that already outlined. After an initial reading and analysis of the problem context and associated task the participant proceeded to the environment and began random exploration for the embedded media elements. Each of these was analysed and sections considered appropriate to the task solution were recorded through highlighting and copying into the PDA, or by the noting of key words in the workbook by hand. Again this was followed by some water testing before she began outlining her solution. This respondent missed the two feature articles dealing with the logging camp. However, from her visual analysis of the measurements taken along the river, she recognised that the pollution from the camp could still be a major factor in the proliferation of weed growth. The noticeable difference in this protocol was the lack of crosschecking of the media reports and related evidence located in the Water Research Centre.

***Action Plan   SH 7 - Problem 1***

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	Views/listens to guide - selects problem
Problem Selection	<p>Listens - grabs - reads aloud while analysing task – makes list in workbook of three main points from task analysis - these points formed basic focus of participant's strategy.</p> <p><i>I'm going to click back on him...</i></p>
Hints	<p>Peter - listens - acts on advice? - goes to Region - random exploration</p> <p><i>OK, ... I'm using my white hat to gather information ...</i></p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign – linked media - note of main points in PDA – yellow hat reference</p> <p><i>I'm highlighting sections that support the problem... that's the yellow hat... I'm highlighting sections that I think are important ...</i></p>

Locate Evidence	<p>TV Report – Fish found dead in river – views/listens - linked media – reads - note in PDA</p> <p><i>...now I'm just doing the same thing... finding bits of information about that support reasons why the fish are dying and ...I'm also doing things that could be used as procedures for the community to adopt and I'll put it in my notes ...</i></p> <p><i>... so, I'll just classify the information I've got...(reviews notes) ... I'm just clicking through other bits that I've highlighted...</i></p>
Locate Evidence	<p>Radio – tip poisons nearby river - h/g key points in PDA</p> <p><i>...I'm again just looking for bits that support reasons why the fish are dying... so that using the white hat, no yellow hat, so I'm looking for information so that's white hat as well...OK, test so far seems to be the tip ...OK, so obviously must be water ..tips at that area... near wetlands.. move where they stood ....running down the banks after rain ....</i></p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign - starts - recognises previous access &amp; stops</p>
Locate Evidence	<p>Newspaper – 'Industry killed fish', says worker – reads - highlights key points &amp; 'grab" to PDA</p>
Locate Evidence	<p>Radio – tip chemicals killed fish (containers) – selects 'good' points - h/g to PDA – reference to chemicals</p> <p><i>OK, so ...I'm again looking at text to try and find information.... so it stills looks like being the chemicals... just trying to sum up what I've got so far...</i></p>
Locate Evidence	<p>TV report – chemical dumping witnessed</p> <p><i>... just highlighting parts of the story...OK, now I think I've done all of the background information bits ....so now I'm going to do something with the water...</i></p>
Locate Evidence	<p>Makes selection of tools (pH, pesticides, oil) - types sampling points in PDA</p> <p><i>... so I'll do upstream then ... just labelling the sampling points ... Now ... now I'll do one near the tip ... ok, so I've got some information here now and now I'm going to go back to the hut thing and get some information.... Returns to WRC</i></p>
Hints	<p>Guide - listens briefly &amp; cuts short – muttering</p>
Locate Evidence	<p>TV Report – residents call for tip closure – views/listens - outlines strategy</p> <p><i>...as I'm going through the different things ... I'm just writing down a few points that will help later....</i></p>
Locate Evidence	<p>TV report – fish found in river – revisit (checking)</p>
Locate Evidence	<p>TV report – Fish found dead in river – revisit (checking)</p> <p><i>...OK, ...(reading/muttering)... go to radio...</i></p>



Locate Evidence	Radio – chemical disposal policy outlined - listened - examines listings
Locate Evidence	Radio – tip poisons nearby river – starts then linked media <i>...I'll go through text it will be a bit quicker...</i>
Locate Evidence	TV report – chemical dumping to be fined – highlights bits & 'grab' – examines notes <i>...now I'm just looking for things that will fill in my report.</i>
Locate Evidence	Radio - Tip chemicals killed fish - starts then stops...goes to linked media – reads – highlights & copies key point to PDA. <i>... OK, I think I'm almost ready to do my report...</i>
Possible Solution	Outlines possible solution to problem - refers to notes - writes ideas in workbook <i>...OK, so I... just go through my information and see whether I've labelled it 'a' or just reasons for the fish dying... obviously its chemicals... Its blue hat... chemicals from the sewerage and from the tip... sewerage...primary treatment ...um....fish killed by chemical substance during heavy rain period.....muttering... so that confirms the chemical thing ... so I'll relabel that 'b' ... just go along.... So tip from agricultural containers ....and .... Personal dumping... licenses.... Clicking through PDA.... Just checking because I've doubled up on information and I'm just deleting it...OK..., so other reasons that the water is getting in apart from the heavy rain is tip ...where its situated.. so now move on to be which is to report detailed findings which is what I've done so move on to ... this is the good bit.. we just have to suggest possible procedures the community might adopt so.. we could logically go through why its happening in the first place then suggest ways we could counteract the problem... so, firstly we could suggest an upgrade to do.... Pause, muttering... I'm ticking them off as I go... tip could be moved, closed, area regenerated ....um....OK,....as for the council it could... get some ...new dumping policy... review dumping procedures for that policy.... Um.... It could mount regular patrols.... On the river... keep a lookout for... frequent testing of the water and impose heavier penalties....dumping ...OK ....so.... checking notes.... Fines ...I don't know what else I can do about fines... and they could produce an education campaign to encourage the community... They could also ... I just thought... provide incentives ... I'm done.</i>

### Action Plan SH 7 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	Views/listens to guide
Problem Selection	Listens – grab – reads - main points in workbook <i>I'm just writing down just what we actually have to do so I don't have to go back to the PDA...just click on her again to get some information on what to do...</i>
Hints	Tatiana – (measurements/fisherman) – note in workbook - acts on advice.



*...OK, so I'm going to go to that actual site and gather some general information...this is the white hat.*

Goes to Region – random exploration

Locate Evidence      Radio – weeds cover river, killing fish - listens

Locate Evidence      TV – River choked by wild willows - Views/listens – note in workbook – linked media – reads - highlights/grabs selected bits to PDA  
*...I'm clicking on linked media and I am going to go through and have a look to information that supports the problem we want ....which is the yellow hat...and take out the information I don't want ...which is the black hat...  
(analyses article)...keep going and get more general information...*

Locate Evidence      TV – Cause of algal growth found - views – note in workbook – linked media – highlights/grabs selected bits  
*...now I'll just take the information that I think is good,,, that's the yellow hat....and just add out what I want to do again...thinking of other...well the willows are one and now weeds and algae are the other...I think that's green hat...*

Locate Evidence      Newspaper – Weed effort fails - reads – highlights/grabs sections to PDA  
*... just going on and finding more information...that's the white hat ....so that would help in the possible solution...muttering...clearing...so it's the weeds...or perhaps not solution because the weeds came back....now I'll just go down to others that I haven't seen yet...*

Locate Evidence      Newspaper – Weed eradication program – reads

Locate Evidence      TV – Weed growth distresses residents - views – note in workbook – highlights/grabs sections to PDA  
*So this is a possible reason for the weeds and what can be done about them ....so this is solutions (refers to own notes)... So water samples would be ... I'll do that next...so I've still got my white hat, then yellow hat, black hat...collecting information and analysing for good bits and bits I don't want....*

Locate Evidence      Newspaper – Farmer doubts beetle solution - reads – highlights/grabs sections  
*... another solution is to release the beetle....so another solution would be spraying...*

Locate Evidence      Radio – expert warns against weed invasion - Starts – stops – linked media – reads – highlight/grabs sections  
*...so its half the weeds?...now I'm going to take tests of the river*  
Goes to Region

Locate Evidence      Selects tools - (oxygen/turbidity/pH/flow/algal count) visual comparison of readings - collects to PDA

*... I'll take it from above the logging site...and I'll take it just below...that's the difference between the two...big jump in the algal cell count...now I might go...now I'll just make my...think I've got enough information ...so, I will go through and add up what I want overall.... which is my yellow and black hat again... so I guess one thing that is probable... OK, I might just go back and clarify the problem.*

#### Problem selection

Reads task outline - reviews own notes - identifies supporting evidence - analyses and rejects evidence

*... main causes are willows, ...weeds and algae... so one is that people have brought in something ....that is supported by ....using my yellow hat . just go and take out the bits I don't want...it might be easier... so that's black hat ...*

(I stopped student from removing data from PDA – student then verbalised strategy for completing task)

#### Problem Solution:

Outlines solution(s) to problem

*... well, I think that the logging area would have... has a big impact on it because if we have a look at the test just before,,, above the logging area in the river the algal cell count is only 120 and after the logging area, just below, the algal cell count is 450...that's a big jump and even further down its 500 still... so that would seem a key reason for the growth of the weeds... solutions for that would be .. Checks notes.... it said earlier that people can't empty the water in their boats out ... and the other thing is the willows and the algae... the people are doing that from their boats... alligator weed... so solutions for that would be the spraying,,, they have cleared it out but that no good as it comes back straight away... release the beetle... but if they release the beetle to eat the weed it would be too much for the ecosystem as it is an introduced animal....so the main causes are basically people from either the logging area or them spreading the weeds down the river...*

#### Question

Just thinking about the strategies that you use ... is this the normal strategy you would use?

*... well, not really ...it would be, because last time when I thought about it , because I didn't use the hats at all really last time, out loud ...but when we talked about it afterwards I realised that I do think that way but not really systematically ...it sort of happens all at once.*

#### Question

Does the hat strategy help you make things more systematic and help you clarify your ideas better?

*... yes it does definitely ...I found it easier to use this time, once I've actually ...because I'm more practiced in it but ... it does, but it has taken me a while to get it in my brain...this is how we do it.*

#### Question

How would you usually do that?

*... usually I would basically get the same thing ...get the problem ...clarify the problem... find exactly what I would need to find ....like what I need to look for... go get all the*

*information and basically pick out the bits that support, or what I need to look for... so, its basically the same thing except I don't actually write anything down.*

Question Do you think you would normally do an information gathering process?  
... yes...

Question And then do some editing of that?  
... yes...

## Summary of Group Profiles

A summary of each of the participants' strategies from this group follows.

	Problem Solving Profile
SH 1	<b>Problem 1</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task – ongoing referral</li> <li><input type="checkbox"/> Seeks Support:- reviews strategy outline (x2)</li> <li><input type="checkbox"/> Locate Evidence:- random exploration in Region - reads/views/listens to media reports - notes key ideas in workbook - returns to WRC - rechecks media reports - checks related articles in filing cabinet</li> <li><input type="checkbox"/> Develop Solution:- apparent individual strategy - recognises relationships between evidence - weak causal reasoning - no prioritising of evidence</li> </ul> <b>Problem 2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide (x2)</li> <li><input type="checkbox"/> Locate Evidence:- initial random exploration of Region (brief) then to WRC - systematic search of media elements - reads/views/listens - no written record - takes measurements related to evidence</li> <li><input type="checkbox"/> Develop Solution:- apparent individual strategy - weak causal reasoning based on interpretation of evidence from memory</li> </ul>
SH 2	<b>Problem 1</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task</li> <li><input type="checkbox"/> Seeks Support:- reviews strategy - acts on advice from guide (x2)</li> <li><input type="checkbox"/> Locate Evidence:- random exploration in Region - reads/views/listens - paraphrases key points - no notes in PDA or workbook - many reports not accessed</li> <li><input type="checkbox"/> Develop Solution:- no apparent plan - narrow focus (dump) - generalisations, without support from evidence.</li> </ul> <b>Problem 2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task - records key points in workbook</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide (x2)</li> <li><input type="checkbox"/> Locate Evidence:- extensive systematic sampling using measurement tools, many unrelated to task - systematic selection of media reports from WRC ( TV/radio only) - reads, using linked media - paraphrases key points - no written notes in PDA or workbook - some evidence missed</li> <li><input type="checkbox"/> Develop Solution:- identifies main causes of problem - expresses difficulties with identifying ways to control - no prioritising of evidence - no evaluation of strength of evidence</li> </ul>
SH 3	<b>Problem 1</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task</li> <li><input type="checkbox"/> Seeks Support:- acts on advice from guide (x2)</li> <li><input type="checkbox"/> Locate Evidence:- random exploration in Region - reads/views/listens to range of reports - notes key points in workbook from selection of these (supported by some paraphrasing) - some categorising and linking of evidence- unrelated measurements taken - returns to WRC &amp; rechecks media reports</li> <li><input type="checkbox"/> Develop Solution:- follows strategy - generalisations, without support from evidence</li> </ul> <b>Problem 2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Clarification:- reads outline &amp; task - copies to PDA</li> <li><input type="checkbox"/> Seeks Support:- no</li> <li><input type="checkbox"/> Locate Evidence:- uses strategy - systematic searching of TV/Radio reports in WRC(x6) - reads &amp; paraphrases - suggests possible solutions - recognises relationships between reducing logging activity &amp; employment - key points written in workbook - makes full</li> </ul>

	<p>range of tests above/below camp (many unrelated to task) - checks related articles in filing cabinet ... <i>alligator weed responds to high nutrient levels ... maybe that needs to be removed ... water hyacinth grows where nutrient levels are high, which is here ...</i> (indicates section of river) - analyses all newspaper reports - paraphrases ... <i>logging increases nutrients causing weed growth ... phosphorus and nitrogen in higher than normal concentrations ... I think that's what my testing showed.</i> - notes key points in workbook</p> <ul style="list-style-type: none"> <li>❑ Develop Solution:- solution based on stopping or relocating logging operations to eliminate waste water - no support from evidence even though many of the issues had been identified during location of evidence - other suggestions on how to minimise weed growth included spraying and use of beetle.</li> </ul>
<b>SH 4</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - ongoing referral</li> <li>❑ Seeks Support:- acts on advice (x2)</li> <li>❑ Locate Evidence:- systematic search in filing cabinet ... <i>I'm just trying to get some background information ...</i> - random exploration of Region - reads selected articles &amp; notes key ideas in workbook - takes measurements up/down river, many unrelated to task - returns to WRC &amp; checks media reports</li> <li>❑ Develop Solution:- uses strategy - possible solution based on generalisations with focus on farming practises (an idea from original inspection of filing cabinet) - limited causal reasoning</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - copies to PDA - note in workbook</li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- examines articles in filing cabinet on weeds - reads &amp; paraphrases key points - highlights sections &amp; copies to PDA (missed article on weed control measures) - takes series of measurements (phosphorus, nitrogen, pH, pesticides) along river &amp; compares visually - makes wrong inference ... <i>the logging camp doesn't seem to be contributing at all ... seems to be gradually getting worse going downstream and the logging camp is no big contributor so there are other factors involved...</i> - checks two TV reports - highlights sections &amp; copies to PDA -</li> <li>❑ Develop Solution:- solution based on generalisations without support from evidence ... <i>she (Alice Butler) believes the willows are choking Possum Creek and personally I think the same thing ... so that's my answer to the problem. Now the main causes are ... the willows ... land clearing ... introduction of foreign species. To fix the problem ... harvest the weeds ... manage the water levels ... reduce the use of herbicides.</i></li> </ul>
<b>SH 5</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - writes key points in workbook</li> <li>❑ Seeks Support:- acts on advice from guide (x2)</li> <li>❑ Locate Evidence:- initial exploration of articles in filing cabinet ... <i>just trying to get some background information.</i> - then random exploration of Region - reads/views/listens - analyses &amp; highlights sections to record in PDA - writes brief notes in workbook and links to initial task</li> <li>❑ Develop Solution - relates evidence to problem - prioritises &amp; recognises relationships between evidence - strong causal reasoning, identifying &amp; providing reasons to support her solution</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - writes key points in workbook- rechecks intermittently</li> <li>❑ Seeks Support:- acts on advice (x1)</li> <li>❑ Locate Evidence:- random exploration of Region - reads/views/listens - analyses &amp; highlights sections to record in PDA - writes brief notes in workbook - measurements relate to evidence</li> <li>❑ Develop Solution - relates evidence to problem - prioritises &amp; recognises relationships between evidence - strong causal reasoning, identifying &amp; providing reasons to support her solution</li> </ul>
<b>SH 6</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - ongoing referral</li> <li>❑ Seeks Support:- acts on advice (x2)</li> <li>❑ Locate Evidence:- initially all TV reports in WRC - highlights key points while reading - paraphrases - outlines ideas - random exploration in Region - takes range of measurements, many unrelated to task (expresses confusion)... <i>I have no idea what they mean so I'm pretty confused at the moment</i> - little supporting notes in PDA or workbook</li> <li>❑ Develop Solution:- uses strategy - generalisations based on memory - no support from evidence</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - copies to PDA</li> <li>❑ Seeks Support:- acts on advice from guide(x4)</li> </ul>

	<ul style="list-style-type: none"> <li>❑ Locate Evidence:- random exploration in region - reads newspaper/TV/Radio reports - highlights key points &amp; copies to PDA - measures phosphorus, nitrogen, salinity, pH, algal count, above/below river &amp; compares readings - returns to WRC - random searching of Animal/Plant book &amp; Filing cabinet - copies sections on alligator weed &amp; control measures to PDA - checks radio reports &amp; highlights/copies sections to PDA</li> <li>❑ Develop Solution:- reviews notes in PDA - no prioritising of evidence - links related evidence ... <i>the fact that some people are dumping weed into the river is one of the problems ... but I thought that the nutrients coming from the camp is contributing to the rapid growth ... because its obvious from the tests that the nutrients, phosphorus and nitrogen have increased ...</i> - no suggested actions to reduce weed growth but PDA contains list that includes biological control, chemical spraying and limiting nutrient flow.</li> </ul>
SH 7	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - records key points in workbook - ongoing referral</li> <li>❑ Seeks Support:- acts on advice (x1)</li> <li>❑ Locate Evidence:- systematic exploration of Region - highlights key points &amp; records in PDA - types in own interpretation in some cases under specific headings related to task - takes measurements related to task (evaluates)</li> <li>❑ Develop Solution:- demonstrated plan of action - links &amp; relates evidence to problem - ranks &amp; evaluates evidence - good causal reasoning</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:-reads outline &amp; task - copies to PDA - ongoing referral</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- systematic exploration of media reports in Region (x9) - analyses &amp; highlights key points &amp; records in PDA ... <i>now I'm working out what's good and bad about each particular point</i> - types in own interpretation in some cases under specific headings related to task - takes extensive measurements related to task (evaluates) above/below camp &amp; along river - checks water quality in previous time zone for comparison - does not crosscheck with available support information in filing cabinet (missed weed control measures)</li> <li>❑ Develop Solution:- examines PDA notes ... <i>from the evidence I'd say the logging camp is contributing to the nitrogen &amp; phosphorus levels in the river which is causing growth of algae in the river ... there's algae been introduced from other places like alligator weed ... and the willows ... are causing most of the problems.</i> - no suggestions to reduce weed growth.</li> </ul>
SH 8	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task</li> <li>❑ Seeks Support:- acts on advice (x4)</li> <li>❑ Locate Evidence:- random exploration between Region &amp; WRC - read/views/listens - highlights key points (not all reports) &amp; records in PDA - measurements taken related to previous evidence</li> <li>❑ Develop Solution:- uses strategy - generalisations based on 'strengths' &amp; 'weaknesses' - no support from evidence</li> </ul>

Table 4.7      Analysis of action steps in cognitive strategies used in individual problem-solving processes (Six Hats Framework).

In clarifying problem one participants SH2, SH3, and SH8 read the problem outline and associated task, and made no other reference to the task for the remainder of the process. The other participants in this group demonstrated an ability to identify the relevant details from the task. They either wrote down the key points and used this as a focus for the evidence they were collecting or continually referred to the task outline throughout their evidence-collection process, linking the data that had been accessed to the specified task. In addition,

two participants, SH4 and SH5, spent an initial period of exploration of the problem space to obtain a broader view of the problem.

When working towards a solution through investigation of the supporting media elements, most of this group began with a random exploration of the region in which the problem is set. Reports were interpreted from primary access to the media source without secondary referral to the linked media. Brief notes were made in the participant's workbook of points that provided support to the particular line of inquiry and linked to the initial task. All participants engaged in some form of explanation about cause-and-effect relationships from the evidence they had collected. However the quality of these responses was varied. Some participants (SH1, SH5, SH7) demonstrated good causal reasoning, recognising relationships between evidence and prioritising the evidence when providing reasons to support a solution. Others (SH3, SH6, SH8) developed solutions that were based on generalisations without support from evidence. Little attempt was made to evaluate or prioritise the evidence collected and this reflected the apparent lack of clarification each of these participants had demonstrated at the commencement of each of the tasks.

With problem two, participants SH3, SH6 and SH7 read through the task outline and copied it to the PDA for ongoing referral throughout the problem-solving process. Participants SH2, SH4 and SH5 proceeded in a similar fashion then reread the task and recorded key words or phrases in their workbook as a focus to guide their investigation. In researching evidence to support the problem, the majority of participants demonstrated analysis skills that included highlighting sections of text that were considered important, noting key words or phrases in the workbook and paraphrasing the main ideas associated with the media report that had been reviewed. With the exception of SH3 and SH7 all participants acted on the advice from the Water Research Officer (Tatiana) in guiding their search strategies. When developing a solution to the problem the quality of responses was again varied with participants SH3, SH5, SH6 and SH7 demonstrating the better causal reasoning based on relationships between evidence in establishing cause and effect. The remainder of this group proposed solutions based on generalisations without the support of evidence.

4.2.2.3 Venn Diagram Framework – Case 3

Participant VD7 was female from the 16 - 20 age group. After listening to the introduction from the guide (Peter) she followed the advice and recorded the problem context and the associated task (Chemical Pollution) in the PDA. After reading the text she identified the problem and wrote this into her workbook ... *I'm going to write down the problem ... killed large number of fish.* Following this she proceeded to the environment where the problem is set and began a random search to gather supporting evidence. With the media reports accessed, this participant preferred to read the information provided. The first article read was a newspaper report dealing with a suspected dumping of acid from industry. The resulting pattern of inquiry showed that this had become the main focus for the participant ... *a possible cause is chemicals leaking into the river from the local tip and it's supported by the boys being burnt by the acid.* The sections of text that were highlighted and recorded in the PDA together with pH measurements taken along the river reflect this trend. This participant appeared to have no clear strategy in solving this problem and only a limited number of media reports were accessed. No support was sought from the guides and no exploration of the Water Resources Centre took place.

Research for evidence to support the solution of the second problem was conducted in a similar manner. Only a limited number of media reports were referenced from within the environment and analysis of these was limited to causal reasoning at a surface level. Little attempt was made to reflect on the information, to identify any patterns or common attributes, or to explain predictions based on available evidence.

Action Plan VD 7 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	Views/listens to guide – selects problem
Problem selection:	Peter– grab – reads - made note in workbook – rereads task ... <i>first I'm going to write down the problem... killed large number of fish...</i> Went to Zone 3 – random exploration

Locate Evidence	Newspaper – Industry suspected of dumping acid - reads – highlights sections & grab to PDA - suggests possible cause <i>... looking at the article I found out its possibly acid...</i>
Locate Evidence	Newspaper – acid burns school boy at local tip – reads <i>...um... local tip...go back and test the water for acid...</i> Returns to Zone 3
Locate Evidence	Measurement tools - selects pH and checks near dump...records reading in PDA <i>... reading is 5...go back to article ...</i>
Locate Evidence	TV – Chemical dumping to be fined - checks linked media – reads – highlights sections & grab - suggests possible cause <i>...and gathering information up...and highlight this part about chemicals in the river ...put in my report ... and put that information up into my notebook... and possible cause of why the chemicals leaked into the river..that information is ... so found a possible cause is chemicals leaking into the river from the local tip and its supported by the boys being burnt by the acid...certainly the acid... and there was acid being in the river...and...going to have a look at other areas to see if there is another problem and not just the tip ...</i>
Locate Evidence	Radio – Tip poisons nearby river - linked media – reads – highlights & grab <i>...OK, ... More information that the chemicals are leaching into the groundwater... bit further down the river ...</i>
Locate Evidence	TV – Fish found dead in river - linked media – reads <i>...I'm just going to go back to the problem and have a look at the first question... the problem...</i>
Problem Selection	Revisited task in PDA – checks own notes
Locate Evidence	Begins further testing in the river - pH only - records readings in PDA <i>.... looking further upstream in the river....and...bit further... further up....test the water further up to see what the pH is.....and... best to get the area with the highest reading....</i>
Locate Evidence	Radio- Chemical dumping radio campaign - linked media - reads <i>...there's more information about pollution further upstream...and there's two causes of pollution in the river so far...</i>
Locate Evidence	Newspaper – Keep out of river - reads – highlights & grab <i>... I'm now in a newspaper article ... put that information into my notebook ...</i>
Strategy Outline	Examines assigned framework



Problem Selection	Checks information gathered – checks task <i>... and look any further up the river...and , so where the problem is...pollutants from industry on the land, ... on the edge of the river ...</i>
Possible Solution	Returns to WRC - consults notes in PDA - reviews <i>...I'll go back and find ways of fixing the problem...back to the top task...and to answer the task...(begins to type in PDA). ...possible reasons...found... runoff...from local industries....into the river... finding the evidence to support the causes...</i>

## ***Action Plan VD 7 - Problem 2***

<b><u>STEPS</u></b>	<b><u>REFINEMENT PROCESS</u></b>
Introduction	Views/listens to guide – selects problem
Problem Selection	Tatiana –highlights/grab – reads – note in workbook <i>...problem is... rampant weed growth...looking for the cause.... Goes to Region – random exploration</i>
Locate Evidence	TV – Cause of algal growth found – views– linked media – rereads – develops Venn diagram – h/g sections to PDA <i>..the contributor...is the wastewater...I'll try using the Venn diagram ...problem... getting rampant weed growth ...and some of the contributors...maybe...the rapid weed growth is found in the stiller parts...and also maybe , due to the waste water...I'll test the water..</i>
Locate Evidence	Takes measurements (all tools) – general scan of river observing changes in readings <i>... start upstream ...look further down the river...</i>
Locate Evidence	Radio – Weeds cover river, killing fish – listens – linked media – reads – note in workbook – Venn comment <i>...in that interview there was a common contributor...it was the stiller parts ...have more weed....further up the river it was less muddier and there was less weed....for one part of the Venn diagram we could use observations...so there is rampant weed growth in stiller parts of the river...and further up the river, where it is muddier , there is less weed...</i>
Locate Evidence	Newspaper – Weed Effort fails – reads – note in workbook in Venn – Checks notes in PDA <i>...some action that's been taken....trying to physically clear the weed ...</i>
Locate Evidence	Radio – Expert warns against weed invasion – listens – note in workbook – linked media – h/g key points to PDA

*...a definite contributor ...due to an increase in level of nutrients entering ..places up here, such as the waste runoff... (indicates logging camp)*

Problem Selection	Rechecks task outline
Locate Evidence	continues random exploration – looks at headings on articles – no new data collected
Problem Selection	Rechecks task outline
Problem Solution	<p>Begins analysing notes and ideas from Venn - begins typing 'solution' to problem into PDA</p> <p><i>...possible main causes...have been firstly the introduction of foreign weed, alligator weed....which has been rampantly ....the waste runoff ....</i></p> <p><i>... actions ...begin physically removing the weeds ensuring that .....the stems and ...pieces are removed ...precautions...should be taken to stop the spreading...</i></p> <p>Indicates completion of Task</p>
Question	<p>Who do you think the main culprit was?</p> <p><i>...probably the boat...</i></p>
Question	<p>What do you think is the main cause of the problem?</p> <p><i>...probably,...the waste water...</i></p>
Question	<p>Where's that coming from?</p> <p><i>...from the place over there ... (indicates the logging company)</i></p>
Question	<p>I noticed you tried to use the Venn diagrams. Do you think that has helped you try to clarifying your ideas better?</p> <p><i>...yes, it did... it sort of gave me different sections to follow instead of looking at the whole problem ...it helped break it down into little bits ...</i></p>
Question	<p>If you hadn't used the Venn diagram, how would you normally go about trying to find a solution to this type of problem?</p> <p><i>....I probably would have looked at the whole thing and not try to look for a cause ...like what was actually happening...but I wouldn't have tried to look for a cause...just go straight through it ...</i></p>
Question	<p>So overall, you think the Venn strategy has helped in clarifying your ideas better?</p> <p><i>...yes ...</i></p>

## Summary of Group Profiles

A summary of the remainder of the participants' strategies from this group follows.

	Problem Solving Profile
VD 1	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification - Reads outline – <i>I'll read through the information to get a general idea of what I have to do ...</i> regular referral to task</li> <li>□ Seeks Support - No support sought</li> <li>□ Locate Evidence - Careful analysis/reasoning of articles related to problem – highlights key points and records</li> <li>□ Develop Solution - Initiates plan of development – relates evidence to problem - <i>... now I'm starting to gather the major points on the reasons for it. We've got sewage, chemicals, the tip, poor cleaning of equipment, maybe poor dumping sites</i></li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>□ Clarification - Reads outline (x2) – selects key points - headings in workbook</li> <li>□ Seeks Support - No support sought</li> <li>□ Locate Evidence - random exploration of region - Careful analysis/reasoning of articles related to problem – highlights key points and records in PDA - additional support in workbook - later cross-checks reports in WRC</li> <li>□ Develop Solution - Relates evidence to problem – recognises relationships between evidence - recognises main cause of problem without suggesting ways to remedy situation <i>... fixing it up comes from making people aware of the problem by putting up a warning sign ... collecting samples to hand in ...</i></li> </ul>
VD 2	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task – headings in workbook</li> <li>□ Seeks Support:- acts on advice form guide (x2)</li> <li>□ Locate Evidence:- systematic check of media reports in WRC – reads from linked media – paraphrases &amp; notes key points in workbook – related measurements checked in region – recognises main problems <i>... OK, the biggest problem is the acid at the tip and pesticides ...</i> searches for support material in filing cabinet.</li> <li>□ Develop Solution:- Relates evidence to problem – recognises relationships between evidence – draws inferences from available evidence.</li> </ul>
VD 3	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline and task – copies to PDA – regular referral to task</li> <li>□ Seeks Support:- acts on advice form guide (x3)</li> <li>□ Locate Evidence:- systematic checking of newspaper/TV reports in WRC – notes in workbook of key points – measurements taken (most not applicable to problem) and compared visually – checks filing cabinet for support information</li> <li>□ Develop Solution:- solution based on generalisations – recognises general problems associated with industry, illegal dumping (agricultural containers), and community – no specific causes or evidence to support.</li> </ul>
VD 4	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task – highlights sections – rereads – copies to PDA</li> <li>□ Seeks Support:- no</li> <li>□ Locate Evidence:- systematic checking of TV in WRC – notes in PDA of key points – paraphrases sections – measurements taken (most not applicable to problem) and compares <i>... I'm testing the river ... moving downstream from the dump ... results are pretty weird ... don't really understand ...</i> checks articles in water pollution folder in filing cabinet, then newspaper reports and links evidence <i>... that information goes with the news report from before .</i></li> <li>□ Develop Solution:- no clear strategy for development of a solution - solution based on generalisations – recognises general problems associated with industry and illegal dumping- no specific causes or evidence to support argument.</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - copies to PDA - rereads - notes key points in workbook</li> <li>□ Seeks Support:- acts on advice (x1)</li> <li>□ Locate Evidence:- examines filing cabinet(water plants/weeds folder) then animal/plant book <i>...I'm just trying to see what type of weed it was. -</i> reviews TV/radio reports - notes key points in workbook -paraphrases main ideas - re-examines articles in filing cabinet but misses articles on suggested actions to remove problem- takes measurements related</li> </ul>

	<p>to previous reports plus unrelated tests - no apparent linking with other evidence</p> <ul style="list-style-type: none"> <li>□ Develop Solution:- based on generalisations - identifies logging camp as one of main contributors, together with the alligator weed - no attempt to suggest ways to remedy situation</li> </ul>
<b>VD 5</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task – copies to PDA – key points in workbook</li> <li>□ Seeks Support:- acts on advice (x1)</li> <li>□ Locate Evidence:- systematic checking of TV/radio (linked media) in WRC – notes in PDA of key points – paraphrases sections – makes inferences... <i>locals seem to think the tip is to blame but we have no evidence as yet.</i> - quick inspection of folder titles in filing cabinet – measurements taken in river system &amp; compared(systematic but no clear focus to previous evidence) – re-examines folders in filing cabinet but ignores ‘farming practices’</li> <li>□ Develop Solution:- no clear strategy for development of a solution - solution based on generalisations - ... <i>I think the tip seems to be the cause of the problems in the river and the dead fish ... obviously there is no mining in the area ... or other industries ... and the results from the tests definitely show the levels are different near the tip compared to upstream.</i></li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - draws three interlocking circles in workbook - rereads</li> <li>□ Seeks Support:- no</li> <li>□ Locate Evidence:- minimum access to reports in WRC(4/11) - brief notes in circles - takes range of measurements above &amp; below camp and visually compares.</li> <li>□ Develop Solution:- solution based on misinterpretation of limited evidence accessed - no clear reasoning or linking between evidence ... <i>I think what's happened is they have logged all of that area and removed all the native trees and that's caused erosion, especially around the river banks and to prevent that happening they have planted willows.</i></li> </ul>
<b>VD 6</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task – intermittent referral</li> <li>□ Seeks Support:- no</li> <li>□ Locate Evidence:- random exploration within region – reads/listens/views minimum number (5/13) – brief notes in workbook(no clear plan) – individual measurements taken &amp; compared visually.</li> <li>□ Develop Solution:- begins to outline solution verbally without referral to own notes – no clear strategy, but defined essential elements of the problem with inconsistencies in reasoning ... <i>I know what's caused the problem ... insecticides being dumped at the tip ... there're not being stored properly and when it rains the runoff is going into the river ... so, if the insecticides were stored properly ... the chemicals treated properly ... you wouldn't be getting runoff.</i></li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - headings in workbook - rereads - copies to PDA - regular referral to task</li> <li>□ Seeks Support:- acts on advice from guide(x3)</li> <li>□ Locate Evidence:- random exploration of region - reads/views/listens/ to range of media reports - notes points from selected reports - takes a selection of measurements in river above/below camp - returns to WRC and checks some media reports - checks articles in filing cabinet(misses article on possible control measures)</li> <li>□ Develop Solution:- identifies main causes - recognises link between alligator weed growth &amp; nutrients from logging camp - suggests using a beetle as control mechanism.</li> </ul>
<b>VD 7</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - records key ideas in workbook – intermittent referral</li> <li>□ Seeks Support:- no</li> <li>□ Locate Evidence:- random exploration in Region - highlights key ideas from linked media- records in PDA - paraphrases - takes measurements (pH only)</li> <li>□ Develop Solution:- apparent plan of action with focus on acid pollution - limited, possibly due to lack of media reports accessed.</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - ongoing referral</li> <li>□ Seeks Support:- no</li> <li>□ Locate Evidence:- random exploration within Region - reads/views/listens - highlights sections from linked media - some paraphrasing - brief notes in workbook - many media reports not accessed</li> <li>□ Develop Solution:- uses plan of action to develop solution - identifies main cause(s) - no supporting evidence - no linking or evaluation of evidence</li> </ul>
<b>VD 8</b>	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>□ Clarification:- reads outline &amp; task - paraphrases</li> <li>□ Seeks Support:- acts on advice(x3)</li> </ul>

	<ul style="list-style-type: none"> <li>❑ Locate Evidence:- random exploration of region – paraphrases – highlights &amp; collects key points in PDA – takes measurements that relate to accessed articles (pH/ pesticides) – reads articles in filing cabinet that relate to problem then concentrates on articles specifically related to industrial pollution.</li> <li>❑ Develop Solution:- no clear strategy for development of a solution - solution based on generalisations – recognises general problems associated with industry and illegal dumping- no specific causes or evidence to support argument.</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - copies to PDA - regular referral</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- systematically takes measurements( phosphorus, nitrogen, algal counts) above/ below camp - random exploration of some media reports (linked media) - notes main ideas in workbook - returns to WRC to filing cabinet (water plants &amp; weeds folder) - highlights and copies sections to PDA - checks media reports &amp; returns to region for additional measurements based on new information</li> <li>❑ Develop Solution:- reviews notes in PDA and workbook - identifies excess nutrients from logging camp as main cause - suggests the use of biological control and herbicides as main actions to control problem</li> </ul>
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Table 4.8      Analysis of action steps in cognitive strategies used in individual problem-solving processes (Venn diagram framework).

For the first problem, all members of this group read through the problem outline and task. Participants VD1, VD3, VD6 and VD7 reinforced what they perceived to be the key ideas through a combination of either paraphrasing or highlighting the text. In addition they referred to the task outline throughout their individual investigative strategy. The remainder reinforced the reading of the task by making individual notes in either the PDA or workbook. For these participants no further reference was made to the task outline.

In working through a series of steps to resolve the problem these participants appeared to have some common strategies in their approach to the task. Even though the search strategies varied from random access to a more structured approach in locating evidence, the analysis of each article exhibited some common characteristics. Participants regularly highlighted key points from within the articles, paraphrasing the main ideas, and recording them for later referral. Throughout this process many participants linked information between articles in suggesting possible causes for the problem. A common feature of their interpretation of the evidence to reach a solution was the inability of group members to specifically identify causes for the fish kill. Instead they generated responses focussing on pollution problems associated with the municipal tip.

With the second problem all participants appeared to spend more time in clarifying the task. Strategies included reading the problem outline and task, highlighting sections of the text and copying to the PDA, writing key words or

phrases in the workbook or combinations of each of these strategies. All engaged in further reinforcement of the task through ongoing referral during the investigative process. When researching information to support the problem most of these participants (VD1, VD4, VD6, VD7 and VD8) engaged in quality strategies in their analysis of the media reports that included highlighting, paraphrasing and the recording of key ideas in their workbook. Of these participants, VD1, VD6 and VD8, initially explored the region where the problem is set apparently to develop an overview or 'big picture' of the problem. Reports that were accessed in this region were later checked in the Water Research Centre.

Of this group only participants VD6 and VD8 identified the main cause(s) of the problem and the possible ways to control them. Participant VD5 based his solution on the misinterpretation of the limited amount of evidence that had been accessed, blaming the problem on erosion caused by logging practices. The remainder of the group indicated the nutrients from the logging camp as the main cause of the problem but did not suggest ways to overcome it. No supporting evidence was used to reinforce their reasoning, possibly because participants VD5, VD6 and VD7 had missed media reports, and articles in the filing cabinet, that may have provided this guidance.

#### **4.2.2.4 Concept Map Framework– Participant CM4**

Participant CM4 was female from the 26 - 30 age group. After listening to the introduction from the guide (Peter) she followed the advice and recorded the problem context and the associated task (Chemical Pollution) in the PDA. After reading the text she paraphrased the problem ... *so we want to find out what is happening, the causes of it and what we can do about it* ... and proceeded to the environment where the problem is set and began a random search to gather supporting evidence. Even though this participant's research strategy involved random exploration she was very thorough in this, mapping all areas of the problem space for embedded information. As each media report was interpreted through reading (newspaper), listening (radio), or viewing/listening (television) the participant paraphrased sections of the report and indulged in a personal

reflection of the issue. Aside from some infrequent noting of a key word or short phrase, no further written information was recorded in either the PDA or the participant's workbook. A series of measurements were taken above and below the tip (many unrelated to the task) and compared before returning to the Water Research Centre to recheck media reports. When developing a final solution to the problem generalisations were used, essentially from memory. The reasons for the fish kill were identified, as ... *from mainly industrial ... industrial waste ... other areas are household wastes*. She demonstrated a lack of clear direction or focus in using appropriate criteria to select the best alternatives from those available or to give careful consideration to the facts, possibilities and consequences of choosing from a number of related situations.

Clarification of the second problem (Water-Plants and Weeds) followed a similar strategy to the one previously outlined with the participant commenting ... *we're looking for the causes of the problem ... and ways to fix it*. Using a similar strategy involving random exploration of the environment she analysed the media elements, highlighted sections of text, paraphrased these and noted key points in the workbook. During this stage of evidence collection she identified the link between nutrients and weeds ... *seems that logging has a bit to do with the weed growth in the area which is causing problems in the river ... too many nutrients in the river ... obviously the weeds are feeding off that*. Later, when carrying out a series of related measurements, this link is referred to again ... *later on I can compare the top of the river, the middle ... the bottom ... where the main lots of the weeds are compared to the logging*. When reviewing the Animal/Pant book and articles in the filing cabinet no clear focus was apparent. This could indicate that this participant had not clearly identified the relationships between some of the evidence collected. This apparent lack of direction was reinforced when developing a solution. Even though she identified the logging camp and introduction of foreign species as the main problems, when asked why the logging company was at fault, she replied: ... *good question ... I've taken their word for it ... I suppose it's the cut-offs from the bark, and everything ... maybe it's what they are throwing into the river*. Examination of this participant's workbook, the PDA records and the audiotape transcripts indicates an awareness of excess nutrients in the river from the logging camp, however no cognitive link had been made between the sewage outflow and the excess nutrients.

## Action Plan CM4 - Problem 1

### STEPS

### REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	<p>Peter – grab – reads - paraphrases</p> <p><i>...so I'll start by clicking on the grab button and read what they've got here...chemical pollution ... so there seems to be a problem of water pollution ...which is affecting obviously the animals' life in the river ... which also effects the human people because they are the ones that want to fish and there's no fishing if the fish are dead ...so we want to find out why it's happening, what the causes of it are and what we can do about it...</i></p> <p>Went to Zone 3 - random exploration</p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign – listens – note in workbook</p> <p><i>...OK ... I thought that was a very good report ... that just shows how much influence humans have and the impact they can have on our rivers... that's true ...you can take one person and it doesn't take much but if you take everybody it can make a big difference... keep that...have another look around...</i></p>
Locate Evidence	<p>Newspaper – acid burns schoolboy at local tip – reads</p> <p><i>...its about boys being burnt while at the tip ...sad story ... but that's more in the tip ...that sort of ... to me that doesn't say anything about them actually...I don't know whether that ends up to be tipped in the water but it doesn't say anything in there about being water pollution...I'll look somewhere else...</i></p>
Locate Evidence	<p>TV – Chemical dumping fined – views/listens – note in workbook</p> <p><i>...I think the way to stop it is to bring in fines to stop water pollution... heavy fines are always an incentive to stop people...</i></p>
Locate Evidence	<p>Newspapers – Industry suspected of dumping acid – partially reads - stops</p> <p><i>...already read that one...</i></p>
Locate Evidence	<p>Newspaper – 'Industry Killed fish , says worker – reads</p> <p><i>...this is good...sounds like a good information section...actually a gentleman who used to work at the local treatment plant, so he would know what they put in the river ...so, they are allowed to put a little bit of waste in the water...good to see tests are actually completed and taken out continually to make sure these companies are actually polluting the rivers with only what they are allowed ...I'll try somewhere else..</i></p>
Locate Evidence	<p>Newspaper – Keep out of river – reads</p> <p><i>...OK, this is about a principal in the local area ... he thinks they shouldn't be playing in the water ...community being worried about their environment ...that's a start at least</i></p>



Locate Evidence	<p>TV – Chemical dumping fined – views/listens</p> <p><i>...I think I have heard that already but I thought that was quite good information so I didn't mind listening again to make it sink in ...</i></p>
Locate Evidence	<p>TV – Resident's call for tip closure – views/listens – note in workbook</p> <p><i>...that was quite interesting ... so the lady seems to think the local tip has a lot to do with it and obviously a lot to do with the illegal dumping... so it was quite interesting to note too it was not quite as easy to fix it as the chemicals are already in the soil so its not as easy to fix...</i></p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign – re-listens – note in workbook</p> <p><i>...that's another point ...I have read this one before but I've just picked up on that one ... that some people are not aware what they can and cannot put down the drain because we always expect that the community will organise some areas where we can take the pollution out of our water before it enters our streams ...and also he didn't know exactly where he could put his paints ...looked through most of this now...</i></p>
Locate Evidence	<p>TV – Chemical dumping witnessed - views/listens</p> <p><i>...appealing for public help...haven't given any incentive for the public to come forward ...look at water levels in the area...</i></p>
Locate Evidence	<p>measurements - selects tools - outlines sampling procedure - extensive readings in PDA</p> <p><i>... click on all of them - phosphorus, nitrogen, oxygen, salinity ,pH balance pesticides ... temperature ...have a look at all of them to see how they compare ...one at the top of the river ...I'll take four ...two towards the middle and one at the bottom...ok... just go and write that in case I go back later ... top of river ... look at my results....wish I knew a little more about science to understand it....Nitrogen 1600 ...Oxygen ...90%... not bad....Phosphorus is 300. I'll name that top/middle ... nitrogen hasn't moved that much ...just name that lower/middle ...Lets compare that with the earlier reading---continues to compare readings...pesticides...that's one of their concerns...pesticides are down towards the bottom ... oxygen is decreasing.... depending where you are in the river it changes ...maybe they need to have a look at obviously...whereabouts in the river are these high levels and also how fast the river flows as that could indicate where it comes from....</i></p> <p><i>...look at stream quality ... that changes as you go down the river as well ... its good to be able to compare things like this ... seeing the change....get out of here...look ...see if there anything we've missed... might go and have a look what's in the Centre</i></p> <p>Returns to WRC – checks newspapers</p>
Locate Evidence	<p>Newspaper – Industry suspected of dumping acid – rereads – comments on Tip Manager's response</p> <p><i>...he is starting to blame...industries need to take more responsibility ...</i></p>
Locate Evidence	<p>TV – Industry kills fish, says worker - checks listing</p>

*...quick, look at the written text to see if I've read it...*

Locate Evidence	Radio – checks listing – Chemical disposal policy outlined - listens – note in workbook <i>...talked about fines... fines won't fix everything... I think we have to do more than that... have a quick look through them all ...</i>
Locate Evidence	Relistens to all radio reports – relistens to Tip Poisons nearby river(x2) <i>... I think I'll listen to that one again ...tests at tip show tip is causing a lot of the pollution and the groundwater underneath used to be wetland ... pollution will seep down into the water and probably down to the river,,, seems like this tip should be well away from the river...</i>
Locate Evidence	radio - tip chemicals kill fish - listens <i>...these companies spend so much money on fines that they should spend some on fixing the problem in the first place ...</i>
Hints	Peter - ( measurements/media reports) <i>...I've done that...</i>
Hints	Peter again - (radio broadcast/filing cabinet(farming)) - acts on advice <i>... OK, I'll check filing cabinet for farming...</i>
Locate Evidence	Filing Cabinet – looks at titles - checks dryland salinity – other salinity articles - paraphrases - some articles irrelevant to task solution <i>...what causes dryland salinity? ....once you start farming and doesn't soak up the moisture.....cause erosion as well... options for control ... vegetation management ...agricultural runoff, use of pesticides, herbicides ...seems to be ... changes brought about by how we deal with the land ... all the farming brings the salinity and pesticides we use ... seems to have a lot to do with industry ... I'll go back to the original question</i>
Problem Selection	reviews task <i>... I'll go back and have a look at the original question to get a better idea ...I think I've pretty well looked at everything now and just see what the task was again... find possible reasons for the fish kill...</i>
Problem Solution	reviews ideas gained through accessing media reports - notes in workbook limited <i>... well, reasons for the fish...mainly water pollution ...from mainly industrial...industrial waste... other areas were household waste ...people not knowing where to treat them ... ends up going into the sewerage ... the sewerage is not able to take all the contamination out of the water before it enters the river ... other possible reasons for the fish ... the farming ...big factor ... cutting down the trees as well</i>

## Action Plan CM4 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	<p>Tatiana – grab – headings in workbook - reads – note in workbook</p> <p><i>....Were looking for the causes of the problem...and ways to fix it...seems to be the weeds that are the problem ... or one of the main problems ...</i></p> <p>Goes to Region – random exploration</p>
Locate Evidence	<p>Newspaper – Logging linked to weed growth – reads - paraphrases - note in workbook</p> <p><i>...logging linked to weed growth ...read through that ... seems that logging has a bit to do with the weed growth in the area which is causing problems in the river...too many nutrients in the river now....obviously the weeds are feeding off that...bit strange how he can make these assumptions when he hasn't even inspected the site...Doctor has made some assumptions that unless these chemicals can be cleared from the river the growth of weeds will continue ....try somewhere else..</i></p>
Locate Evidence	<p>Radio – Logging linked to weed growth – listens – note in workbook</p> <p><i>...has a responsibility to contracts so he knows that he does contribute to the problem in the river but has obligations to fulfil...so he won't change and look at the environment instead...</i></p>
Locate Evidence	<p>TV – Cause of algal growth found – views/listens– note in workbook</p> <p><i>...weeds not the only problem....its smells as well so the water is obviously becoming stagnant.....fishing not as good as it used to be ...</i></p>
Locate Evidence	<p>Newspaper – Weed effort fails – reads</p> <p><i>... good to see the residents are behind it.... that's one way to try to stop it...by using the resident's to clear out the weeds...efforts didn't help very much... they are growing back already ... when they did that it made things worse down the river....it was a temporary solution not a long term one....</i></p>
Locate Evidence	<p>TV – River choked by wild willows – views(x2) – note in workbook</p> <p><i>...I'll read through this once more....willow trees are obviously used to help the area as well ....it made it worse... they broke and fell in the water ...not very strong and didn't do the job they were supposed to do...</i></p>
Locate Evidence	<p>Radio – Expert warns against weed invasion – listens – note in workbook</p> <p><i>...he was also talking about human pollution and how we pollute our rivers as well....the activities we use...not just fix one problem, need to look at the whole problem, not just one thing...</i></p>

Locate Evidence	Newspaper – Weed Eradication program – reads – note in workbook <i>...irrigation farmers must report any weeds found in river...Inform authorities</i>
Locate Evidence	Radio – Weeds cover river, killing fish – listens – note in workbook <i>...obviously effecting the life in the water ... mustn't be enough oxygen...will need to go and have a look at the oxygen in the area...</i>
Locate Evidence	Measurements – selects tools, phosphorus, nitrogen, oxygen, algal count, coliform bacteria – takes readings at top, middle & bottom of screen (PDA records) - extensive comparisons <i>...click on P for phosphorus, ...nitrogen, ....oxygen...later on I can compare the top of the river, the middle...the bottom....where the main lots of the weeds are compared to the logging...especially look at where the river's travelling .and where the weeds are in relation to the logging ...quick look while I'm here ...</i> (checks readings in PDA) <i>... now I'll go onto the centre to check my reports ...</i> Returns to WRC
Locate Evidence	TV – Weed growth distresses residents – note in workbook <i>...O.K, they say what affects it but haven't said how to fix it...not very much help...</i> Checks all media reports from clipboards & newspaper articles
Locate Evidence	Animal & Plant Book – seems unclear – random exploration <i>...checking the plants &amp; animals folder ...that's obviously a list ...quite a lot...quite a listing of the trees and shrubs ....just having a look at one weed, pondweed...reproduce by means of seeds...have a look in the filing cabinet...</i>
Locate Evidence	Filing Cabinet – waterplants & weeds folder (weed control, waterplants, willows, alligator weed, salvinia) – outlines causes (logging, willows, foreign species) <i>...OK, ...water weed identification....showing different types of weeds...floating weeds.....weed control options...this is quite good, because you have to find the extent of the problem which is what they are trying to find out...determine the causes...well, we've worked out that the causes so far are the logging...the willows that they tried to put in...the foreign species they have found ...its also effecting the water life there... problem requires intervention ...control measures....haven't really discussed how to fix it yet ...tried a few short terms methods like pulling out the weeds...consider the financial costs...I think that's the biggest problem at the moment , people are worried about the cost in fixing it, but we have to look at the long term effects...</i> <i>...suggestions for how the weeds can be controlled ... check the waterways ... take plants to authorities to identify ...</i> <i>....alligator weed and where it was found....more about weeds ...a serious one is salvinia.</i>
Problem Solution	reviews notes from workbook & begins to structure a 'concept map' - talks through process <i>...that's about it...I might reorganise this into some form that is readable...and...if I re-look at it...</i>

*...main problem...water plants and weeds...problems we have are virtually...come down to a few areas...definitely got the logging...with...causes of that is their logging...the willow trees ...foreign species...other weeds...also have to look at how we are going to fix them...the people involved...the residents...the authorities...the logging company...seems as though everyone wants to fix this except the logging company at present...  
 ... the ways to fix it...I don't think we have really got to this...we have the authorities trying to fix the problem...doing investigations ... looking for solutions and the residents are trying to help...haven't really found any ways to control it...problem is virtually the weeds and the logging company ...methods to control it ... haven't really said ... obviously we have to do something with the weeds and the logging company but they haven't said how they might go about doing it, except they are doing investigations ... that's about it ...*

Indicates completion of task

- |          |   |
|----------|---|
| Question | <p>Why is the logging company at fault?</p> <p><i>Good question...I've taken their word for it...I suppose it's the cut-offs from the bark , and everything...maybe its what they are throwing into the river ...</i></p>   |
| Question | <p>I see you've used a strategy that resembles a flow of ideas, like a flow chart. Do you think the concept mapping strategy does help you in clarifying your ideas or organise your own thoughts?</p> <p><i>Definitely...I can't say I've really used it before I started at Uni, but I usually write whatever is in my head and it goes straight onto paper, like an essay type thing...what I've started doing is just pinpointing major issues...it has helped...try to pick the main ideas and decide which is the most important...</i></p> |
| Question | <p>How would you normally go about solving problems like this?</p> <p><i>Probably go through and read everything once ...and probably not write anything down ...or write down the main bits...then go through the second time and add a bit to that...you have a bit of background knowledge then....</i></p>  |
| Question | <p>Did you normally go about writing down ideas on paper?</p> <p><i>I have started...I never used to ...now that I've started my marks have improved....actually gives you an avenue to look....</i></p>  |
| Question | <p>How have you found the process with the tape-recorder on? Has it bothered you?</p> <p><i>No, I thought it would but it hasn't really.</i></p>  |

## Summary of Group Profiles

A summary of each of the participants' strategies from this group follows.

	Problem Solving Profile
CM 1	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads problem outline &amp; task</li> <li>❑ Seeks Support:- acts on advice from guides</li> <li>❑ Locate Evidence:- random exploration - reads/views/listens - copies whole article to PDA - paraphrases when reading - makes inferences on some issues - cross-references measurements with media reports</li> <li>❑ Develop Solution:- based on generalisations with some reasoning to support based on relationships between pieces of evidence</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads - paraphrases - headings in workbook - regular referral</li> <li>❑ Seeks Support:- as a checking mechanism before developing a solution (x3)</li> <li>❑ Locate Evidence :- random exploration - reads/views/listens - copies whole article to PDA - paraphrases when reading - makes inferences on some issues ...<i>the cause could be sewage ... or logging ... or both</i> - cross-references measurements with media reports ... <i>so he says it's the phosphorus and nitrogen levels, which I've already highlighted ... but, where's it coming from?</i></li> <li>❑ Develop Solution:- identifies main causes but missed establishing the relationships between the problem(s) and possible control measures ... <i>main cause ... the phosphorus &amp; nitrogen in the river caused by the emissions from logging ... and that's debatable really whether that's actual logging or sewage from the system ... introduced weed ... I can't see any solution to it.</i></li> </ul>
CM 2	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads problem outline &amp; task</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- random exploration - reads/views/listens - little analysis of media reports - no checking - measurements taken with little relationship to problem</li> <li>❑ Develop Solution:- no evidence of goal setting or ability to describe problem and select possible strategies and solutions - no revisiting and evaluating</li> </ul>
CM 3	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads problem outline &amp; task - refers back to task at regular intervals</li> <li>❑ Seeks Support:- acts on advice from guide (x3)</li> <li>❑ Locate Evidence:- methodical exploration - analyses reports - highlights sections and records in PDA for later reference ... <i>grabbing information and then I'll decide what I'm doing with it later</i> - takes measurements &amp; relates to previous evidence</li> <li>❑ Develop Solution:- individual strategy - recognises relationships between evidence - ranks evidence ... <i>take out the information in correct order would be the way to do it.</i></li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads problem outline &amp; task - heading in workbook</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- random &amp; brief exploration in region - read limited number of linked media articles - highlighted &amp; records sections in PDA - checks nutrient and coliform bacteria levels above/below camp.</li> <li>❑ Develop Solution:- initially identifies the sewage and introduction of weeds from other countries as causes of the problem - concentrates on sewage from camp in final summation without support from evidence</li> </ul>
CM 4	<p><b>Problem 1</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - paraphrases</li> <li>❑ Seeks Support - acts on advice from guide (x3)</li> <li>❑ Locate Evidence - random, but thorough, exploration - reads/views/listens to reports - some paraphrasing mixed with opinion/inference - brief notes in workbook (little structure) - measurements taken (no clear focus)</li> <li>❑ Develop Solution:- little evidence of ability to develop a sequential program of action to achieve solution - generalisations without support from evidence.</li> </ul> <p><b>Problem 2</b></p> <ul style="list-style-type: none"> <li>❑ Clarification:- reads &amp; paraphrases - notes key points in workbook</li> <li>❑ Seeks Support:- no</li> </ul>

	<ul style="list-style-type: none"> <li>❑ Locate Evidence:- reads/views/listens to reports - paraphrases - notes key ideas in workbook - attempts at linking ideas - takes nutrient &amp; coliform bacteria measurements above/below camp - checks reports in WRC - checks articles associated with weeds in filing cabinet (random searching - no clear focus)</li> <li>❑ Develop Solution:- identifies the logging company and the introduction of foreign species as the main causes during the evidence collection – does not relate to this when developing solution. – no prioritising of evidence – no comparing/contrasting of evidence to identify relationships between issues thereby unable to clearly identify actions to reduce weed problem.</li> </ul>
<b>CM 5</b>	<b>Problem 1</b> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - records key points in workbook</li> <li>❑ Seeks Support:- no</li> <li>❑ Locate Evidence:- systematic exploration - reads/views/listens to reports - highlights sections &amp; records in PDA - measurements taken based on prior observations</li> <li>❑ Develop Solution:- little evidence of ability to develop a sequential program of action to achieve solution - generalisations without support from evidence.</li> </ul>
<b>CM 6</b>	<b>Problem 1</b> <ul style="list-style-type: none"> <li>❑ Clarification:- reads outline &amp; task - refers back on regular intervals</li> <li>❑ Seeks Support:- acts on advice from guide (x3)</li> <li>❑ Locate Evidence:- measurements taken initially ... <i>I'm going to see how chemically polluted it is ...</i> - then random exploration - reads/views/listens to limited number of reports - expresses confusion ... <i>I've got no idea what I'm looking for ..</i></li> <li>❑ Develop Solution:- little evidence of ability to develop a sequential program of action to achieve solution - generalisations without support from evidence.</li> </ul>

Table 4.9      Analysis of action steps in cognitive strategies used in individual problem-solving processes (Concept Mapping).

All participants used a strategy that began with a reading of the problem outline and the specific task. With the first of the assigned problems, four participants reinforced this process by either paraphrasing the key ideas (CM4), recording the key ideas in the workbook (CM5), or referring back to the task on a regular basis throughout the process (CM3, CM6). After initially reading through the problem context and associated task, the other participants (CM1, CM2) made no further attempts in referring to the task until they were ready to prepare a solution to the problem. With the second problem, each participant demonstrated a different technique in clarification of the problem. Participants CM1 and CM4 read through the task, paraphrased the main points, wrote headings in the workbook to guide them in the gathering of evidence and referred regularly to the problem during the process. On the other hand, participant CM3 initially read through the task and wrote headings in the workbook.

In working through a series of steps to resolve the first problem a range of cognitive approaches were used. The degree of analysis for most participants included an initial reading (newspapers), listening (radio) and viewing/listening (television) of the related media elements, followed by the recording of the main points of the article in either the PDA or workbook. Some participants (CM1, CM3, CM4, and CM6) paraphrased sections of articles that had been accessed,

expressing opinions or making inferences about the issues that had been encountered. With the exception of CM2 and CM5, the participants sought support from the Water Research Officer in guiding their line of inquiry. In developing a solution to the problem most participants did not support their argument with evidence that they had collected, but instead based their reasoning on generalisations. Participants CM1 and CM3 appeared to have clearer strategies, using reasoning skills based on some prioritising of the evidence that they had located and analysed to support the solution to the problem.

With the second problem both CM1 and CM4 were more thorough and focussed with their problem-solving strategies. Their initial time spent in clarification of the problem appeared to benefit their search strategies. Their analysis of the media reports appeared to be better focussed and the degree of paraphrasing and linking between related evidence were more apparent. For this problem participant CM3 appeared to spend less time on initial clarification of the problem. However, her search strategies for supporting evidence, although less thorough than the others completing this problem, were focussed on information that had been accessed through random exploration of the region where the problem was set. By coincidence the media reports that had been accessed were directly related to the specifics of the problem and later measurements taken had a direct relationship to these articles. Participant CM4 had used the workbook to develop a series of associated links between the ideas that had been developed. However these did not appear to have any hierarchical relationship. Even though sufficient information had been accessed to develop an appropriate solution to the problem little prioritising of evidence was apparent. No comparing or contrasting of evidence to identify relationships between issues was noticed and, as a consequence, this participant appeared unable to clearly identify the actions that could be taken to reduce the problem.

*... problems we have are virtually ... definitely got the logging ... the willow trees ... foreign species ... other weeds ... also have to look at how we are going to fix them ... the people involved ... the residents ... the authorities ... the logging company ... seems as though everyone wants to fix the problem except the logging company at the present ... the ways to fix it ... I don't think we have really got to this ... haven't really found any ways to control it.*



### 4.2.3 Phase 3 - Research Question 2

The data was reviewed to address the research question:

*What possible strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?*

This phase of the analysis was directed towards an evaluation of how effective each of the assigned frameworks was in assisting the participants with their approaches to problem solving. The main focus of this phase was to determine whether the support framework was used and the apparent effectiveness of the framework to assist with the collection and analysis of evidence to support the problem. To determine the effectiveness of the individual strategies used by each of the participants the range of artefacts used in the data collection was examined for evidence that demonstrated use of the assigned support framework. The criterion used by the researcher in analysis of participants' use of their assigned framework were based on what the theoretical aspects of each framework suggested would assist learners in achieving more successful strategies in problem solving.

Using an interpretive case study approach (Erickson, 1986) the audio-tape transcripts of each participants' talk-aloud protocol were examined. As participants made decisions relating to solving the problem(s), the verbalisation of their cognitive processes and subsequent actions represented the construction of an individual problem-solving process. The researcher's interpretation of these theories and actions forms the basis of this stage of the analysis. Further confirmation of assigned strategy use was made from an examination of each participant's workbook.

An iterative approach was again used to interpret the profiles for each participant. For each of the assigned support frameworks an events matrix was developed and used to determine the extent of framework use for each participant. The criteria established for each of the frameworks were based on the

outlines presented to participants in each of the initial group tutorials at the beginning of the study. Table 4.10 illustrates this events matrix for each framework and includes the associated criteria used to establish each individual’s problem-solving strategy.

Framework	Events - Criteria and Examples
Critical Thinking	<div> <input type="checkbox"/> uses a number of identifiable learning skills <input type="checkbox"/> analyses and evaluates evidence <i>... I've grabbed the information that I thought was relevant. (CT5)</i> <input type="checkbox"/> makes inferences and evaluates them <i>... you have to wonder if these pits allow the chemical to be leached into the river anyway. (CT6)</i> <i>... the beetle is the choice favoured by government ... you have to question why ... is it cost related ... spraying ... there might be other problems associated with that. (CT6)</i> <input type="checkbox"/> uses the best evidence available <i>...identifying the strengths and weaknesses of each way in dealing with the problem ... (CT4)</i> <input type="checkbox"/> avoids inconsistency and contradiction </div>
Six Thinking Hats	<div> <input type="checkbox"/> gathers information - white hat <i>... putting my white hat on now because I'm gathering information ... (SH3)</i> <input type="checkbox"/> good points/strengths - yellow hat <i>... I'm highlighting sections that support the problem ... (SH4)</i> <input type="checkbox"/> weak points/weaknesses - black hat <i>... putting on my black hat because a weakness in this is ... there is no point in attacking the weeds if you don't attack the problem ... (SH4)</i> <input type="checkbox"/> feelings - red hat <i>... my gut feeling, using my red hat, is that it's a people problem ... (SH2)</i> <input type="checkbox"/> new ideas - green hat <i>... I think this is a green hat ... new ideas ... perhaps, maybe its coming from the tip but its not the tip's fault ... (SH6)</i> <input type="checkbox"/> metacognitive strategies - blue hat <i>...OK, now I think I'm switching to my blue hat because I'm thinking about what to do next ... I think I've gathered enough information ... and now I'm going to do some testing ... (SH3)</i> </div>
Venn Diagram	<div> <input type="checkbox"/> uses a number of items to compare <input type="checkbox"/> selects common characteristics <input type="checkbox"/> selects uncommon characteristics </div>
Concept Map	<div> <input type="checkbox"/> hierarchies - most general concepts to most specific <input type="checkbox"/> propositions - concept labels linked by words <input type="checkbox"/> crosslinks - connections between unrelated concepts <input type="checkbox"/> examples - specific events to illustrate concept </div>

Table 4.10      Criteria used in assessing use of support framework.

When each participant indicated completion of the task the researcher took the opportunity to question participants about aspects of their individual problem-solving process. Responses to these questions were also audio-recorded and later transcribed. Segments of these transcripts that relate to participant use of their assigned framework are included in each of the cases that follow.

4.2.3.1      **Critical Thinking Framework**

*Case 1 – Participant CT2*

Participant CT2's approach to the problem-solving process indicated a number of identifiable learning skills, including the ability to give a brief review of information that had been read, heard or observed. This participant made inferences throughout her problem-solving protocol when accessing the range of available media elements. However, little evidence of evaluation of these statements was observed during the development of reasoning to support her solution. During the analysis of the evidence collected to support her line of inquiry she appeared to distinguish between points in the media that were related to the specifics of the problem under consideration (through highlighting) and those points that were unrelated. In preparing a solution to the problem(s) she regularly referred to her extensive handwritten notes, making decisions regarding the best alternatives for solution(s) to the assigned problem(s).

From an observer's perspective the participant appeared to be using the critical thinking framework in her actions. However, her comments during an unstructured discussion at the completion of the problem-solving procedures indicate her personal approach to problem solving.

Question	Is this the way you normally go about solving problems? <i>...yes, I don't think I would do anything differently...just gone with what I'd do anyway, even though I've read the critical thinking ...I've just reverted back to what I would normally do anyway.</i>
Question	Did the strategy help you focus your ideas better or clarify the problem better for you? <i>Yes, I think that ...really the strategy just clarified how I should go about it and that's why I kept going back to sort of look at how I should start.</i>

## Case 2 – Participant CT4

Participant CT4 began each of the assigned problems through a ‘big picture’ approach aimed at providing a broad overview of the problem space.

*... I’m not really into gathering stuff at the moment ... I just like to look at everything first ... like pictures and television clips and stuff ... to find out what I’m really looking for, first ...*

With both problems investigated, this random exploration resulted in this participant failing to access some of the media reports. As a consequence her efforts focussed on a narrower range of possible causes. The strategy to obtain relevant information from the media reports was restricted to her initial access, reading the newspapers, listening to the radio and viewing the television reports. No reinforcement or checking was evident through revisiting the reports or highlighting text by accessing the reports via the linked media. Brief handwritten notes were generally used to record key points that demonstrated some analysis in determining the relevance of the information. Further indications of analysis and evaluation of evidence was provided through statements such as:

*... it says here ... several times that spraying is too expensive ... and this beetle ... I don’t know that I’d introduce a beetle without extensive testing ...*

Throughout the process, her analysis of the media reports indicated some evidence of ranking or prioritising of the possible sources of the problem.

*... there are a few problems and the most important of them is that camp seems to be the problem ...*

When outlining possible solutions to each of the problems her responses were based on generalisations without support from evidence.

Part of the dialogue associated with a series of unstructured questions follows.

Question	Do you normally go about solving problems of this nature in the way you have done?  <i>Well...I like having this here...you mean the critical thinking strategy? ... yeah, you could have a look at that and think ...oh, yeah, I’ll write down some possible problems and then think about the solutions whereas I’d probably sit and think “what questions do I need to ask?” and what I had to do...</i>
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Question	So you think that strategy has helped clarify the problem for you?  <i>Yeah so when you are looking at a program like this and there are different solutions. But no one (solution) that you should go for...I think it’s easier to follow something like this and just see where.... None of your ideas are wrong to write them down and see what you think...</i>
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Question

If you didn't have that strategy in front of you how would you go about this anyway?

*I think I'd be a bit lost because I'd be looking around, writing things down ...probably get stuck and probably not got to a solution ...I probably wouldn't try to get a solution myself whereas it says here to select one and try it...so, I guess I'd select...pick one like spraying and go back to that and say no that's too expensive and may not work ....it sort of encourages you to keep on going with it....*

A summary of each participant's protocol in applying her/his support framework to the two problems is presented in the following table.

Framework	Critical Thinking – Problem 1							Critical Thinking – Problem2						
Participants	1	2	3	4	5	6	7	1	2	3	4	5	6	7
EVIDENCE														
Uses a number of identifiable learning skills (6)	Y w	Y s	Y s	Y	Y s	Y	Y	Y s	Y s	Y s	Y s	Y	Y	Y
Analyses and evaluates evidence	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y w
Makes inferences and evaluates them	Y	Y	Y	Y	Y	Y			Y	Y	Y	Y w	Y	
Uses the best evidence available (crosschecking)		Y	Y		Y				Y	Y	Y	Y w		
Avoids inconsistency and contradiction	Y	Y	Y	Y	Y	Y			Y	Y	Y		Y	
Use of alternative strategy	Y						Y	Y						Y

w = weak indication
s = strong indication

Table 4.11     Use of Critical Thinking Framework

All participants in this group exhibited a degree of skills associated with critical thinking as an approach to problem solving. The apparent weakness that many participants in this group demonstrated was the inability to categorise information from within the media reports they had accessed. Little deductive thinking was evident from these participants, as they appeared unable to develop a logical conclusion from evidence that had been collected to support their argument.

### 4.2.3.2 Six Thinking Hats Framework

#### Case 3 – Participant SH5

This participant's approach to the process of problem solving could be described as methodical and purposeful. Each report accessed - newspaper, radio or television - was analysed via the written text by highlighting sections that were considered relevant to the problem.

*I'm clicking on linked media and I'm going to go through and have a look at information that supports the problem we want ... which is the yellow hat ... and take out information I don't want ... which is the black hat.*

After a period of data collection, switching among hats to analyse the media reports, she demonstrated the ability to categorise information into useful and less useful categories as she reflected on the data that had been collected:

*... putting on my blue hat ...so, I'll just classify the information I've got.*

Preparation of a final solution involved linking the related evidence to one of the main categories or key points the participant had identified from the original problem outline and assigned task. This evolved through a process of iteration and reflection on each piece of evidence noted in both the PDA and the workbook.

Question: Just thinking about the strategies that you use ... is this the normal strategy you would use?

*... well, not really...it would be, because last time when I thought about it , because I didn't use the hats at all really last time, out loud....but when we talked about it afterwards I realised that I do think that way but not really systematically ..it sort of happens all at once....*

Question: Does the six hat framework help you make things more systematic and help you clarify your ideas better?

*...yes it does definitely ...I found it easier to use this time, once I've actually...because I'm more practiced in it but .. it does, but it has taken me a while to get it in my brain...this is how we do it.*

Question: How would you usually do that?

*... usually I would basically get the same thing....get the problem.. clarify the problem... find exactly what I would need to find ....like what I need to look for... go get all the information and basically pick out the bits that support, or what I need to look for... so, its basically the same thing except I don't actually write anything down.*

### Case 4 - Participant SH3

This participant applied the support framework throughout the investigation of both problems. As she moved from information gathering to analysis and later reflection on the data that had been collected, she acknowledged each change in hat as the focus in her thinking processes also changed. When accessing media reports she would read the associated text and note key points in her workbook. In approaching the first problem her initial search pattern consisted of random exploration of the region where the problem is set. This was later followed by a systematic search of the media reports in the Water Research Centre to check that she had accessed all relevant material. With the second problem a search of the media reports was undertaken from within the Water Research Centre. The region where the problem is set was visited solely for the purpose of taking a series of measurements, algal count, pH, phosphorus and nitrogen, even though a degree of confusion was expressed:

*... testing water samples ... I'm not sure what I'm testing for so I'll test for everything and compare them...*

Even though this confusion was expressed, when analysing other information, she demonstrated an ability to use prior observations to show a relationship between information that had been previously accessed.

*... logging increases nutrients causing weed growth ... phosphorus and nitrogen present in higher than normal concentrations ... I think that's what my testing showed ... logging might need to be checked ...*

When finally evaluating the evidence that had been collected for the problem(s) she refers to her blue hat before proceeding to review her notes and relate these to the problem criteria:

*... OK, I think I've checked all the information and now I'm going to put my blue hat on to see what is needed ... some possible suggestions ... whose responsible ... I think they might need to check on the logging company ...*

The following is an extract from the verbal protocol of this participant's thoughts towards the use of the assigned framework.

Question	<p>In terms of your own strategy how would you normally go about solving this type of problem?</p> <p><i>...probably the same sort of way but I got distracted verbalising ....I found in vocalising...verbalising it and trying to put on these different hats I found it distracting...</i></p>
Question	<p>Do you think the six hat framework is of value for you in trying to clarify your ideas better?</p>



...personally, I don't ...but I think along these ways,...I'm very thorough... and when I do have a problem, I do gather all the information and think of all the good points and bad points and I like to see things on paper so for me to do anything on computer I still need to jot things down because I need to see the good points and bad points in front of me...so although I probably do most of these things anyway, when I've got a problem ...

Question

You're referring to the hat strategy?

The hat strategy, yes...I would gather the information...I would pull out the good points, the bad points , how I feel about them and come up with solutions, but I wouldn't sort of think 'ok I'm putting on my green hat, my blue hat or I'm thinking creatively now'...I wouldn't be...consciously aware of the different steps...I think I'd do it but not switching from one to the other... I think I automatically do this but don't think so much about doing it....do you know what I mean?

A summary of each participant's protocol in applying her/his assigned framework to the two problems is presented in the following table.

Framework	Six Thinking Hats - Problem 1								Six Thinking Hats - Problem2							
Participants	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
EVIDENCE																
Gathers information (white hat)	Y	Y (2)	Y (4)	Y (3)	Y (3)	Y	Y	Y	Y*	Y	Y (3)	Y	Y (3)	Y*	Y*	
Good points - strengths (yellow hat)	Y			Y (2)	Y (2)		Y	Y (2)	Y*	Y*	Y*	Y (2)	Y (3)	Y*	Y*	
Weak points (black hat)			Y	Y			Y	Y		Y*	Y		Y (3)			
Feelings (red hat)		Y (2)				Y		Y		Y	Y					
New Ideas (green hat)		Y (2)		Y*	Y*	Y	Y*	Y*	Y*	Y	Y (2)	Y*	Y	Y*	Y*	
Metacognitive strategies (blue hat)	Y*	Y	Y	Y	Y (2)	Y	Y	Y	Y*	Y	Y (2)	Y*	Y*	Y*	Y*	

• = not verbalised, but apparent from other data

Numbers indicate frequencies of referral to hat colour - indicates change in cognitive strategy

= no data (participant withdrew)

Table 4.12     Use of Six Thinking Hats Framework

All participants in this category demonstrated the use of the framework throughout their individual problem-solving approaches. The purpose behind the six hats strategy is to encourage use of all six hats to switch among the different modes of thinking. It is apparent from the table that not all participants used the framework fully, although all participants demonstrated at least three changes in their thinking strategies as they pursued their individual problem-



solving strategies. Two areas that many participants did not address were those dealing with personal feelings about the evidence related to the problem and analysing the evidence for weaknesses, such as personal bias or conflict of interest, in the media reports.

### 4.2.3.2 Venn Diagram Framework

#### *Case 5 – Participant VD7*

This participant used a similar strategy to solve each of the assigned problems. Gathering of information to support possible solutions was undertaken through random exploration of the region in which the problem was set. Each of the media reports were accessed through the written text and analysed while reading. Key ideas that were considered important were highlighted and paraphrased. Some points were noted in either the participant's workbook or the PDA. Throughout the process this participant would refer back to the problem outline and task, apparently to refocus on the essential aspects of the investigation.

Preparation of a solution for the first problem did not involve the use of a venn diagram. Instead, this participant began by revisiting the notes that had been assembled and then typing a summary of ideas into the PDA. The ideas generated were limited to acid contamination and chemical pollution associated with local industries. Developing a solution for the second problem involved the use of the venn diagram framework. In the initial stages of information gathering this participant prepared a series of circles and noted key points from media reports within them

*... the contributor ... is the wastewater ... try using the venn diagram ... problem ... getting rampant weed growth ... and some of the contributors ...*

As more information was accessed she further developed the venn diagram.

*... in that interview there was a common contributor ... it was the stiller parts ... have more weed ... further up the river it was less muddier and there was less weed ... for one part of the venn diagram we could use observations ...*

This process was continued throughout the information-gathering process, using the circle headings of 'observations', 'contributors', and 'action to be taken'. The focus of the characteristics in each of the circles was on the weed growth, however no relationship was developed between this and the logging company.

Sections of the audio-tape recordings relating to participant-use follows.

- Question

I noticed you tried to use the venn diagrams. Do you think that has helped you try to clarifying your ideas better?  
*...yes, it did... it sort of gave me different sections to follow instead of looking at the whole problem ...it helped break it down into little bits ...*
- Question

If you hadn't used the venn diagram, how would you normally go about trying to find a solution to this type of problem?  
*....I probably would have looked at the whole thing and not try to look for a cause ...like what was actually happening...but I wouldn't have tried to look for a cause....just go straight through it ...*
- Question

So overall, you think the venn strategy has helped in clarifying your ideas better?  
*...yes ...*

**Case 6 - Participant VD4**

In researching the assigned problems this participant used a minimum number of media reports to develop an awareness of the problem and the issues surrounding it. Analysis of each article was through the written text. The procedure used for both problems was to read the text, highlighting what were considered to be key points, collecting highlighted sections in the PDA, and occasionally paraphrasing the main ideas. With problem one no attempt was made to use a Venn diagram strategy, the focus of her investigation being based on three headings (why? main cause? actions?) listed in the workbook and a listing of points under the appropriate heading. Throughout the process some analytical reasoning skills were apparent from the verbal protocol. When checking for supporting evidence in the filing cabinet she remarked;

*... farmers use phosphorus ... I'll need to recheck that ...*

and when reading a newspaper report dealing with acid burns;

*... that information goes with the news report from before ... more support for possible causes ... look at all my information to see what links I can find ...*

When assessing the data to develop a solution she expressed confusion with what some of the data meant and uncertainty in what to do next to finalise her answer.

*... I've got some ideas in my PDA ... mainly about the industries ...I'm not sure what to do ...I probably should have used the circles to help ... it's not a strategy I'm familiar with.*

With problem two an initial attempt was made to develop a strategy based on the Venn approach. Three circles were drawn in the workbook, each assigned a

heading relating to the problem, 'why', 'cause', and 'action'. These headings were extended in the workbook to 'why it grew in the first place', 'main causes', and 'suggest actions'. As the participant worked through her strategy to resolve the problem her ideas associated with each of these key points were noted in a list in the workbook under the extended headings. No notes were made in the Venn diagram.

The following is an extract from the verbal protocol of this participant's thoughts towards the use of the assigned framework.

Question	Would you normally go about solving problems of this nature in this way? <i>Yes, although I probably don't always do this, which I think is a good idea...</i>
Question	You mean using Venn diagrams or writing things down? <i>...like categorising things,,, I don't always do that, I think I rush into things...</i>
Question	So, is that why you don't try to go back to the question, because you have to go back...you would rather see it on paper in front of you? <i>...I just think that when I write it down I'm thinking about it and I'm going over it again and I'll tend to go back to a bit of paper...I think this (indicates strategy) is a good idea doing it that way but I don't always do that...I just rush in...(laughs)</i>
Question	You didn't use the Venn strategy as such, do you think they could help you or you don't think it helps you at all? <i>...I think it could because I could have used the circles and have weed problems or causes in one bit and suggested actions in another bit ...and I probably would have found all the things would have come to the same conclusions...I know how it works but I probably wouldn't use them...</i>

A summary of each participant's protocol in applying her/his assigned support framework to the two problems is presented in the following table.

Framework	Venn Diagram - Problem 1								Venn Diagram - Problem2							
Participants	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
EVIDENCE																
Uses a number of items to compare		Y	Y			Y		Y <sub>w</sub>	Y*			Y	Y	Y*	Y	Y*
Selects common features (intersection)		Y	Y					Y							Y	
Selects features not common (non intersection)		Y	Y					Y				Y	Y	Y	Y	
Use of alternative strategy	Y			Y	Y	Y	Y	Y	Y							Y

• = not using circles but inferred from other data
= no data (participant withdrew)

Table 4.13     Use of Venn diagram Framework

As is evident from the above table, few participants used this approach in either their planning or their development of a solution in each of the problems attempted. For the first problem, participants VD2 and VD3 made use of the strategy but were unable to continue in the study. Participant VD2 used two circles ('cause' and 'solutions') in an attempt to use the strategy but they lacked substance and showed little overlap in the intersection. Evidence was collated outside the circles in point form. Participant VD3 used three circles, 'cause', 'outcomes', and 'solution' to record the key ideas associated with each. However, no attempt was made to develop common features in the intersection of the circles. The remainder of this group worked through the problem using an alternative strategy based on their personal preference. In each case the supporting evidence was collated in a series of points under specific headings that reflected the key ideas of the task. Participant VD1 used a strategy involving listing key points under specific headings in the workbook for both problems.

In attempting the second problem participants VD4, VD5, VD6 andVD7 made some attempts to develop their overall plan based on concentric circles to represent some clarification of the problem, its causes, and possible solution. However there was a noticeable variation in the degree of success achieved by these participants with this approach. Participants VD5 and VD6 used two circles in developing a solution and listed a variety of points in each. In addition, both

used an alternative strategy incorporating a series of points under headings based on the task outline. Two participants, VD4 and VD7, were more successful. Each used three circles with appropriate headings and recorded a series of points analysed from evidence inside the circles. As with the other participants, little analysis of the information within the circles was apparent and neither participant demonstrated the ability to group similar or dissimilar characteristics of the data they had collected. However, both participants demonstrated this linking between evidence in the list of support information they had also collected.

#### 4.2.3.3 Concept Map Framework

##### *Case 7 – Participant CM4*

This participant began each of the problem-solving tasks by reading aloud through the associated text, paraphrasing her interpretation of the key points of the task, and noting these in the workbook. Her investigation began with a random, but thorough, exploration of the region in which the problem was set. All of the media elements accessed were reviewed in their original presentation, newspapers were read, radio reports were listened to, and television reports were viewed. Many of these articles were rechecked within the Water Research Centre for reinforcement:

*... I think I've heard that already but I thought that was quite good information so I didn't mind listening again to make it sink in ...*

Key points from these articles were often paraphrased and noted in the workbook under headings that represented a flow of ideas or concepts relating to the problem under investigation. Although not clearly in a form normally represented by a concept map, the manner in which the ideas were assembled illustrated a hierarchical flow of ideas from general concepts to more specific ideas. Some evidence of cross-linking of ideas was also apparent. When preparing the final solution to each problem this participant began developing a structure resembling a concept map to help focus her ideas on ways to address the specifics of the task. However, little effort was made to elaborate or expand these ideas in detail.

This participant's comments during an unstructured discussion at the completion of the problem solving procedures indicate her personal approach to problem solving.

- Question                      I see you've used a strategy that resembles a flow of ideas, like a flow-chart. Do you think the concept mapping strategy helps you in clarifying your ideas or organise your own thoughts?  
*Definitely...I can't say I've really used it before I started at Uni, but I usually write whatever is in my head and it goes straight onto paper, like an essay type thing...what I've started doing is just pinpointing major issues...it has helped...try to pick the main ideas and decide which is the most important...*
- Question                      How would you normally go about solving problems like this?  
*Probably go through and read everything once ...and probably not write anything down ...or write down the main bits...then go through the second time and add a bit to that...you have a bit of a background knowledge then...*
- Question                      Did you normally go about writing down ideas on paper?  
*I have started...I never used to ...now that I've started my marks have improved...actually it gives you an avenue to look...*

### ***Case 8 - Participant CM3***

The first problem was approached in a methodical fashion with the participant developing an initial overview of the problem. Several media reports were accessed, analysed, and sections of the text were highlighted and recorded in the PDA.

*... I'm grabbing information and then I'll decide what I'm going to do with it later.*

She then proceeded back into an earlier time zone to take measurements of the river.

*... I'm going back to the area previously before the industry is there so I can get some idea of what it was like previously ... and the water quality ...*

On returning to the region where the problem is set she continued to check media reports, highlighting sections that were relevant to her problem solving. During this information-gathering phase she made regular referrals to the task, and to the guide, for additional assistance. Returning to the Water Research Centre, she chose articles from the filing cabinet that were directly related to the media reports that had been previously accessed, commenting:

*... I'm just trying to get some information on things they can do to rectify the problem ...*

After a period of reading and analysing, including highlighting and recording sections to the PDA, she referred to her notes in the PDA and outlined her plan of action for developing a solution.

*... now, to put the report together as a possible solution ... apart from reading through the notes and taking out the information I thought would be relevant in correct order would be the way to do it ... it's a very long process, I don't concept map ... but this is the way that I do most of my work ... and I know probably that it's time consuming ... more than time consuming because there's information that I have to go over that may not be relevant ...*

With the second problem a similar strategy was used in analysing the media reports. In this instance only a limited number of reports were accessed, coincidentally being the ones that had a direct bearing on the problem solution. Measurements were taken of phosphorus, nitrogen and coliform bacteria above, below and level with the camp to confirm the ideas that had been drawn from the media reports. The participant then began preparing a solution based on the data collected in the PDA. An outline resembling a flow chart was attempted in the workbook, with the main heading 'water plants and weeds' linked to sub-headings 'human habitation' and 'logging'. Referring to her notes she outlined what direction her solution plan is taking:

*... what I was planning to do was figure out if it was due to human habitation ... and the reasons for it ... which is the sewage ... and the introduction of other weeds from different countries ... and then the efforts they use to get rid of it ...*

Question	Do you think there is a main cause? <i>... the main cause would be the logging camp.</i>
Question	What are they doing to contribute to the problem? <i>Their sewage flows directly into the river, and they don't plan on doing anything to fix it.</i>
Question	I notice you didn't specifically use a concept map framework. Any reason for that? <i>This time I just used ...just looking at the picture and prior knowledge that that would be the reason for it.</i>
Question	How do you normally go about solving this type of problem? <i>I'd just read and waste time.</i>
Question	So you gather information? <i>I gather information... and go through it to see if it is relevant to the actual problem...I tend to now go to the index and look ...that's generally how I do it.</i>

Question

Does the ideas of concept mapping help you clarify the problem?

*It does help me if I sit down and think about it...but I'm set in my ways ...if I sat down and thought about this first (indicates the concept map strategy) I would probably look at more issues.*

A summary of each participant's protocol in applying her/his assigned framework to the two problems is presented in the following table.

Framework	Concept Map - Problem 1						Concept Map - Problem2					
Participants	1	2	3	4	5	6	1	2	3	4	5	6
EVIDENCE												
Propositions – concept labels linked by words	Y w									Y		
Hierarchies – most general concept to more specific				Y	Y	Y w	Y w		Y w	Y		
Crosslinks – connections between unrelated concept				Y w						Y		
Examples – specific events to illustrate concept	Y w			Y w	Y		Y w			Y		
Use of alternative strategy	Y	Y	Y			Y	Y		Y			

w = weak use of strategy - inferred from other data

 = no data (participant withdrew)

Table 4.14     Use of Concept Map Framework

Participants approached the use of this framework with varying degrees of success. Some participants identified key concepts from the problem context and task outline and recorded these as headings in their workbook. As evidence was located and analysed key points were added to their ‘map’ of the problem space but for most no hierarchical order was established. Instead the key points were added in a chronological listing reflecting the order of access from their individual search patterns. Most ‘maps’ illustrated a flow of ideas, sometimes linked with arrows, that represented an individual collection of ideas associated with a personal approach to solving the problem.



## 4.3 Summary

This chapter examined the problem-solving strategies employed by a sample of pre-service education students. Two inquiry-based problems of an ill-structured variety were used in the study and presented in a virtual setting through the CD-ROM, *Exploring the Nardoo*. Such technology-supported learning environments provide a useful means of engaging learners in scientific inquiry allowing opportunities for learners to engage in problem solving experiences that are difficult to create in classroom situations. Participants were provided with, and instructed in, the use of one of four support frameworks to assist them in their investigation of the problem(s).

The data analysis for this chapter focussed on addressing the sub-questions:

*What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?*

*What possible strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?*

From the data collected, it was apparent that participants experienced little difficulty in using the general features of *Exploring the Nardoo* and, more specifically, accessing the information within the CD-ROM. Analysis of the 'action steps' taken by individual participants demonstrated that the navigation was understood and that their apparent understanding of the information structure was supported by the audio-tape recordings and the researcher's observational notes.

Participants used a variety of strategies in their approach to problem solving. Some participants were able to articulate the problem space and identify different opinions and perspectives on the problem. Others appeared to have few clear goals or objectives in their strategies. In general terms, it appeared that those participants with limited subject knowledge engaged in more primitive

search strategies. When attempting to develop a possible solution(s), and assess the viability of the evidence to support their argument, a majority of participants failed to focus their solution on the precise aspects of the problem. For these participants it appeared as though they had not clearly identified the purpose of the investigation from the initial reading of the problem.

In the use of the designated support framework there were substantial differences in the approaches taken by participants. The frameworks were provided, to assist participants, as thinking tools that could be used to help them judge and assess the credibility of potentially conflicting information and to develop strategies to resolve these conflicts, to clarify issues, to think strategically and critically, and to make judgements and decisions. Based on the data collected the following generalisations are made:

- ❑ both the Six Hats and the Critical Thinking frameworks provided stimulus for participants to seek out information;
- ❑ the Venn Diagram and Concept Mapping frameworks focussed more on the organization of ideas once they had been identified.

In either case participants, when instructed in one framework for use in problem solving, did so with greater diligence for the first two frameworks than the others.

The outcomes and implications arising from this data analysis will be discussed more fully in the following chapter.

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# Chapter 5

## Findings & Conclusion

# Chapter Five

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By its very nature, problem solving is a learner-centred, discovery-based strategy that challenges learners to become active participants in a reasoning process that facilitates learning. Central to this process is the development of skills, which enable the learner to identify problems, form hypotheses, search for and collate information, take measurements and observations, interpret and analyse data, and propose solutions. The learning environment used for this study, *Exploring the Nardoo*, incorporates problems that challenge learners to become active participants in the learning process.

This chapter is organised into a discussion section and a conclusion. The discussion section relates the findings from the study, the literature review and the research methods employed. The chapter concludes by outlining issues that need further investigation and makes suggestions for future research directions that provide for the development and use of cognitive tools for supporting learners in developing problem solving strategies.

## 5.1 Introduction

This study endeavoured to introduce a mechanism for enhancing learners' individual processes of problem solving through the use of a support strategy or framework in the learning process. The research was undertaken to gain further understanding of the scientific thinking skills of novice learners engaged in solving problems of an ill-structured nature. Its focus was on the general reasoning and problem-solving strategies that are involved in the discovery and modification of ideas associated with a given task and any causal relationship that exists between them.

The following discussion is centered on two major issues that relate to the research questions. These issues are; the cognitive strategies used by learners when problem solving, and the impact of an introduced strategy upon the learner's individual approaches to problem solving. The method used to address these issues was a qualitative one that relied upon an interpretation of verbal data, observational notes and handwritten artefacts in building a 'thick' description (Patton, 1990) of events that transpired.

Effective reasoning requires the ability to develop arguments and assess their validity, to judge the plausibility of unsupported statements, to identify courses of action and to reflect on the consequences in choosing a particular approach (Nickerson, 1986). In the present study, learners who presented viable solutions to posed problems utilised strategies that demonstrated better integration of the information from the embedded media reports. The quality of the solutions indicated that these participants had formed a better mental representation of the problem and had developed solutions that demonstrated a more conceptual and causal understanding of the problem space. This supports previous studies (Voss & Wiley, 1997; Keys, 1995) where learners who engaged in reasoning and argumentation strategies produced better quality responses to their assigned writing tasks. The use of these higher-order thinking strategies had produced better recognition of inferences and a more thorough understanding of the underlying principles and relationships between the task and the subject matter. However, in this study, a number of participants demonstrated strategies that indicated a lack of clear understanding of the requirements of the task. This was reflected in the final

outcome where, on completion of an information-gathering process undertaken in support of the problem, little reasoning or reflection had occurred resulting in superficial or simplistic solutions to the problem.

## 5.2 Cognitive Strategies used by Learners

A number of studies into the differences in strategies between novice learners and expert practitioners while problem solving have been presented (Ross & Loftin, 1994; Comacho & Good, 1989; Smith & Good, 1984). A common feature of these studies has been the use of well-structured problems to achieve their findings. This study sought to determine the strategies employed by novice learners using problems of an ill-structured nature that require the learner to engage higher-order thinking skills to achieve a successful outcome. This research was undertaken to address the question:

*What cognitive strategies do learners use, in problem clarification and problem resolution, when attempting ill-structured problems within a technology-supported learning environment?*

When presented with a problem, learners need to clarify the initial problem and construct some internal representation of the problem space (Appleton, 1995). This assertion is based on the cognitive view that all understandings are organised as mental schemata (Piaget, 1978) that may undergo change through integration of further experiences. In this study the variation in the quality of the final solutions may be due to some participants forming different initial representations of the problem. This may be a reflection of prior subject matter knowledge, personal experience or a combination of both. The quality, completeness, and coherence of this initial representation will influence the efficiency of the resulting course of action taken in the overall problem-solving strategy (Chi et al, 1981).

A number of the participants in this study exhibited characteristics of novice learners. They tended to work at a surface level without examining the task in depth and they tended to work until they considered the task was

completed without reflecting on what quality of evidence had been collected or without revising the information or thinking about what was required. Little evidence of questioning, self-reflection or metacognition was evident. As novice learners they may have developed a single strategy from their previous background and attempted to apply this to all situations. Jonassen and Grabowski (1993) suggest that individual cognitive strategies are developed and maintained over time, often as a result of trial-and-error approaches. Research by Tweney (1987) has shown that the manner in which learners obtain new information is limited by their current mental representation of the task and the learning goals that have been set. Once a pattern has been established these strategies do not change significantly and are often maintained across a range of tasks. For some of the participants in this study this appeared to be the case. When participants were asked if this was the normal way they went about solving problems the following replies are indicative of established strategies:

*... yes, I think ... yes I don't think I would do anything differently ... just gone with what I'd do anyway, even though I've read "Critical Thinking" I've just reverted back to what I would normally do anyway... (CT2 - problem 2)*

*... apart from reading through the notes and taking out the information I thought would be relevant in correct order would be the way I'd do it ... it's a very long process ... I don't concept map ... but this is the way I do most of my work ... (CM3 - problem 1)*

*... so, one of the things I do when I'm planning... would be to do a flow diagram, so I'd have my problem ... being chemical pollution ... and I'd separate it, when I started finding things out, into different areas ... and make a plan out of 4 or 5 different headings with the different points under each one and from that plan you can look at it and ... if I don't have enough information on it you can go back and find more ... (VD1 - problem 1)*

Other participants exhibited a strategy where their attention to the problem was focussed and narrow. This focus appeared to be directed towards an outcome based on initial perception of the problem. These participants

appeared to have little structure in their strategies and less developed monitoring skills. Their strategy appeared to revolve around a predetermined goal as they proceeded to gather data and move on a fixed path towards a solution. Nickerson (1986) suggests that some learners exhibit biased information-gathering strategies in building a case for some conclusion or decision that has already been made. For some of the observed strategies of participants in this study this appeared to be the case.

*... first I'm going to test the water to see how chemically polluted it is ... I'm trying to find an industry that would pollute the water (CM8)*

*... my idea is better management of the tip (VD4)*

*... after looking at this first article I found out it's probably acid (VD7)*

Once they had formed an initial representation of the problem they proceeded to focus their strategies towards this outcome. These participants did not demonstrate an ability to evaluate evidence that either supported or was contradictory to data regarding the relevant features of the problem. Other participants were more focussed in their approach and provided solutions based on richer and more detailed strategies that included closer monitoring of the data with respect to the issues under investigation and an ability to draw a logical conclusion from related data that supported the argument.

*.... I'm looking at all the articles here ... now I'm looking at the one which says industry suspected of dumping acid ... remains a mystery but they're thinking it's the nearby industrial estate ... So contractors are illegally dumping maybe at the tip or into the sewerage system ... just writing a list of the businesses to get an idea of what could be the possible cause ... especially if it was acid-related ... just looking at that list I might put a tick against the ones that might have acid involved in their processes... where they would need to dump large amounts of acid... (CT2 - problem 1)*



*... well, I think that the logging area has a big impact on it because if we have a look at the test (measurement) above the logging area in the river the algal cell count is only 120 and after the logging area, just below the camp, the algal cell count is 450 ... that's a big jump, and even further down its 500 ... so that would seem a key reason for the growth of the weeds ... (SH5 - problem 2)*

These two examples indicate that the participants were able to define and describe the problem, to identify an ideal outcome, and to select and test possible strategies and solutions, while refining and evaluating their approaches when required.

Most participants arrived at a solution to each of the problems investigated. For a number of these participants the solution proposed was generalised and did not specifically focus on the actual cause(s) of the problem. This demonstrated that each participant had been able to assimilate the related information that supported his or her individual internal cognitive structures. The non-linear environment of *Exploring the Nardoo* was designed to allow participants the opportunity to manipulate the learning path to suit their own requirements and to construct solutions to the challenges that are presented. Participants demonstrated different avenues of exploration of the problem space in forming a mental representation of the task and, in so doing, they adapted their access to supporting evidence to suit their own cognitive style. When exploring this multi-modal presentation of information many participants demonstrated either a visual preference for text-based resources or an auditory preference. Some participants used a combination of both strategies and these participants tended to produce more detailed analysis of the data that generated stronger causal relationships when proposing possible solutions.

Studies into informal reasoning (Means & Voss, 1996) indicate successful problem solvers need to have background knowledge of the problem, good search strategies, and the ability to use and apply the information accessed to their individual mental representation of the task. Analysis of data in this study supports this view with several participants, for example CT3, SH5, CM3, VD1, providing more qualified responses with solutions that demonstrated an ability to distinguish between information that was relevant to the problem under consideration and information that was irrelevant. This was further exemplified

by an ability to identify relationships between familiar media items, by comparing and contrasting techniques in identifying related evidence and discrepancies across a number of media elements, by making inferences, and the ability to identify the reasons for a solution to the problem under investigation.

Another influence on the way information is processed and used at a later stage in the reasoning process may depend on the degree of processing in working memory. The ability of some learners to utilise working memory more effectively than others may be related to the information-processing ability of the learner or the transfer of prior knowledge from long-term memory (Means & Voss, p164). Learners are unique and by their very nature have a range of abilities. As an individual each learner must perceive, respond, process, store and retrieve his or her own information using his or her own distinctive strategies. Those learners with higher ability have a capacity to interrelate more elements in working memory than those with lower ability (Means & Voss, 1996). In research reported by Kuhn (1991) learners with average or lower ability retrieve information with little or no application of reasoning skills. It was apparent in this study that a range of abilities did exist among the participants and differences in the ways in which participants perceived, encoded, stored and retrieved information. No measures of cognitive style were made in this study. However, other research (Goodenough, 1976; Tyler, 1993) into one measure of cognitive style, field dependence/field independence, provides an indicator into a possible source of the performance differences among learners when engaged in information-processing tasks. Field dependent learners have a tendency to be passive in their approaches to a task and to use a narrow range of ideas, focussing on those ideas that are considered more important. Field independent learners are more participative, using trial-and-error methods in exploring the problem space to achieve their goals. The cognitive style individual participants brought to this study may be fundamental to their information processing habits. These habits affect the way in which individuals perceive, think and problem-solve and continue to do so in a way that is stable over time (Messick, 1984). This may be one reason why a number of participants in this study did not use their support framework, preferring to rely on their previously developed individual strategies for problem solving. However, there is more to individual learning strategies than cognitive style. Additional factors associated with the study such as familiarity with the surroundings and the computer system, time pressures,

motivation and anxiety, may mediate or interact with individual strategies and affect overall performance in successfully concluding the task.

Acquiring information or developing meaning from text is a constructive process consisting of an interaction between the specific contents of the text and the characteristics of the learner (Voss & Silfies, 1996). The more developed a text is with respect to its topic, the less the learner needs to draw on his or her own knowledge in developing an appropriate representation. In the problems used in this study the nature of the text often reflects personal opinion, not necessarily based on fact. Its assessment is open to a variety of interpretations or biases that impinge on the final evaluation of the text as evidence to support a particular point of view. When the information in the text is not sufficiently analysed for its relevance to the problem, there is a greater need for participants to use their knowledge in order to make inferences that will provide for a more complete mental representation. If the learner has limited or poorly developed knowledge structures then there is the potential for inadequate inferences to be made and the need for additional guidance, through the use of a support mechanism. This is illustrated in the following extract from Problem 1:

*... I'm sinking here ... seeing I have no science background here this is really*

and later

*... I don't know ... totally lost ... OK, now what I'm going to do is go back because they (guides in Water Research Centre) said if you need help go back here ... I fell into the trap of finding some information but then I'm lost with the information I've got so I decided to go back ... and ask for help and he (Peter) suggested going through the media reports (SH3).*

If we acknowledge that learners bring to the task different approaches based on their individual cognitive style then it should be anticipated that a variety of responses would be produced. Such individual cognitive styles reflect the ways in which learners react to the task and the information that supports it (Jonassen & Grabowski, 1993). In this study it appears that such individual differences contributed to the particular problem-solving strategies used. The manner in which participants interacted with the problem space, how they extracted and

perceived information from it and the manner in which they organised and reflected on this information to support their final outcome is indicative of these differences. The argument is advanced that if designers of technology-supported learning environments are to develop products that support current western educational goals then consideration needs to be given to the development of varied support structures to meet the different needs of the variety of learners engaged in problem-solving tasks. Such structures would help focus and guide novice learners in achieving solutions that more clearly compare with the solutions of experts.

### 5.3 Impact of Support Framework upon Learners

This study introduced four frameworks into the problem-solving process in an attempt to support the participants as they investigated the problems assigned to them. Research into the effectiveness of each framework was undertaken to address the question:

*What strategies support problem clarification and assist learners in accessing and making effective use of information when completing a specific task?*

A 'Critical Thinking' framework was introduced to one group of participants in this study to assess its effect on their higher-order thinking skills. Such thinking takes place in the upper levels of the hierarchy of cognitive processing (Bloom, 1956) and is usually indicated by evidence of processes involving application, analysis, synthesis and evaluation. In this study, the main indicators supporting the concept of critical thinking centre on developing reasons to justify a particular point of view, to offer, analyse and evaluate the significance of evidence to support a claim, and to interpret and apply the evidence to the situation under investigation. With the exception of one candidate all participants in this group demonstrated some of the skills in the processes of this framework. Their search strategies were effective and these participants portrayed an ability to analyse and evaluate evidence and to generate inferences on the basis of access to media reports with related evidence to support a solution to the problem. However, even though these participants

demonstrated the ability to develop clear goals and apply themselves to the task, and to collect, analyse and synthesise evidence, a number of them appeared to lack the ability to reason effectively in developing a solution. An example of this is indicated in the following discussion:

Question: Do you normally go about solving problems of this nature in the way you have done?

CT4: *Well. I like having this here ... (indicates framework) ... you could have a look at that and think ... yeah, I'll write down some possible problems and then think about the solutions ... whereas, I'd probably sit and think "what questions do I need to ask?" and "what do I have to do?"*

Question: If you didn't have that framework in front of you how would you go about this anyway?

CT4: *I think I'd be a bit lost because I'd be looking around, writing things down ... probably get stuck and not get to a solution ... probably wouldn't try to get a solution myself, whereas it says here to select one and try it ... so, I guess I'd select ... pick one like spraying and go back to that and say ... that's too expensive and may not work ... it sort of encourages you to keep going with it.*

Application of the 'Six Thinking Hats' framework (De Bono, 1985) has been practised extensively in education and the wider community as a cognitive strategy to support lateral and creative thinking. The framework functions as an instructional method at a metaphorical level through the switching of hats as a practical method of engaging different aspects of thinking when investigating a problem. In both problems used in this study analysis of the verbal reports demonstrated that participants did use the Six Hats framework to assist them in changing the cognitive focus of their problem-solving strategies. As was anticipated, there was a variation in the manner in which individuals applied the framework. This was due to the variation in individual strategies used by these participants when investigating the problem space. The quality of the problem-solving strategies and the possible solutions suggested to each of the problems

indicated that this framework did provide support to many of these participants in the problem-solving process.

The 'Venn Diagram' framework (Gunstone & White, 1986) was the least successful of the four frameworks introduced in this study. In the investigation of Problem one it became obvious that the participants in this group were relying on established individual strategies in their pursuit of a possible solution. Only two participants made an attempt to use the Venn diagram approach in the analysis of the evidence that had been collected in relation to the first problem. While the attempted use of this framework did increase for the second problem (four participants) it was apparent that all participants were not comfortable in using this approach. This may have been due to one or more of several factors; insufficient preparatory training of participants in the use of this framework; the strategy did not suit the particular learning approaches used by these participants; excessive cognitive load being placed on participants during the process; or inadequate support from this approach for the problem solving in this context.

Visual organisers, such as concept maps, have been found to improve learner comprehension and promote higher-order thinking skills (Clarke, 1992; Ferry, 1996). Some researchers however, have noted that some learners respond negatively to concept-map instruction (Novak & Gowin, 1984) while other research (Bousquet, 1982) indicates that the degree of construction and benefits of concept mapping varied between different types of learners. Concept maps provide a mechanism for learners to compare and analyse their own thinking. Ferry (1997) has shown that concept maps can also represent the depth and complexity of understanding of related concepts. When learners construct a concept map they are required to identify important concepts in the content domain, spatially arrange them, link them and attach explanatory notes. The order in which these processes occur varies according to learner characteristics.

While some researchers have indicated successful use of concept mapping after short periods of instruction (Novak et al, 1983; Wallace & Mintzes, 1990) this was not supported in the current study. It was apparent that a basic understanding of the procedure involved did not provide the learners with sufficient confidence

and skills to produce concept maps that contained powerful, integrated networks to support their problem-solving strategies. The maps produced here were generally poorly constructed, lacked clear conceptual development and did not appear to assist participants in making effective use of the information they had collected. While the majority of participants were able to research information relating to the problem and engage in further analysis and synthesis of the information, there was a demonstrated lack of effective reasoning ability by most participants. Suggested solutions were often based on generalisations that indicated an inability to identify information that was needed to evaluate the strength of an argument. Such solutions often demonstrated a lack of deductive reasoning and a failure to identify relationships between two or more similar pieces of evidence related to aspects of the problem.

Research into cognitive load theory (Sweller, 1988; Sweller & Chandler, 1994) suggests that when processing information within problem-solving situations learners may engage strategies that are more familiar to them. This is based on the notion that our limited working memories make it difficult to assimilate multiple elements of information simultaneously. Because of the complexity of the task some problem-solving activities leave learners lost or confused causing them to resort to more familiar strategies in an effort to reduce the cognitive load placed upon them by the task and in the operation of the instructional system. The additional cognitive processing involved with the verbalisation of the process and the application of the assigned strategy may also have added to the cognitive load experienced by some participants here. This may explain why participants in this study did not use the framework allocated to them during their investigations. It was apparent during the progress of participants through their problem investigation that many participants were resorting to memory recall and processing of information that related to the task. This contention was supported by the limited use of written notes in their workbooks and little, if any, supporting information recorded in the PDA.

An indication of additional cognitive load being placed on some participants is indicated in the following discussion between the researcher and one of the participants from the Six Hats framework group.

- Question: How would you normally go about solving this type of problem?
- SH3: *Probably the same way, but I got distracted verbalising it and I was probably more aware of this thing... (indicates framework) ... how I was doing it, than doing it ... so, if none of this was involved I think I would ... it wouldn't have taken me so much time ... I found in putting on these different hats distracting.*
- Question: Do you think the hat strategy is of value for you in trying to clarify your ideas better?
- SH3: *Personally, I don't ... but I think along these ways ... I'm very thorough ... and when I have a problem, I do gather all the information and think of all the good points and bad points and I like to see things on paper, so for me to do anything on computer I still need to jot things down because I need to see the good points and bad points in front of me ... so, I probably do most of these things anyway ... but, I wouldn't sort of think, "O.K, I'm putting on my green hat, my blue hat, or I'm thinking creatively now ...".*

## 5.4 Use of Guides

While the participants in this study used a variety of strategies independent of their prior subject knowledge, those with limited domain knowledge appeared to engage in more primitive search strategies. These findings support the conclusions of several researchers that learners with extensive prior knowledge outperform their cohorts with limited prior knowledge (Hill & Hannafin, 1996; Jonassen, 1997; Means & Voss, 1991; De Corte, 1990). During their search strategies the majority of participants attempted to gain support from the use of the guides. While the guides were used to provide some direction for their information-gathering strategies it appeared that additional assistance was required.

*The fellow (Peter) just suggested to look at the media reports so that's what I'll do ... if I can't find more information I'll come back and ask him for some more help (SH4 - problem 1)*



What support was actually being sought is unclear, however what was apparent from the verbal transcripts is that the information provided by the guides was not always of assistance at that specific time of data collection.

*I'm just trying to think where else I can look for stuff ... go back to the guy (Peter) and see what else he has to say ... (checks guide) ... he suggested I go to the media reports but I've been to all of them ...(checks guide again) ... he's no help (CT4 - problem 1).*

also

*I'll check the guide ... (checks guide) ... already done that ...hmmm, I've got no idea what I'm looking for ... going back to the resource centre ... (checks guide) ... I've looked under farming ... (checks guide) ... I think that's about all I can do (CM6 - problem 1).*

The hints were intended as a directional cue to indicate sources of information and provide an indicator to the focus for the inquiry. While this appeared to be effective in directing participants towards information sources it was apparent that a number of participants were not completely satisfied with the assistance provided by the guide(s). This appeared to take place when they were unsure of what direction or course of action they should now take and may have occurred because they were looking for assistance with their problem solving and learning strategies while working in an unfamiliar and complex environment. There appears to be a need within such environments for a clearer and more informative support mechanism that provides guidance in the development of higher-order thinking skills when engaged in scientific reasoning associated with complex problem solving activities.

## 5.5 The need for scaffolding

De Corte, (1990, p.12) argues "... that powerful learning environments are characterised by a good balance between discovery learning and personal exploration on the one hand, and systematic instruction and guidance on the other ". Current literature recognises that novice learners bring a wide range of

individual differences in abilities, needs and motivation to the set task. If we are to encourage and develop in novice learners those skills considered necessary in the 'real world' through the use of educational resources that exemplify this approach then designers of technology-supported learning environments need to provide suitable cognitive tools for this purpose. Tools that can assist learners to accomplish cognitive tasks have been termed in the literature as 'cognitive technologies' (Pea, 1985), and 'mindtools' (Jonassen, 1996). The conceptual foundation of these tools is that they provide cognitive support to learners during problem solving through the development of metacognitive skills.

Reasons for using computer-based tools for supporting informal reasoning stem from the belief that such tools provide learners the opportunity to investigate and manipulate ill-structured situations at a stage where learners' limited expertise would make this difficult. In this study many participants tended to retain their original perceptions of the problem (and its possible solution). These learners failed to recognise inconsistencies in the data or chose to ignore them, as they did not 'fit' with their preconceived ideas. Linn (1994) argues that the skills needed by learners in attempting complex learning tasks, such as problem solving, can be improved by assisting learners in becoming more metacognitively aware in their approach to the task. If novice learners, with limited background knowledge, are to be assisted with their problem solving and learning processes then they need support mechanisms that promote the development of their higher-order thinking skills. By providing an on-screen support mechanism learners have the opportunity to examine the strategies and hypotheses that they have developed in their attempt to reach a solution to the assigned problem. Support mechanisms, such as scaffolds, may be used by learners to assist the planning process and in the development of higher-order thinking skills (Land & Hannafin, 1996).

In this study participants demonstrated that they were able to navigate the learning environment and collect information that related to river pollution issues. However, as they tried to develop possible solutions, few participants endeavoured to assess the viability of the data collected. For many, the solutions represented a 'first impressions' view of the problem as they had not focussed their solutions on specific aspects of it. This indicates a lack of ability to clarify what the problem specifically asked them to do. Additional support mechanisms,

in the form of cognitive tools, could assist in this process allowing learners to create meaning from the data collected and relate this information more specifically to the required task.

Within *Exploring the Nardoo* is a selection of cognitive tools to support problem investigation. Gordon (1998), in investigating the use of one of these tools, the genre' templates, found that learners who used the templates were more able to synthesise information into meaningful knowledge and concepts. However, it was apparent that for many of the participants this tool did not provide sufficient support in improving the quality of the argument, nor in the effective use of evidence. The results of her study also demonstrated that the templates best supported those learners who already possessed well-developed metacognitive skills and strategies. Brown and Palinscar (1989) also found that scaffolds are not needed when cognitive structures are sufficiently developed but only when these structures are incomplete or poorly organised. To provide assistance for those novice learners who are less metacognitively aware, support tools are needed that provide a form of 'coaching' (Brown, Collins & Duguid, 1989; Collins, Brown & Holum, 1991) to help develop more appropriate methods to arrive at a viable solution.

Although this study did not address the teaching of informal reasoning skills through exposure to ill-structured problems in classrooms, research conducted by Kuhn, (1991) and Perkins, (1985) suggest that it would be a difficult task to develop these skills in lower-ability learners to the level demonstrated by higher-ability learners. If we are to utilise technology-supported learning environments to provide learning situations that foster the development of reasoning and argumentation skills then designers need to consider the provision of appropriate support structures.

## 5.6 Conclusion

There is an expanding interest in western educational settings in utilising technology to support teaching and learning across the K-12 curriculum. This has lead to a growth in both CD-ROM educational software and the World Wide Web, to assist the development of higher-order thinking skills through a focus on problem-solving approaches. Such approaches facilitate knowledge construction and

stimulate cognitive processing by allowing novice learners to construct meaning through interactive problem solving in different contexts.

The more successful participants in this study appeared to achieve more successful outcomes through developing and following an intentional action plan (Jonassen, 1997). When dealing with complex problems such a strategy must be flexible enough to deal with the unexpected situations and conflicting evidence that may arise. In seeking solutions to problems that lack definition and clear outcomes, without flexibility learners become confused and need support or guidance to direct their learning path. Within an educational setting learners may be helped with the development of their strategic knowledge (Larkin, 1989) through direct instruction. However, improvements in strategic knowledge through the development of general problem-solving strategies may be more appropriate for well-structured problems in specific knowledge domains than for ill-structured problems encountered in domains requiring a broader spectrum of knowledge.

To facilitate learners' development of cognitive strategies, another option is the production of cognitive tools (Jonassen, 1992) that will facilitate learners' development of cognitive strategies for clarifying, processing and analysing information in ill-structured problem-solving. This study argues from this perspective, especially for those novice learners with weak metacognitive strategies that may undergo cognitive overload due to the lack of domain knowledge and the complexities of the learning environment. For learners to develop adaptable processing skills and to acquire cognitive structures suitable for ill-structured problem-solving, learning environments are needed that foster such goals. Cognitive tools are ideally suited, by virtue of their flexibility, to provide the support needed in guiding the novice learner through the complexity of ill-structured tasks where a lack of domain knowledge and a minimum of cognitive flexibility (Spiro et al, 1991) exists.

The findings from this study support the ideas put forward by Linn and Clarke (1995), Voss and Wiley (1995) and De Corte (1990), that many learners have difficulty in analysing and critiquing information that has been accessed by them while problem solving. When presented with information relating to an issue under investigation they prefer to accept the information rather than question its relevance. When developing support structures in technology-supported learning environments the support system should assist learners to engage and critique the

information presented in order to facilitate the development of autonomous problem-solving skills. Learners need support systems that help them identify weaknesses in arguments and encourage them to question the relevance of information presented through the use of multimedia resources. The cognitive tools provided for scaffolding/coaching learners should reflect this in their design by allowing learners to maintain control of their learning environment. Such tools should allow learners to take responsibility for their learning through the restructuring of information, through analysis of the data and should assist with the development of reasoning and argumentation skills to support a particular point of view.

Throughout the investigation process it appeared that many of the participants were not accustomed to dealing with problems of an ill-structured nature. This supports work from other research ( Sinnott, 1989; Voss & Post, 1988) which indicates that learners engage different strategies when working with well-structured than with ill-structured problems. It is also apparent from the differences in strategies adopted here that individual learners may use different strategies for different types of problems (Jonassen, 1997).

It would be inappropriate to generalise the results of this study to all problem-solving situations in technology-supported learning environments. The problems investigated were based on environmental issues and set in a fictitious inland river catchment system. These problems were of an ill-structured variety and involved information acquisition and analysis strategies to achieve a specific outcome. The research design used here dealt with a group of novice computer users from a pre-service education background who were engaged in the problem-solving process for a concentrated, but limited, period of time. Within the framework of these limitations the following conclusions may be drawn in relation to the four problem-solving frameworks used.

The two frameworks Six Thinking Hats and Critical Thinking provide stimulus for learners to seek out data and make some preliminary analysis of the suitability of the data in seeking a possible solution to a problem. Participants using these frameworks presented clearer representations and better argued their problem solutions. One reason for the apparent success of these two frameworks may be that they are scaffolding mechanisms that activate specific cognitive processes in the learner. The other two frameworks, Venn diagram and Concept mapping, focussed

more on the organization of ideas once they were identified. Participants here, when tutored in one of the first two frameworks and then asked to use it for problem solving were more successful than those tutored in and applying one of the second two. It is conjectured that this was due to the focus of these two frameworks on data identification.

Several participants who had a broader science background did indicate that domain knowledge assisted their approach to reaching a possible solution. These learners were more systematic in clarifying and focussing on their approaches to the problems. Even though they recognised additional information it did not distract from their perceived path towards a possible solution. Other participants expressed difficulty approaching their assigned problem because of their lack of domain knowledge.

This exploratory investigation of learner support frameworks raises more questions than it answers, but it does indicate that learners engaged in interactive computer-based learning need support to represent the knowledge and information they have acquired in the process. This could be achieved through the development of additional cognitive tools to support the process through helping learners identify patterns, links and similarities in these complex information environments. This study indicates that:

- learners are assisted in the problem-solving process through the posing of questions that help generate ideas;
- questions that are generated need to be specific to the context of the problem domain;
- when theories or ideas are generated learners need support in testing and ranking such theories based on their relative merit in supporting the problem solution.

## **5.7 Implications for Future Research into Supporting Frameworks**

Problem solving requires a range of skills and background knowledge from the learner. David Jonassen (2000) suggested that the skills required of the learner involve a combination of recognizing variations in the type of problem (degree of structure, complexity and abstraction), the form of representation of

the problem (context, cues/clues, and modality), and the individual's knowledge (both in terms of the domain of the problem and the strategies for operating and persevering within the problem domain). This suggests that the strategies in this study would have specific applications in a framework design depending on what aspect of problem solving is highlighted, particularly if learners concentrate on the generation of ideas rather than merely suggest a mechanism through which a solution might be found. In short they provide not only an idea-generating framework but also ways of organising the ideas to ensure that a solution can be produced. This study has provided support for the design elements that Jonassen proposes.

The application of the four frameworks used in this study supports the contention that there are several processes at work in the development of a problem solution. A series of frameworks each with its own strength is preferable for supporting learners with different processing needs. The concept mapping approach does generate a range of ideas but it requires an additional support to turn the range of ideas into a supported argument. Tools like '*Inspiration*'™ assist with the task by enabling the initial ideas to be represented in a different mode to assist with the structure of the argument. However, the nature of the argumentation requires an additional manipulation of the content and hence even this tool cannot help with the final presentation of the ideas.

However, this tool exists outside the problem space and, where resources are being accessed and directly manipulated, it is not accessible. Thus if one requirement in the design of a cognitive framework structure is that it be available in conjunction with the problem space, this tool will not be suitable. Further it can be argued that such tools do not support domain-specific reasoning should that be required. This study sought to overcome this issue by linking the tools directly into the problem space. For this study the importance of domain-knowledge has been underscored in that those learners who could operate within the knowledge domain produced better reasoned solutions and their strategies were more direct and focused. Even though each participant was presented with a cognitive framework strategy, those with less relevant frameworks found that the sequences they followed did not lead to well-reasoned solutions. Thus if the approach used does not match the task a solution is not easily achieved and

supported. In all cases the results supported the contention that the solution and the reporting and support for that solution were two quite different processes.

Constructivist learning theory shifts the focus for organising knowledge construction from the teacher to the learner. Learners therefore need to develop a range of information-processing skills to cope with this change. When faced with the responsibility for knowledge construction, learners need to rely on their own management resources. While some may have the metacognitive skills to cope with this responsibility many fare poorly in the perceived complexity of technology-supported learning environments. Such learners see the task as daunting and complex and feel ill-prepared for creative freedom and choice of direction. Such learners need tools to support them in representing the knowledge they are acquiring and in facilitating higher-order thinking.

In Chapter 2, a theory-action model proposed by Land and Hannafin (1996) was introduced. This conceptual model presented a technology-based framework for learning that enables learners to suggest and test theories that may be generated when working on problem-solving activities in open ended learning environments (OELE's). As they investigate issues and collect and review data in such a framework learners develop a theory about a solution to the problem and take action to test the theory. Studies into the effectiveness of the framework demonstrate that learners' theories are resistant to change (Land & Hannafin, 1997). In addition the studies supported other research (Ross & Loftin, 1994; Comacho & Good, 1989; Smith & Good, 1984) on the tendency for novice learners to focus on the surface features of the problem. A similar pattern was observed in this study. An analysis of participants' search strategies and the researcher's observational records indicated that few participants were testing a theory associated with the development of a solution. The actions taken by many participants resembled a random trial-and-error approach that lacked any obvious focus towards developing a particular theory. These learners often spent more time accessing resources that did not directly relate to the specific task. In view of these findings it may be more appropriate to design a technology-based tool that assists learners in developing higher-order thinking skills through a framework that assists in the collection and sorting of information and ideas that relate to the problem solution.



Earlier in this dissertation a model of the problem-solving process was proposed (Fig. 2.1). This study has demonstrated that in general participants had little difficulty in data collection and generating a solution. However, many of the participants from each of the four frameworks demonstrated weaknesses in clarifying the problem, checking their ideas or theories and refining the process. These weaknesses in the proposed model are highlighted in Fig. 5.1.

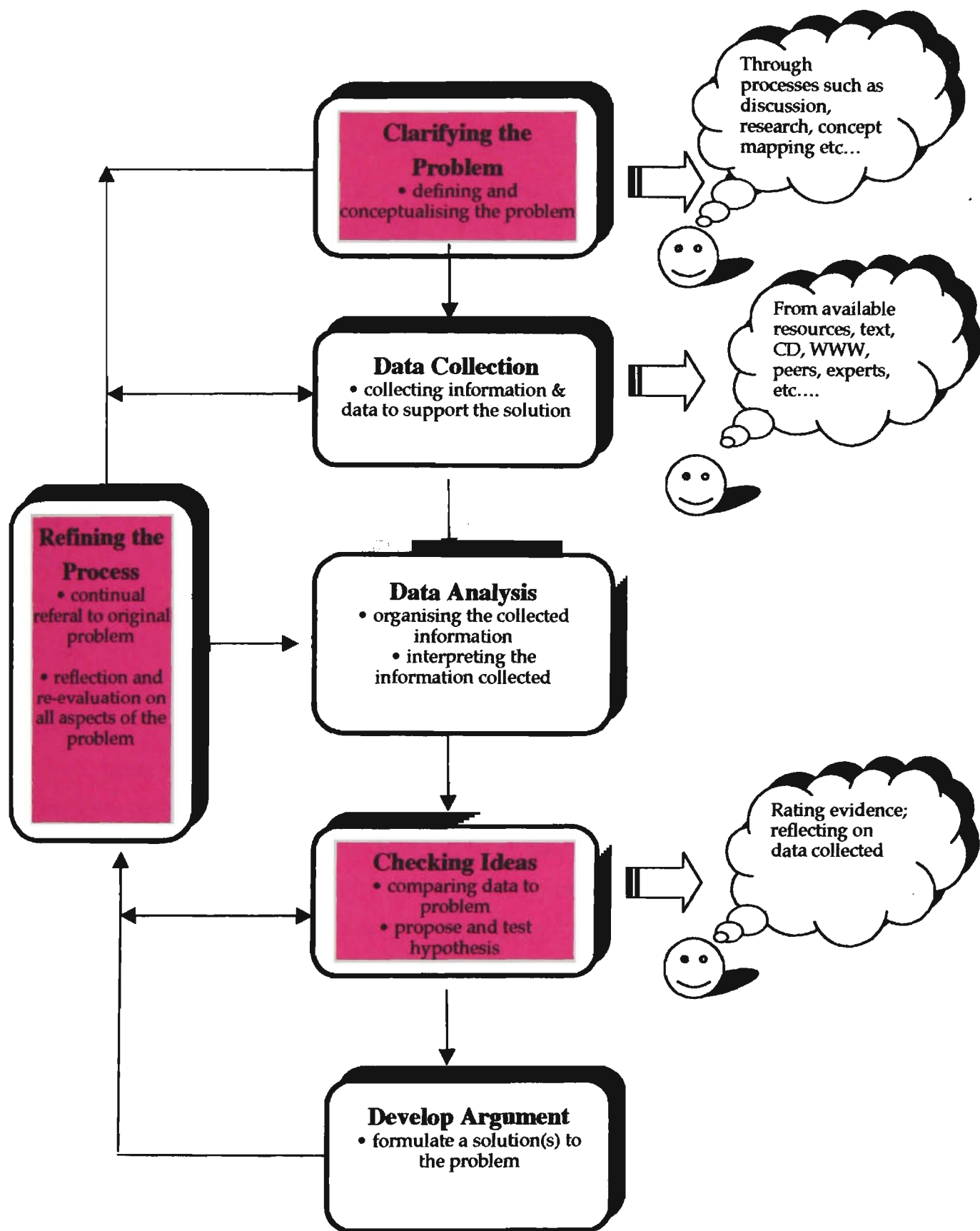


Figure 5.1 Demonstrated weaknesses in Problem-solving

To address the apparent weaknesses demonstrated by many learners in the effective processing of information when problem solving the following design framework is proposed (Fig. 5.2). This goal-directed cognitive framework would support learners by allowing selection from a series of cognitive tools that scaffold them in problem clarification, solution formulation and argumentation. Following on from what appeared to be the two most useful information gathering strategies, Six Thinking Hats and Critical Thinking, the integration of similar elements from each of these frameworks might be presented in a series of three steps each with at least two clarifying questions. Additional questions may be used to dissect the information as required.

To assist with problem clarification, the original task could be loaded into the cognitive tool that would display a series of questions, appropriate to the domain of the problem, for learners to answer or address. Examples of questions could include: What is my goal or purpose? What information do I know from the problem? What information do I need? Who are the participants? Such analysis of the problem would help define and conceptualise the essence of the task more clearly, perhaps redefining the initial perception of the problem.

Solution formulation may involve questions that help direct learners in the analysis and synthesis of information that supports the problem solution. This component of the tool would allow learners the opportunity to check their theories and refine the process prior to developing their argument. Questions would be generated that reinforce this strategy. One function of the tool would be to suggest options and allow learners to test each option before ranking or discarding it.

The Argumentation section of the tool would present learners with a structure to value possible solutions to the problem. Evidence collected in developing a solution may be used to either support a particular theory or refute it. Patronis, Potari and Spiliotopoulou (1999) refer to this aspect of argumentation as 'defence' or 'attack'. The argument is considered consistent ('stable') when information collated supports the theory and inconsistent ('invented') when contradictory information needs to be examined. Such qualitative arguments in real-world problems often involve social, economic, ecological and practical issues; for example, development versus conservation of the natural environment. Reasoning skills associated with the development

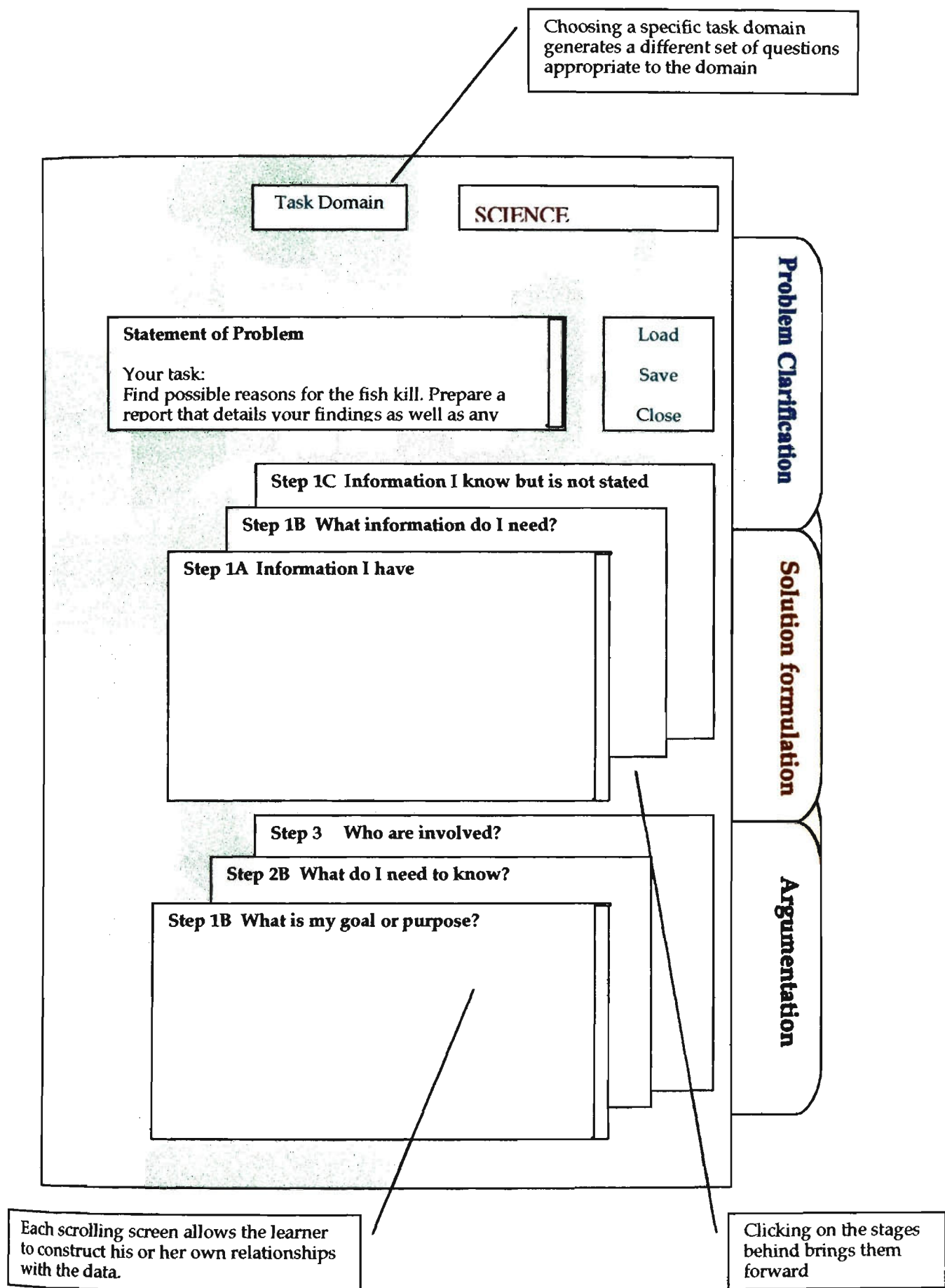


Figure 5.2 Proposed Solution Framework

of arguments covering such a diverse range of issues are seen as being a characteristic of experts (Means & Voss, 1996; De Corte, 1992; Voss & Post, 1988). To help novice learners in this process this section of the tool would have the capacity of adding the theories generated through exploration of the problem space. Each theory may be examined in more depth by having the capability of adding and viewing the data that supports or refutes the ideas generated. This data may then be ranked on its strength in supporting the original idea. Each theory may also be ranked in a similar manner when developing the final argument.

The development of cognitive tools to further support novice learners from a variety of backgrounds is needed to help them process information more effectively in technology-supported learning environments. These tools would help learners to identify patterns, links and similarities in complex information environments encouraging the development of more effective reasoning skills. Such tools need to be developed and designed so that they assist novices in developing more specific strategies that lead to appropriate solutions. Further research involving a variety of learning environments may demonstrate a broader scope for the development of a scaffolding system for different types of learners in different domains. This may provide a clearer indication of what types of learners could be advantaged, and in what learning environments, by using technology-based support structures. In addition, this study did not explore the degree to which individual differences influence problem-solving outcomes. Replicating this study with a larger number of learners and focussing on individual differences as they pertain to problem solving within technology-supported learning environments may be of further benefit.

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# Appendices

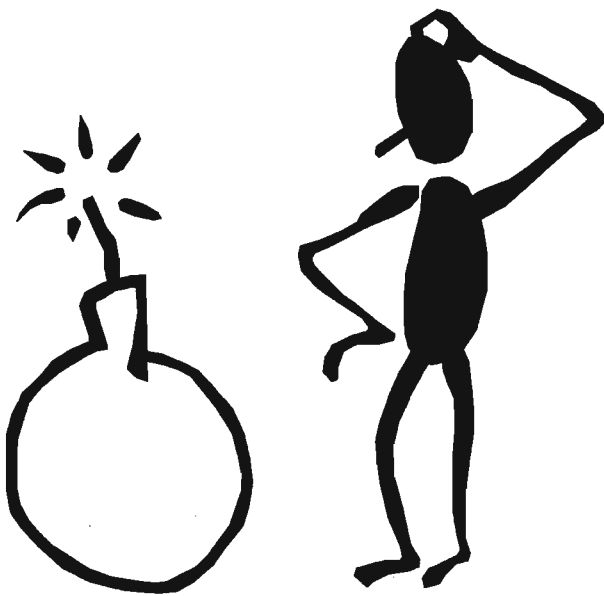
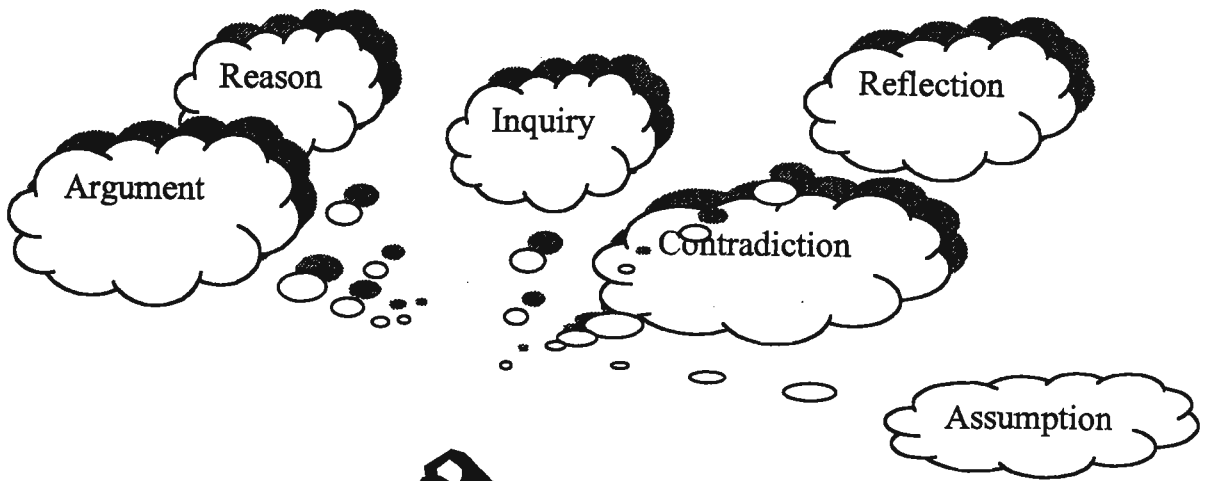
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<b>Appendix 1</b>	Support frameworks used in the study
<b>Appendix 2</b>	Scientific Reasoning skills (Keys, 1995)
<b>Appendix 3</b>	Researcher’s observation booklet
<b>Appendix 4</b>	Participant post questionnaire
<b>Appendix 5</b>	Participant consent form
<b>Appendix 6</b>	Individual Action Plans of participants
<b>Appendix 7</b>	Publications from Study

# Appendix 1

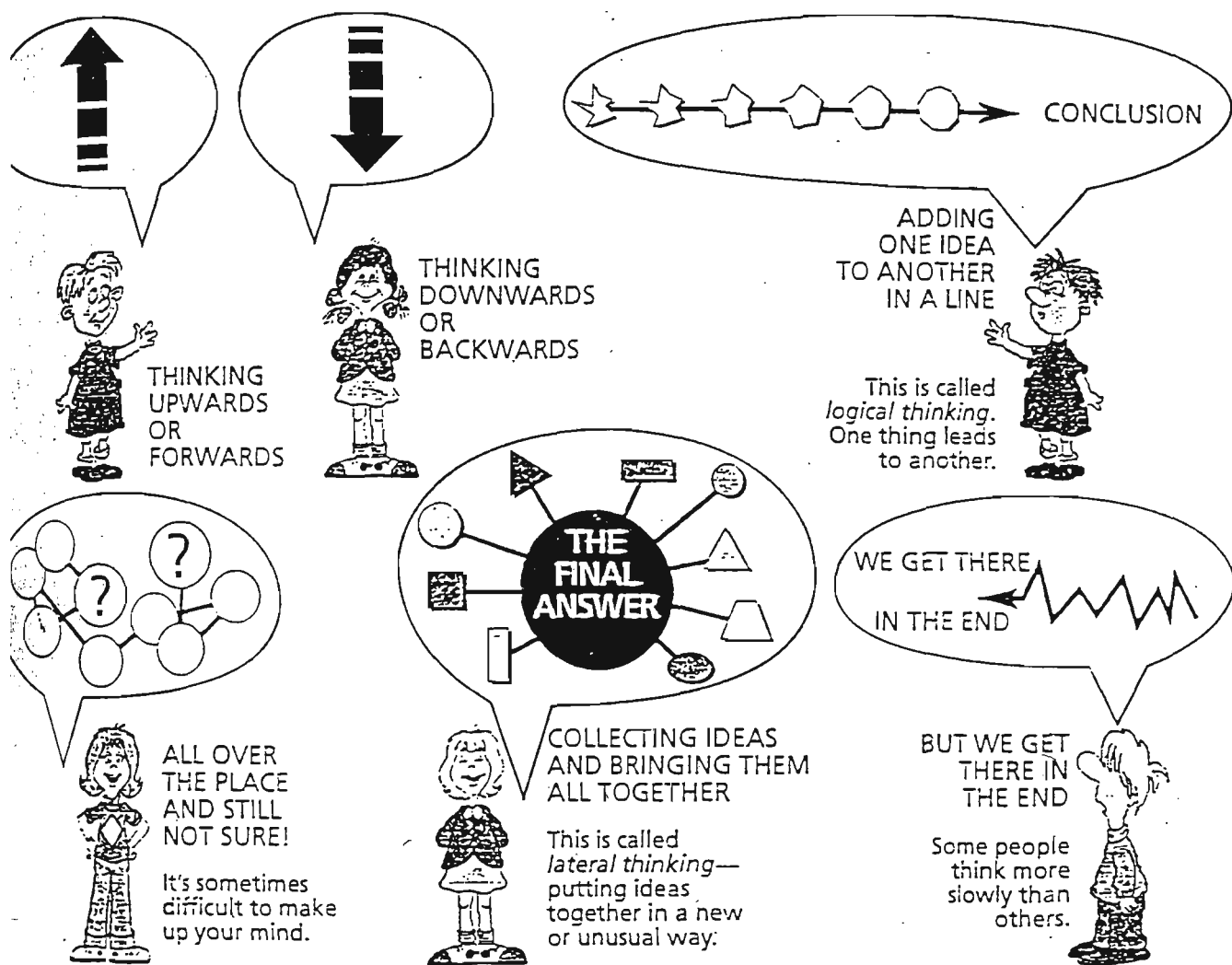
## *Support frameworks used in the study*

# Critical Thinking



## Introduction : How do you think?

There are many different ways of thinking as illustrated by the following diagrams. Thinking one way is not always better than thinking another way and there are times when one way may be more useful than another.



How do you think? Does one of the diagrams describe you or do you think in a different way?

On the next page have a go at drawing a diagram of the manner in which you think.

## **Problem Solving.**

Problem-solving tries to challenge students through the development of their thinking skills – reasoning, inquiry, concept formulation, translation and reflection.

Many problem solving strategies revolve around:-

- knowing the facts
- understanding the facts
- making use of what you know
- explaining what you know
- working out something new
- judging the results

In your own thinking number the steps in the order you would place them.

Are there other steps you would use?

Are some more important than others?

When is it important to think laterally?

When is it important to think logically?

Newspapers, magazines (and the WWW) offer a mixture of fact and opinion. It all comes under the heading of 'news' or 'information'. When you compare this with radio or television stories you may hear and see different versions of the same story. How can you arrive at the 'truth'?

In these reports :-

- some things are facts
- some reports are not accurate
- some things may not even be true
- people who are interviewed sometimes express opinions rather than facts
- news reporters sometimes express opinions as well as facts

As problem solvers how will you monitor and analyse these possibilities?

Are there other points that you believe should be checked?



# Some Fallacies about Teaching Thinking

(Edward de Bono)

- **intelligence is the same as having thinking skills**

This is not the case. Intelligence is an indication of potential, not necessarily good thinking.

- **teaching knowledge is sufficient**

Definitely not so. Knowledge is only gained and applied when it is meaningful. Good thinking skills are essential to make the best use of knowledge.

- **Thinking skills are taught in every subject**

Partly true, however, they are usually limited to information sorting, analysis and debating skills.

Critical thinking involves prioritising, seeking alternatives and considering other views.

- **Any thinking will develop better thinking**

Often, practising a skill, e.g. two finger typing, only reinforces existing habits. The improvement only comes about through a systematic approach.

The term “critical” does not mean thinking which is negative or finds faults, but rather thinking which evaluates reasons and brings thought and action in line with our evaluations

The critical thinker:

- distinguishes between poor and strong reasoning
- uses a number of identifiable learning skills
- analyses and evaluates reasons and evidence
- makes assumptions and evaluates them
- uses the best and most complete evidence available
- avoids inconsistency and contradiction

The uncritical thinker:

- doesn't reflect on or evaluate reasons for a particular set of beliefs
- by simply agreeing or disagreeing, accepts or rejects conclusions
- lacks skills to analyse and evaluate
- doesn't notice assumptions and therefore fails to evaluate them
- has difficulty in sorting out ideas
- is oblivious to contradictions

## The Use of Questions

When students explore demanding problems they tend to jump straight into information gathering without carefully mapping out the many questions they should be examining in their search for knowledge and understanding.

“ Without strong questioning skills, you are just a passenger on someone else’s tour bus. You may be on the highway, but someone else is doing the driving” (Jamie McKenzie)

Most important thinking requires one of the following prime questions:

### Why?

- why does the sun fall each day?
- why do people throw litter out their car windows?
- why do people steal?

### How?

- how can I get cash from the bank?
- how can I get home at 3.00am?
- how can I earn more money?

### Which?

- which school will we send our children to?
- which solution is best for this situation?
- which road will I take to go to Brisbane?

Most questions in classrooms come from the teacher – they tend to be **recall questions** rather than questions requiring **higher level thought**.

# The POSTER strategy

(Reference: Wilks, S (1995))

## Describe it!

### Situations

Where is this occurring? ☐ What is the big picture?

### Contexts

Who? ☐ Where? ☐ How? ☐ When not?

What? ☐ When? ☐ How many?

## How POSTER it!

### Problem

How many problems are there? Restate each.

Which are the most and least important problems or parts?

### Solutions

Brainstorm all possible solutions, no matter how silly they seem.

Don't evaluate them yet, just accept them. No answers are wrong.

Think laterally.

'Piggyback' on each others' ideas.

### Solution selection

State criteria for a good solution.

Evaluate each idea by applying the criteria and thinking through the implications. Identify the strengths and weaknesses of each. (A criteria grid could also be used to compare different solutions.)

Select one to try.

### Test plan

Develop an action plan, predict difficulties and then try your plan.

### Evaluate short-term progress

How is it going? What is working well and what does not seem to be working? What needs fixing?

### Review and revamp in the longer term

Is it working? What needs to be 'fine tuned'?

**Example.**

Despite bar codes and other security measures, students and readers are cutting or removing crucial and much sort-after pages from texts, and smuggling them out of school and public libraries. This is draining library funds as replacement books have to be bought and security staff need to be paid. These extra funds could have otherwise been used to purchase additional books and services.

### **Example.**

The supermarket has been losing stock due to shoplifters. Uncertain whether staff are involved, management wants to try new methods to reduce shoplifting. Certain types of goods are being taken, mainly expensive chocolates, cosmetics and meats. These come from different aisles. Electronic surveillance cameras and undercover security staff have not found reasons for the increased loss. What can be done to expose the culprit or culprits.

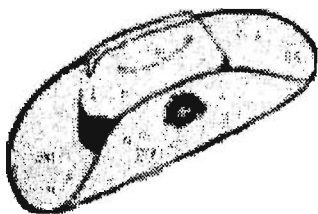
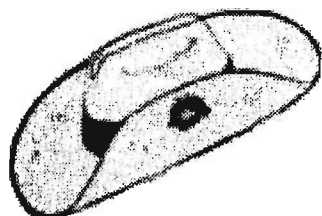
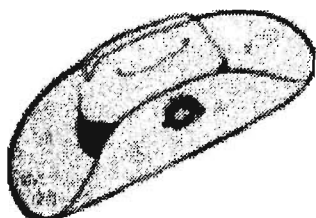
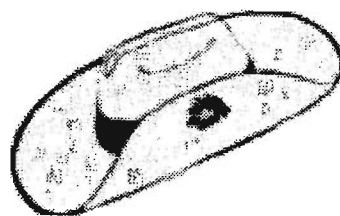
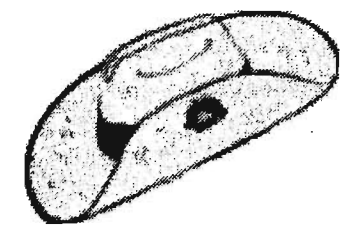
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Paul, R, Biinker, A.J., Martin, D & Adamson, K (1993). *Critical Thinking Handbook*, Hawker Brownlow Education, Australia



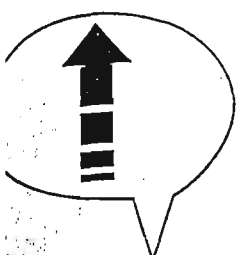
# Six Thinking Hats



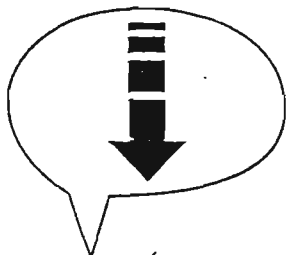


Introduction :    How do you think?

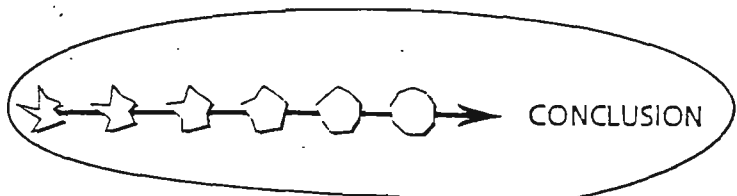
There are many different ways of thinking as illustrated by the following diagrams. Thinking one way is not always better than thinking another way and there are times when one way may be more useful than another.



THINKING UPWARDS OR FORWARDS

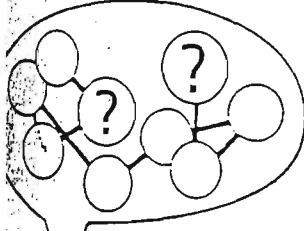


THINKING DOWNWARDS OR BACKWARDS



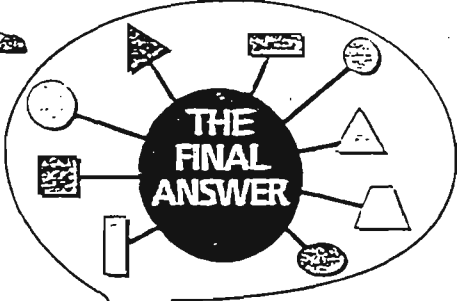
ADDING ONE IDEA TO ANOTHER IN A LINE

This is called *logical thinking*. One thing leads to another.



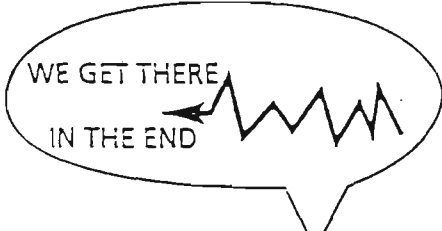
ALL OVER THE PLACE AND STILL NOT SURE!

It's sometimes difficult to make up your mind.



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Some people think more slowly than others.

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- judging the results

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Are some more important than others?

When is it important to think laterally?

When is it important to think logically?

# Introduction

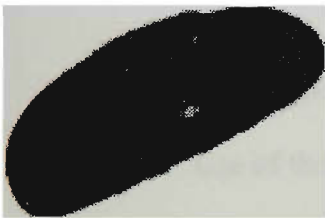
When we attempt practical thinking, there are three fundamental difficulties:

- *emotions* – we rely on instant gut feelings, emotion and prejudice as a basis for action with the resulting **lack of thinking**.
- *helplessness* – feelings of inadequacy occur ( ‘What do I do next?’ or ‘I can’t do this’)
- *confusion* – as a result of trying to keep everything in mind at the same time.

The ‘six hats’ method is a practical way of overcoming these difficulties by:

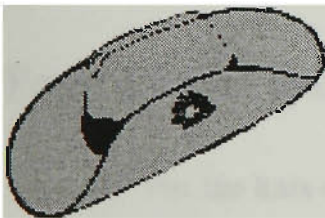
- allowing emotions and feelings to be used in appropriate places
- providing a basic framework or steps for thinking actions
- provides a pathway leading in one direction at a time.

In the six hats method, thinking is divided into six different approaches represented by a different colour hat



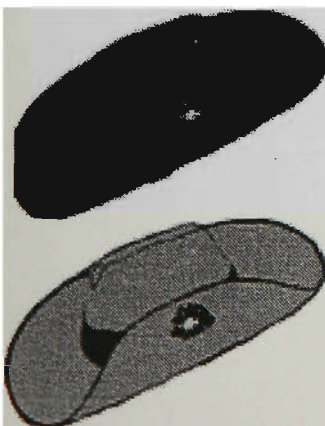
## **Red Hat.**

Emotions, intuition, feelings and hunches.  
How do I feel about this right now?



## **Yellow Hat.**

Good points  
Why is this worth doing?  
Why can it be done? Why will it work?



## **Black Hat.**

Bad points, caution, judgement, assessment.  
Is this true? Will it work?  
What are the weaknesses?  
What is wrong with it?



## **Green Hat.**

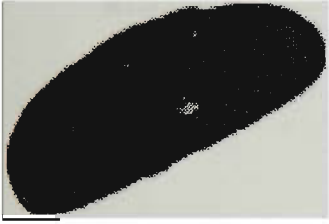
Creativity, different ideas, suggestions and proposals.  
What are some possible ways to work this out?  
What are some other ways to solve the problem?

**White Hat.**

Information and questions.

What information do we have?

What information do we need to get?

**Blue Hat.**

Organising your thinking.

What have we done so far?

What do we need to do next?

**NOTE:** the blue hat is different from the others because it involves the direction of the thinking process.

Use of the blue hat initiates the next hat to be used.

## Four uses of the hats in the classroom.

1. Put the hats on.
2. Take the hats off.
3. Switch Hats
4. Signal your thinking.

**Example 1.**

Read the poem and use the suggested hat to write a response.

A man said to the universe:  
“Sir, I exist!”  
“However”, replied the universe,  
“The fact has not created in me  
A sense of obligation.”

Stephen Crane.

**Red Hat**

**White Hat**

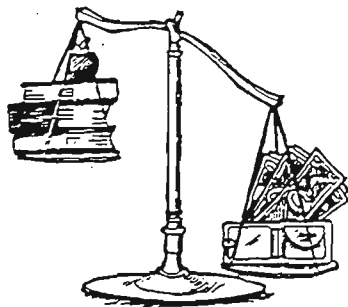
**Yellow Hat**

**Black Hat**

**Green Hat**

Example 2.

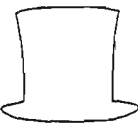
Which Hat?



Directions: Six different students comment on a proposal. Read the students' comments, then write the type of thinking each is doing on the lines next to the hat shape by each person's name.

**Proposal:** No secondary school student should be allowed to work at a paid job more than six hours a week.

Types of Thinking		
Look for facts	Find weaknesses	Think about thinking
Tell feelings	Find strengths	Offer new ideas



\_\_\_\_\_

\_\_\_\_\_

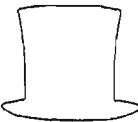
**Ralph:** I think that's a stupid idea!



\_\_\_\_\_

\_\_\_\_\_

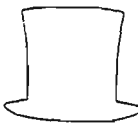
**Lauren:** It might help students concentrate a little more on their schoolwork.



\_\_\_\_\_

\_\_\_\_\_

**Chiang:** Would that restriction apply during holidays as well?



\_\_\_\_\_

\_\_\_\_\_

**Jack:** Maybe schools could pay you for doing homework.



\_\_\_\_\_

\_\_\_\_\_

**Tony:** The problem is that many students would drop out of school instead of quitting their jobs.



\_\_\_\_\_

\_\_\_\_\_

**Shana:** How about if we get some more information first and then look at the good and bad points?

# Six Hats at a Glance



**Red hat:** Feelings. What are my feelings about this?



**Yellow hat:** Strengths. What are the good points?



**Black hat:** Weaknesses. What is wrong with this?



**Green hat:** New ideas. What is possible?



**White hat:** Information. What are the facts?



**Blue hat:** Thinking about thinking. What thinking is needed?

## Remember:

- ✓ There are six different coloured hats.
- ✓ Each hat stands for one kind of thinking.
- ✓ You can put on or take off one of the hats. When you put on a hat, you play the role attached to that hat.
- ✓ You can ask someone else to put on a hat, take off a hat or switch hats.
- ✓ When you are wearing a hat, you must use only the type of thinking indicated by that hat colour.

## The Black Hat.

(what is wrong with this?)

The main uses of the black hat are:

- checking for evidence
- checking for logic
- checking for feasibility
- checking for impact
- checking for fit
- checking for weaknesses


The two main purposes for using the black hat are:

- find weaknesses
- make assessments

### Example 3. On Guard!

The following memo is handed out at school. Read the memo, then write what is wrong with the idea. Identify weaknesses, errors and bad points.

MEMO



To: students  
From: Your principal

Many students were discovered to be carrying weapons at school. In one instance, two students were injured in a knife fight.

In order to prevent further violence, guards will be stationed at school entrances. All students will be searched for weapons before being allowed to enter. Any student caught with a weapon will be suspended.



# The Yellow Hat

Yellow hat thinking is a deliberate effort to find benefits and its uses can be in the following areas:

- good points
- benefits
- reasons why an idea works
- likelihood

The main purposes for using the yellow hat are:


- assessing value
- extracting benefits
- making something work

## Example 4. Smart Dressing

Read the following advertisement then write what you think might be the benefits of Everwear clothing.

**Everwear**

Now a ~~unique~~ new idea in clothing: Everwear. Everwear clothes are guaranteed to keep you cool in hot weather and warm in cold weather. Scientifically designed to keep your body at a comfortable temperature of 22°C. Everwear never gets dirty, and it even repels rain! Now on sale at fine stores everywhere.



## The White Hat.

The main uses of the white hat can be summarised as three questions:

- what information do we have?
- what information do we need?
- how do we get the information we need?

The two main purposes for using the white hat are:

- to stimulate thinking
- to check thinking

### Example 5. The Missing Jacket.



Suppose you discover your favourite jacket is missing. What information do you need in order to find out what happened to it? How would you get that information?

## The Green Hat. (Creative Thinking)

We can look at four main activities of green hat thinking:

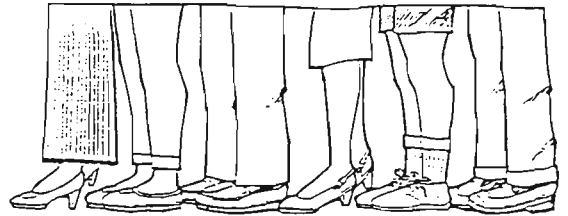
- generating reactive ideas
- generating starting ideas
- generating further and better ideas
- generating new ideas

The main purpose of green hat thinking is to be generative, productive and to move thinking forward.

### Example 6 Line Up!

You like to visit a little restaurant that's usually quiet. This night, however, you find a long line of people at the door. In Fact, the line trails out into the street.

What are some possible explanations for this?



## **The Red Hat** (feelings, emotions, intuitions)

The value of the red hat is that it recognises emotions, feelings, hunches and intuitions as a valid part of thinking.

The two main uses of the red hat are:

- making feelings known
- making assessments and choices

### **Example 7**

What changes do you expect to find in the world ten years from now? Put on your red hat and tell your hunches and intuitions about:

Population growth

Public transport

Televisions

Family relations

Space exploration

# The Blue Hat

(thinking about thinking)

The blue hat is most often used at the beginning, the middle and the end of a thinking session. The five main uses are:

- defining focus and purpose
- setting out a thinking plan or agenda
- making observations and comments
- deciding the next step
- defining outcomes and summarising

Three questions to ask with the blue hat are:

- what thinking is needed?
- what is the next step?
- what thinking has been done?

## Example 8

You are home alone during a thunderstorm when you hear water dripping in the next room. You discover that there's a leak in your bedroom ceiling.

Read the following thinking steps and number them in their correct order.

Think about what I have done

- did my plan work?
- why or why not?

Choose one plan.

- which plan do I want to try?
- which one is most likely to work?
- easiest? Quickest?
- which will result in the least mess?

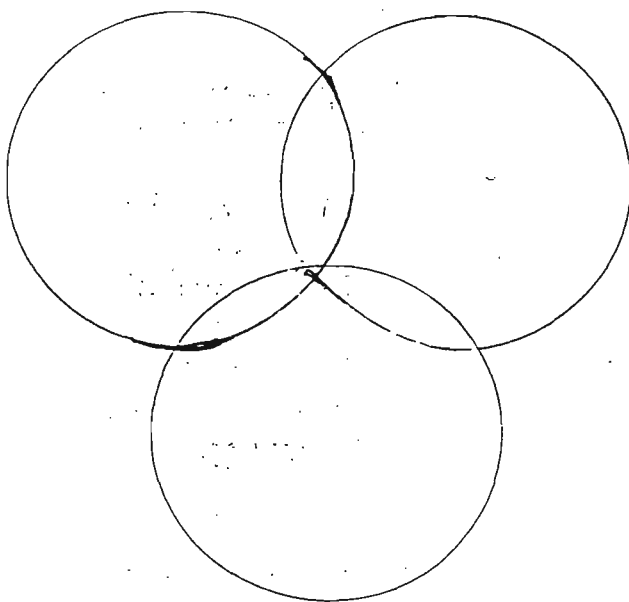
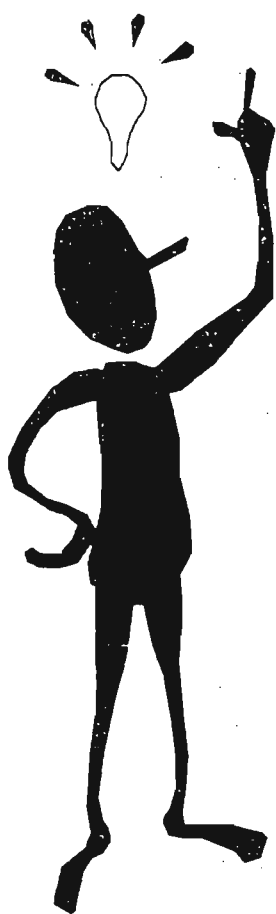
Think of the possible plans.

- what are all the things I could do about the leak? (Ignore it. Fix it. Try to protect the surfaces on which the water is leaking. Catch the water. Call someone for help. Or what else?)

Think about getting ready to try out the plan.

- what is involved in trying out the plan?
- what equipment do I need?
- where can I get it?
- What should I do first? Next? Last?

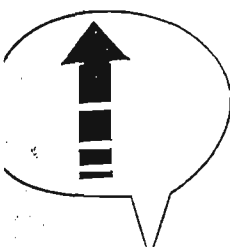
# Using Venn Diagrams



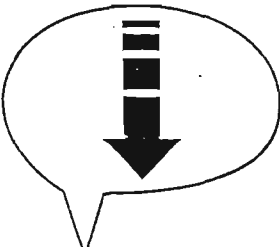
for  
problem Solving

**Introduction :**    How do you think?

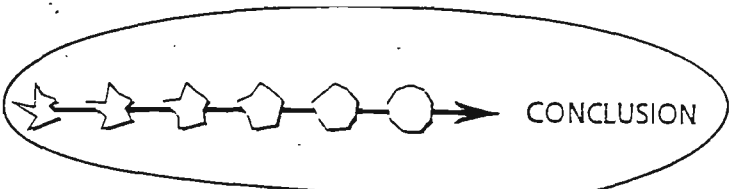
There are many different ways of thinking as illustrated by the following diagrams. Thinking one way is not always better than thinking another way and there are times when one way may be more useful than another.



THINKING UPWARDS OR FORWARDS

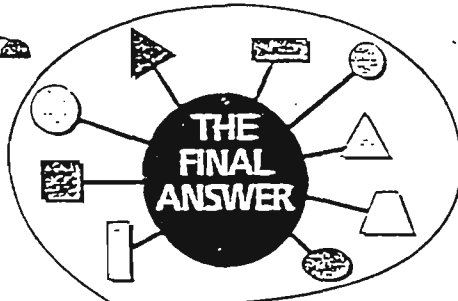


THINKING DOWNWARDS OR BACKWARDS



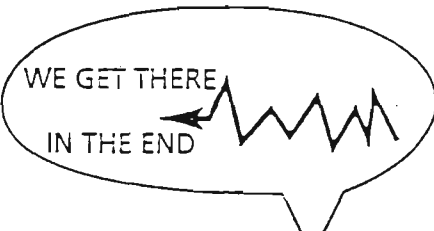
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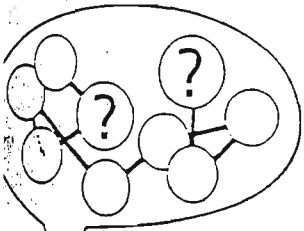
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It's sometimes difficult to make up your mind.

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Many problem solving strategies revolve around:-

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- working out something new
- judging the results

In your own thinking number the steps in the order you would place them.

Are there other steps you would use?

Are some more important than others?

When is it important to think laterally?

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One method suggested to help solve a problem is in the use of **Venn Diagrams**.

Venn Diagrams help you describe and compare the elements and characteristics of items. These include:

events, people, situations, wants, ideas, concepts

Many problems involve investigative learning requiring logical reasoning to sort and classify information in order to clarify the specifics of the problem.

Initially 'the problem' may generate questions such as:

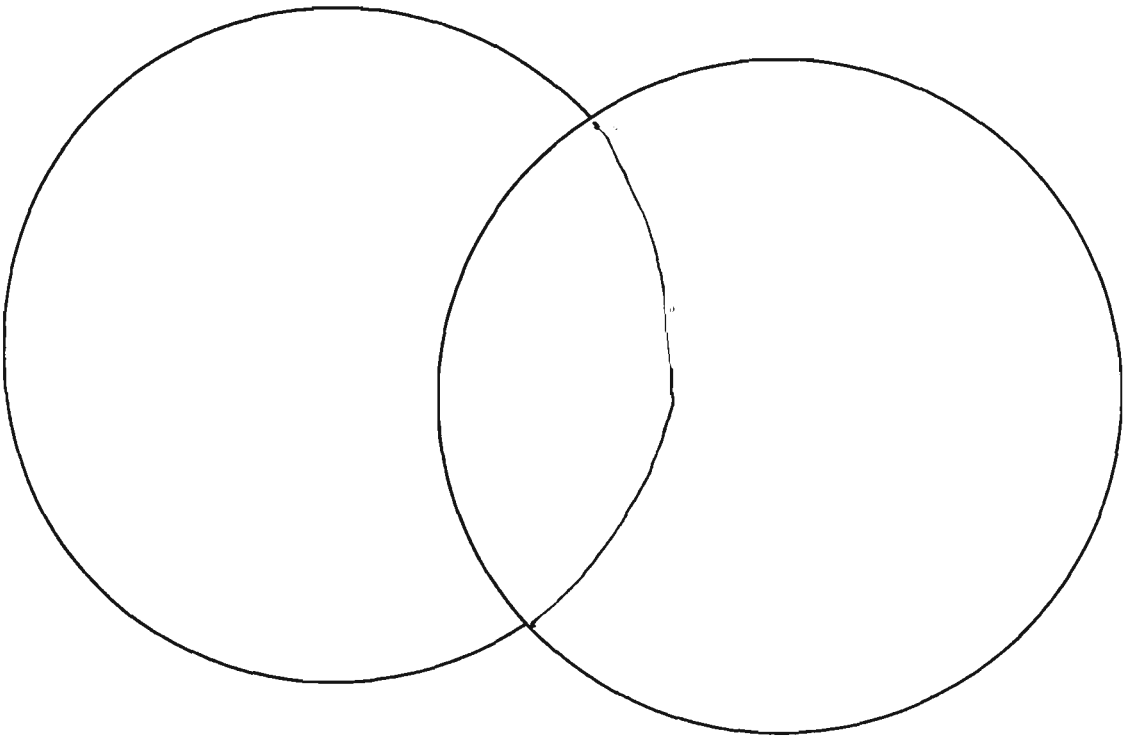
- What do I need to know?
- what elements or ideas can I identify from the problem?
- what specific questions can help in answering the problem

Once the questions have been generated and some information gathered a venn diagram can be prepared to help analyse the information based on the following questions:

- what items do I want to compare?
- what characteristics do the items have in common?
- how are the items similar and different based on the characteristics?

### **Example – two items**

Describe and compare the characteristics of A and B



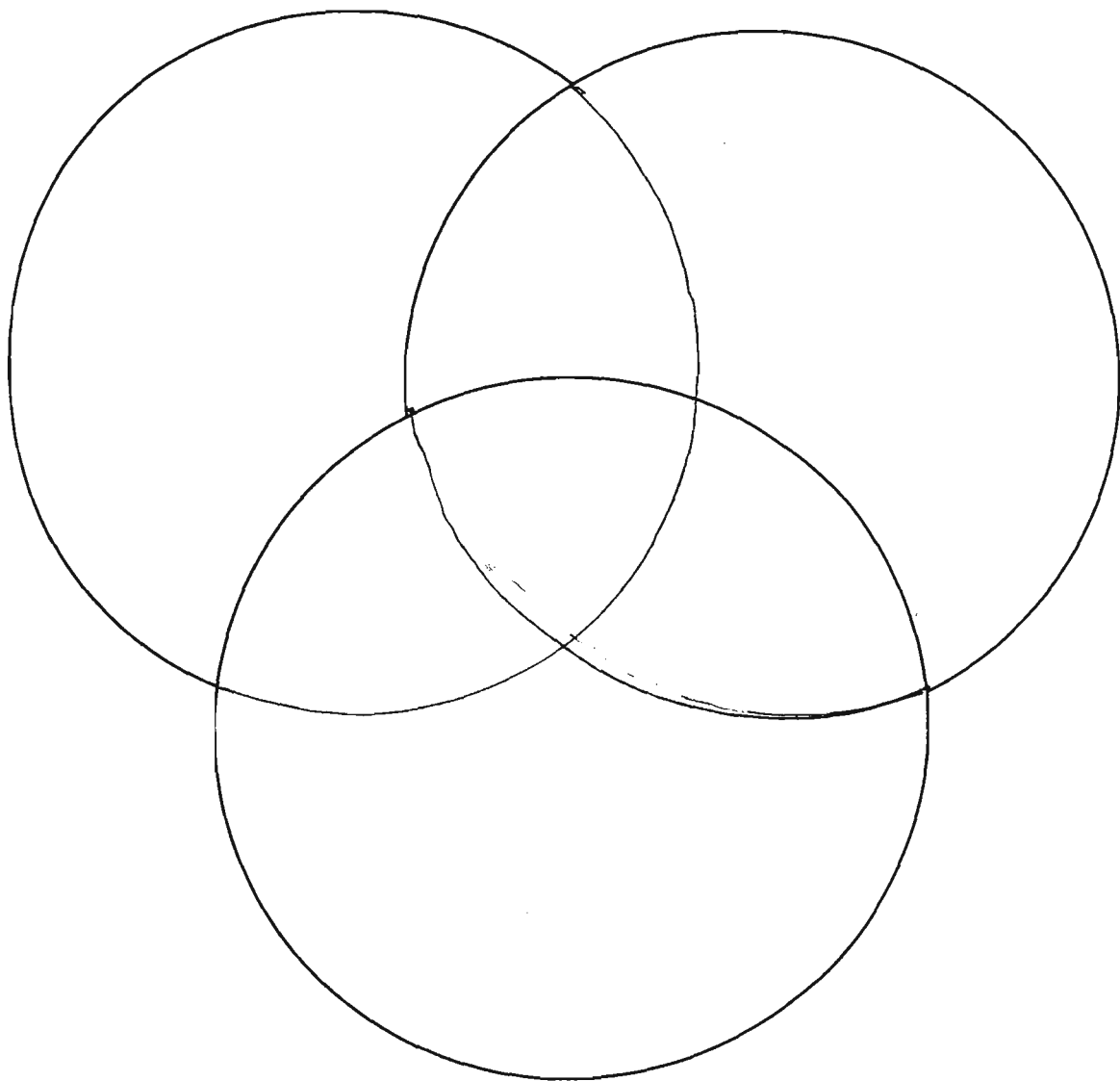
What items do you want to compare?

What characteristics do the items have in common? (intersection)

How are the items similar/different? (nonintersection)

**Example – three items**

Describe and compare the characteristics of A and B and C



What items do you want to compare?

What characteristics do the items have in common? (intersection)

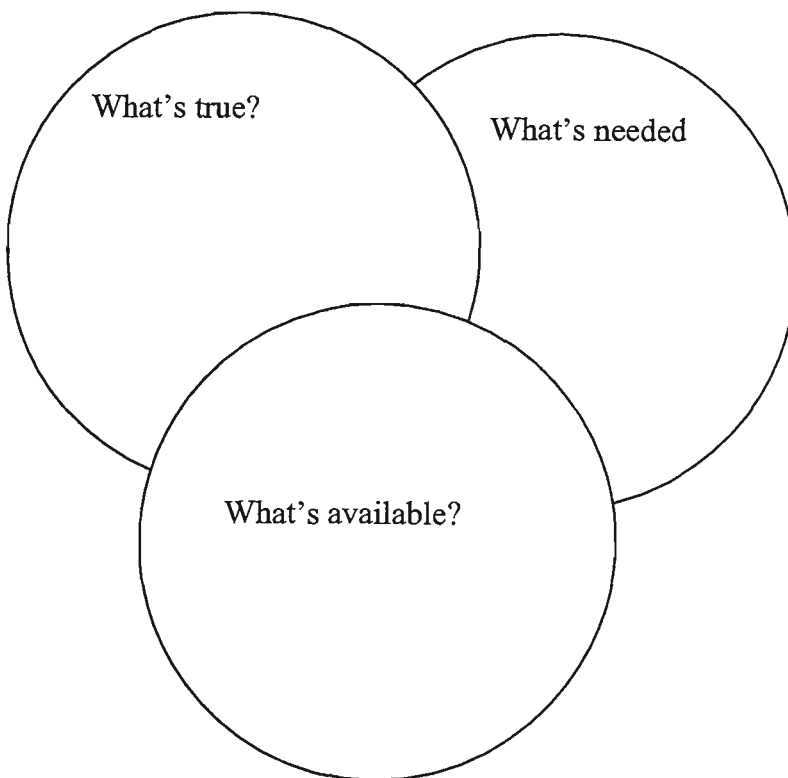
How are the items similar/different? (nonintersection)

In using this approach for a problem solving strategy adopt the following steps:

- ask yourself “what are three elements of the problem?”
- write each of these three elements in one of three overlapping circles
- ask yourself “ what can I do differently to resolve each overlapping set of elements?” (for circles A and B)
- repeat this with the overlap for the other two sets of circles
- fill in the overlapping areas with your responses.

One way to develop a strategy to resolve a problem may be:

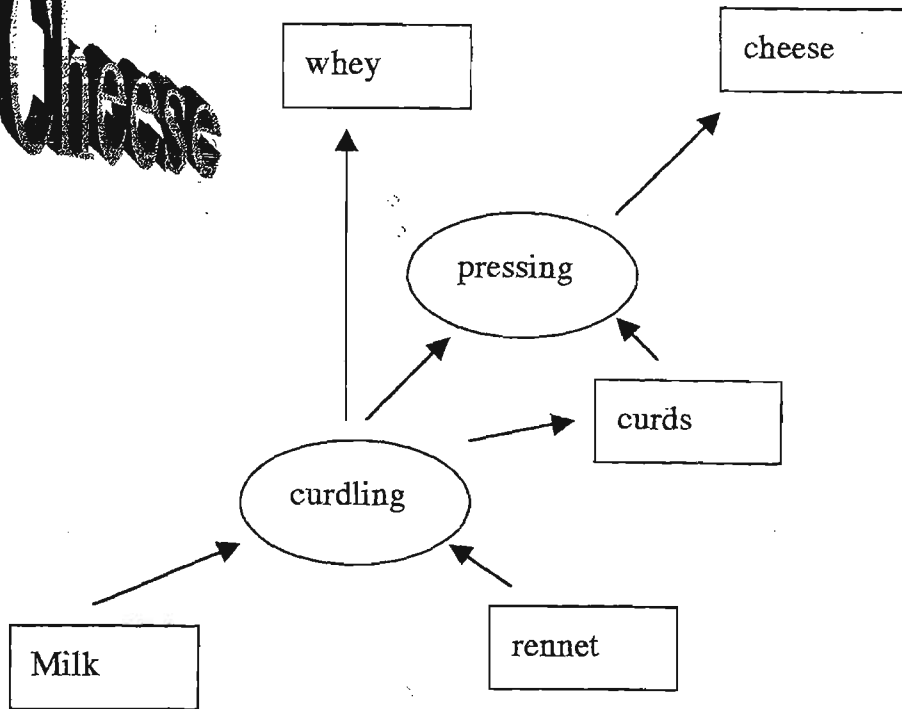
- ask “what is true?” (situation, patterns, trends, facts)
- ask “what’s needed?”
- ask “what’s available?” (resources, skills, testing)



**Example**

An environmental consulting firm, *Ecosolutions*, has recently employed you. Omar Digdeep, owner of Omar's Onions, has contracted the firm to determine why his onions have failed to take root. He has tried the latest watering systems and the finest organic fertilizer. Omar suspects that runoff from a nearby bleaching company has contaminated the groundwater under his farm. How could you help Omar solve his problem?

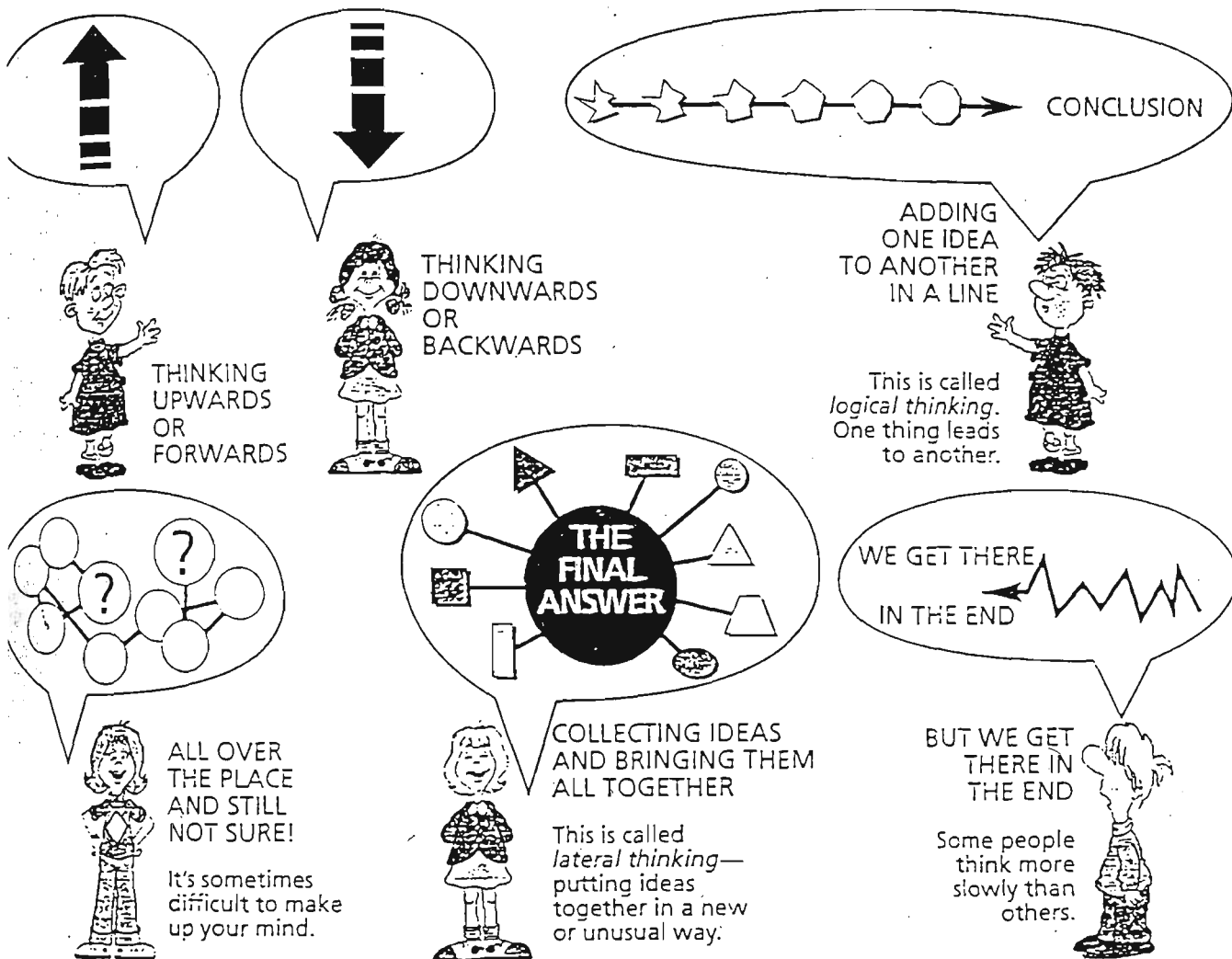
# Making Cheese



## Concept Mapping

## Introduction : How do you think?

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Are there other steps you would use?

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The technique of **Concept mapping** (Novak, J.D) is a thinking method that can be used to help any individual or group to describe ideas about some topic (or problem) in a pictorial form.

Concept mapping can be done for several purposes:

- to generate ideas (brainstorming)
- to design a complex structure (web sites, hypermedia )
- to communicate complex ideas
- to aid learning by integrating new and old knowledge
- to assess understanding or diagnose misunderstanding

Concept maps usually have four parts:

- propositions – two or more concept labels linked by words
- hierarchies – maps usually proceed from the most general concept to the most specific.
- crosslinks – connections between sets of concepts which appear unrelated to each other
- examples – specific events or objects that illustrate a concept

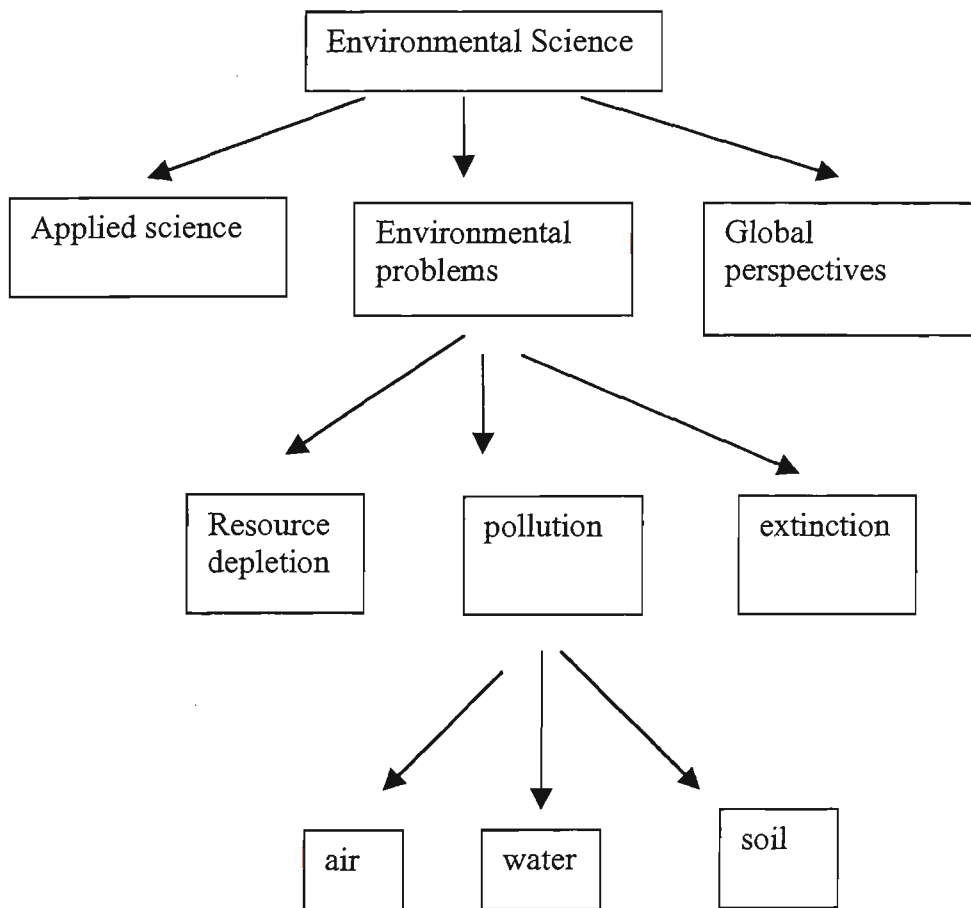
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#### **Web References**

[http://www.to.utwente.nl/user/ism/lanzing/cm\\_home.htm](http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm)

<http://www.graphic.org/concept.html>

## Example 1



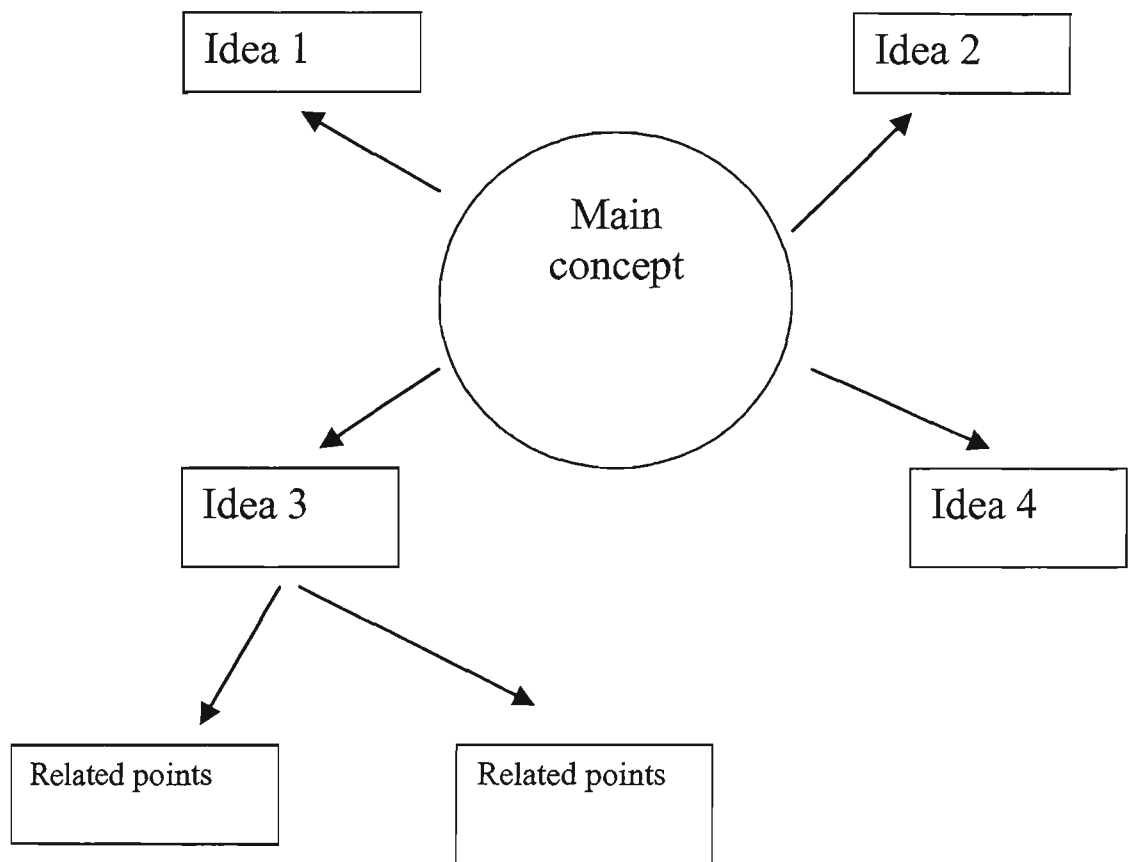
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<http://www.graphic.org/concept.html>

**Example 2**



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**Web References**

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<http://www.graphic.org/concept.html>

To make a concept map:

- **determine the main ideas or concepts**  
make a list of the main ideas in the material for which you are making a concept map.
- **place the concepts in order from the most general to the most specific**  
place the most general on top and work down to the most specific
- **determine the relationships between concepts**  
connect all relationships with lines and write a linking word or phrase that explains the relationship.

### **Group Example**

Draw a concept map using the following terms:

Fish, all living things, plants insects, trees, animals flowers, Earth, birds. Write as many links between concepts as possible

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### **Web References**

[http://www.to.utwente.nl/user/ism/lanzing/cm\\_home.htm](http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm)

<http://www.graphic.org/concept.html>

## Group Example

Read the following passage and identify the *main concept* and *key concepts*. When finished, go back and identify some *linking words*. Then construct a concept map of the paragraph.

“There isn’t a clean spot in the Atlantic from Bermuda to the African coast” reported a sailor who made the journey. “a river of polystyrene cups and bits of plastic stretches across the ocean.” If you walk along a beach, you see some of these cups, bottles, and bags that have washed up out of the ocean. “Accidental oil spills also contaminate ocean water”, he continued, and ‘oceangoing ships have also dumped wastewater and garbage overboard.”

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<http://www.graphic.org/concept.html>

# Appendix 2

*Scientific Reasoning skills (Keys, 1995)*

# Scientific Reasoning Skills

## 1. Skills used in assessing prior models

- *posing predictions* – identifying a possible outcome for a future event based on intuitive conceptions, prior scientific knowledge, or a specific set of data
- *evaluating predictions* – judging the merit of a prediction
- *explaining/justifying predictions* – using intuitive conceptions, prior scientific knowledge, or textbook-based information to explain or justify a prediction

## 2. Skills in generating new models

- *evaluating observations* – reflecting on an observation to determine (a) its appropriateness as a record of a scientific event, or (b) its relationship to drawing conclusions
- *identifying patterns and properties* – stating ways that data demonstrates patterns; organising data to discern a pattern; or pointing out properties common to objects or symbols in a data set.
- *Drawing conclusions* – stating the outcome of a scientific event and comparing with a predicted outcome.
- *Formulating models* – constructing a verbalised model of a scientific event using all available sources of information.

## 3. Skills used for extending models

- *inferring* – making a conjecture about and explaining a situation related to a scientific event using all available information sources.
- *comparing/contrasting* – verbalising similarities and/or differences between objects or events.

## 4. Skills used for support

- *discussing concept meaning* – engaging in conversation to construct or clarify meaning of scientific terms, objects, symbols or events.
- *identifying relevant information* – locating and/or reviewing specific information from text, charts, diagrams etc.

# Appendix 3

*Researcher's observation booklet*



# Researcher's Observational Record for Participant Data Collection

## Problem 1



Radio - Chemical disposal policy outlined



Radio - Tip chemicals killed fish



Radio - Chemical dumping radio campaign



Fish found dead in river



Radio - Tip poisons nearby river



Chemical Dumping to be Fined



Chemical Dumping Witnessed



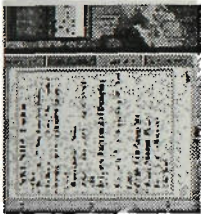
Resident's Call for Tip Closure



Newspapers – Keep out of river



Newspapers – acid burns school boy at local tip



Newspapers – Industry suspected of dumping acid

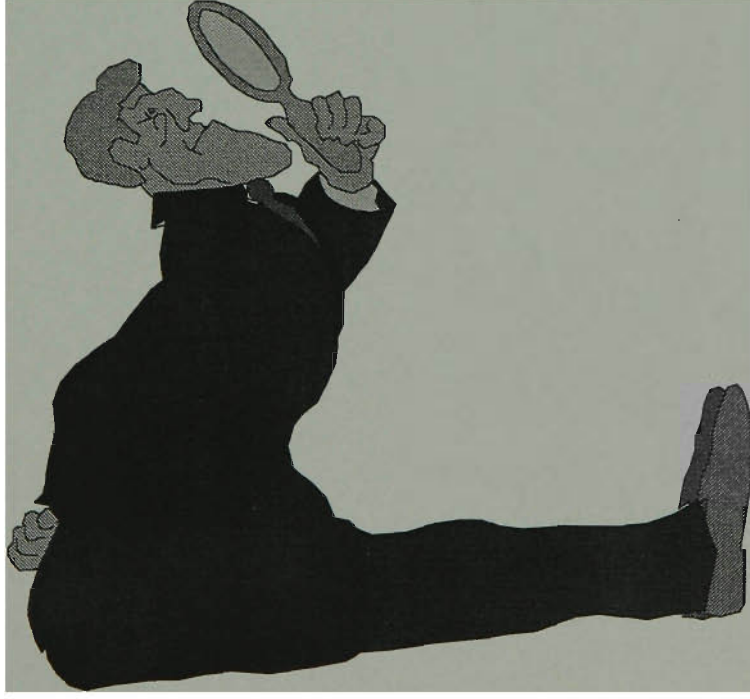


Newspapers – 'Industry killed fish', says worker



# Researcher's Observational Record for Participant Data Collection

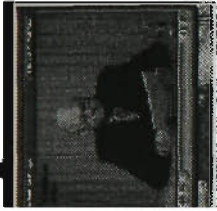
## Problem 2



Radio – Weeds cover river, killing fish



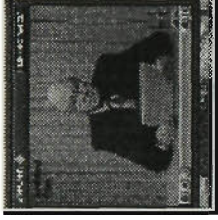
TV – Weed growth distresses residents



Radio – Logging linked to weed growth



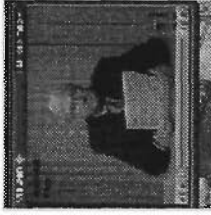
TV – Cause of algal growth found



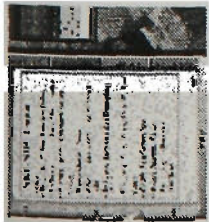
Radio – Expert warns against weed invasion



TV – River choked by wild willows



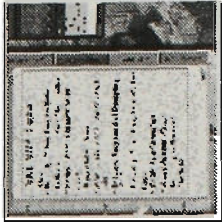
Newspapers – Weed Effort Fails



Newspapers – Farmer doubts beetle solution



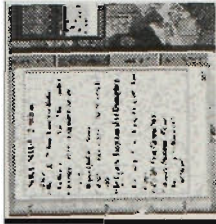
Newspapers – Weed Eradication program



Water Research Centre



Newspapers – Logging linked to weed growth



# Appendix 4

## *Participant post questionnaire*

Post Questionnaire

1) Place a tick in the **boxes** provided to indicate your gender and age

<b>Gender</b>	<input type="checkbox"/>	female	<input type="checkbox"/>	male		
<b>Age</b>	<input type="checkbox"/>	18 – 25	<input type="checkbox"/>	26 – 30	<input type="checkbox"/>	31 – 35
	<input type="checkbox"/>	36 – 40	<input type="checkbox"/>	41 – 45	<input type="checkbox"/>	over 45

2) Which **one** of the four groups used in this study were you assigned to?

<input type="checkbox"/>	Critical Thinking	<input type="checkbox"/>	Concept Mapping
<input type="checkbox"/>	Six Thinking Hats	<input type="checkbox"/>	Venn Diagram

3) Did you use the Personal Digital Assistant (PDA) to help organise your information?

<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
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4) Did you find the advice, provided by the ‘Environmental Officers’, useful in assisting you solve the problem?

<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
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5. Did you find that there was too much information or data to be investigated in the time allocated?

<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
--------------------------	-----	--------------------------	----

6. Did you start with a plan of action to help you understand the problem?

<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
--------------------------	-----	--------------------------	----

7. If you did use a plan, how did you solve the problem?

<input type="checkbox"/>	Using personal strategy
<input type="checkbox"/>	Using assigned strategy
<input type="checkbox"/>	Using combination of personal & assigned strategy



Problem Solving in Technology-supported Learning Environments

8. Describe how you organised your key ideas?

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9. Did you start by looking at the overall problem or did you break it down into smaller parts?

☐

overall problem

☐

smaller parts

10. If you used your assigned strategy, do you feel it assisted you to organise your thoughts, knowledge and information?

☐

Yes

☐

No

(b) Describe how you think your assigned strategy assisted you with this process.

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(c) If you used your assigned strategy, do you think it helped you solve the problem?

☐

Yes

☐

No

(d) Describe how you think your assigned strategy assisted you to solve the problem.

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Problem Solving in Technology-supported Learning Environments

11. How would you rate your success in solving the problem(s)?

☐

Very high

☐

High

☐

Low

☐

Very low

If 'Low' or 'Very low', what was the biggest difficulty in solving the problem?

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12. How would you normally go about solving similar problems?

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Thankyou for participating in this survey  
Gwyn Brickell

**Appendix 5**

*Participant consent form*



Human Research Ethics Committee

CONSENT FORM

**Problem Solving in Technology Supported Learning Environments**

**RESEARCHER : Gwyn Brickell**

I have been given information about **Problem Solving in Technology Supported Learning Environments** and discussed the research project with Gwyn Brickell. I understand the researcher is conducting this study as part of a Doctorate in Education supervised by Prof. B. Harper and Dr. B. Ferry in the Faculty of Education at the University of Wollongong.

I have been advised of my involvement with this research, and have had an opportunity to ask Gwyn Brickell any questions I may have about the research and my participation.

I understand that my participation in this research is voluntary, I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my assessment with the Faculty of Education at the University of Wollongong

If I have any enquiries about the research, I can contact Gwyn Brickell, (42213553) or Prof. B. Harper (42213465) or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457.

By signing below I am indicating my consent to participate in the research entitled **Problem Solving in Technology Supported Learning Environments**, conducted by Gwyn Brickell as it has been described to me in the information sheet. I understand that the data collected from my participation will be used for a thesis and I consent for it to be used in that manner.

Name: .....

Signed: ..... Date: ...../...../.....



## PARTICIPANT INFORMATION SHEET

**Research Title:** Problem Solving in Technology Supported Learning Environments

**Researcher:** Gwyn Brickell

**Background:** The study is being conducted as part of a Doctor of Education degree supervised by Professor Barry Harper and Doctor Brian Ferry in the Faculty of Education at the University of Wollongong.

As an Ed.D student, I want to find out:

- what strategies students use in investigate problems presented in technology supported learning environments.
- how students can be better supported in problem identification.

To do this I am requesting your participation in my research.

**The Study:** During the course of this study I will be asking you to participate in the following:

- a tutorial session on thinking strategies that support problem solving
- a tutorial session on using the CD-ROM *Exploring the Nardoo*
- to attempt and develop a solution for a computer based problem where I will be recording (via audio tape and electronic notebook) and making written notes on your problem solving strategies.
- an interview to discuss your thoughts/reflections on your problem solving processes.

**What you should know:**

- The study will be both anonymous and confidential. In both the analysis and reporting of the data you will not be individually identified.
- As noted on the 'Consent Form' you are free to withhold consent or withdraw consent to participate at any time –

this decision will not have any effect on your participation/assessment in the subject.  
Concerns with the conducting of the research can be addressed to the Complaints Officer, Human Research Ethics Committee, University of Wollongong (02) 4221 4457

Thanks for helping me with this study! If, at any time, you have any questions about the research, please don't hesitate to contact me.

Gwyn Brickell

Faculty of Education  
Building 23, Room 121  
Phone : 42213553  
Email : Gwyn\_Brickell@uow.edu.au

# Appendix 6

## *Individual Action Plans of Participants*

# Participant Action Plans



## Problem 1

# Action Plan CT 1 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem ‘Clicking on river investigations ... chemical pollution’
Problem selection:	listened – grabs problem - reads
Hints	Peter (media reports) - listens - acts on advice
Locate Evidence	Radio report – advertisement - started report then stopped - long break –reading? Planning? Refer to handnotes - continue exploring over right hand side of screen – took samples in river (PDA)
Locate Evidence	TV – Chemical dumping to be fined – views and reads linked media – note in wkbk
Locate Evidence	Radio – Chemical dumping radio campaign – listens – note in wkbk
Locate Evidence	TV – Chemical dumping witnessed – viewed and read linked media – note in wkbk
Locate Evidence	Radio – Chemical disposal policy outlined – listens – note in wkbk Returned to WRC
Locate Evidence	filing cabinet - quick look at headings of articles – no article selected
Locate Evidence	TV board – made notes – looked at two stories in earlier region - <i>... can't remember if I've got it all. It says there's a lot of pollution from the tip and...um...from people actually putting rubbish into the ...well...polluting the water and being caught with it but there hasn't been anything implemented...um...they are saying there's a fine ...um...and there's a policy that's outlined but there's no...um...control on the policy so therefore you would need to actually... the policy that's out there....um...to have some sort of control and have severe fines in place and possible close the trip...</i>  At this point student indicated that the investigation was complete and wanted to prepare a 'solution' to the investigation. (my impression.... Signs of discomfort in student – nervous, uncertainty)
Question	comment from me regarding putting a structure together <i>...on paper or on....</i>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)



Question

advise on using PDA to write

...*in that order*...assuming that public awareness is in place or ....

Question

Me again

...*in point form* ?..

- NOTE**
- student positioned PDA over right side of screen blocking media elements – these were not accessed. On returning to WRC students selected both Radio and TV charts but did not open any articles – when asked later, student replied she “forgot”!
  - little evidence of strategy use

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CT 6 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Strategy Outline	brief review of critical thinking strategy booklet
Introduction	views/listens to guide – selects problem <i>Ok I'm opening up now... I'm going to go straight into the research centre ...Ok, I'm going to the little box called chemical pollution</i>
Problem selection:	listens – grabs problem - reads - highlights key points - paraphrases - writes key points in workbook <i>Ok. I'm going to do as he said and grab and read what it has to say...I'm in the zone 3 tanundra region...."</i> <i>Ok it says here there has been an increasing number of dead fish and I need to find why this is so ...I might see if they have any hints for me ...</i>
Hints	Peter again(x2) media reports – participant accessing media in WRC <i>OK....might go into the newspaper to see if there are any media reports ...</i>
Locate Evidence	Newspaper articles - Acid burns school boy at tip – reads, analysed article by highlighting key points - writes key points in workbook <i>... tanundra region zone 3... OK... its got here acid burns school boy at local tip ... indicates there is a problem with acid... and... by clicking on these articles you can read what it says....Acid is being dumped at the tip in some unmarked drums....</i>
Locate Evidence	Newspaper - Industry suspected of dumping acid - reads & paraphrases - (Participant made list of businesses in workbook while verbalising thoughts – ticked ones associated with acid) - outlines strategy for working towards solution. <i>.... I'm looking at all the articles here...now I'm looking at the one which says industry suspected of dumping acid.... remains a mystery but they're thinking it's the nearby industrial estate...So contractors are illegally dumping maybe...at the tip or into the sewerage system...reading/muttering....just writing a list of the businesses to get an idea of what could be the possible cause ... especially if it was acid related...I'm actually writing all these notes on paper because I find it faster than typing....just looking at that list I might put a tick against the ones that might have acid involved in their processes... where they would need to dump large amounts of acid...</i>
Locate Evidence	Newspaper - "Industry killed fish", says worker - reads - links sewage treatment to illegal dumping in notes (workbook) - suggests possible solution. <i>...now looking at an article on sewerage treatment...reading...OK, it indicates here a problem with businesses being able to have opportunities to breach their conditions for dumping without being detected...so a possible solution would be to increase the amount of time they come out and test their waste...</i>

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>Newspaper - Keep out of river - reads &amp; paraphrases - expresses opinion</p> <p><i>... I'm just going to go back to the tanundra page ... keep out of river article...so, there's dead fish and even consuming the fish there is making people unwell...It seems in the article about the tip, the tip manager wants to put the blame on the industries whereas I guess he can be in control of what's coming in as well ... I might close out of there now and just have a look at some TV reports...</i></p>
Locate Evidence	<p>TV report – Fish found dead in river – views/listens - verbalises process - linked media - reads - highlights sections - notes key points in workbook.</p> <p><i>OK, she suggested to look upstream to see what the problem is..... now going to read some of the linked media... OK, this is the written report of what's just been said...environmental officer involved...people have been warned away... OK, just...going to the next article...</i></p>
Locate Evidence	<p>TV report – Chemical dumping to be Fined – starts to view - stops, then linked media - reads/analyses - -paraphrases - notes in workbook - expresses opinion</p> <p><i>... I might just read it.... Ok so there's going to be big fines if you're caught dumping....it seems to be a problem with people being able to dump without being detected...OK, its got here the chemical substance may have entered the river during recent heavy rain... so its been washed away from somewhere.... possible source of it actually being dumped in the river where its coming from somewhere during...I'll see if I can find out where its coming from...</i></p> <p><i>so, the water authority is looking at setting up regular patrols so that's a possible solution.... OK, many people are not aware that chemical dumping effects both the community and environment so maybe there needs to be a bit more education for the local community...</i></p> <p><i>OK, so they're wanting people who saw anything unusual to come forward so another solution is for the community to be more aware and report anything suspicious...OK, the river environment is going to take some time to recover and is there anything the community can do to help that recovery....</i></p>
Locate Evidence	<p>TV report - Resident's call for Tip's closure - reads - paraphrases - notes in workbook - expresses opinion</p> <p><i>I'm looking at the next.... Going to read the linked media report...OK, it seems the dead fish are in the river near the tip, so it could be wash-off from the tip...chemicals could be leaching from the soil in the tip...the residents want to close the tip but it may not necessarily be the ideal solution...the leaching will still continue....OK, site needs to be regenerated....OK, a possible idea is to actually move the tip away from being so close to the river... that still does not mean that people don't have to dump things properly...</i></p>
Locate Evidence	<p>TV report – Chemical Dumping witnessed – read/analysed – suggested possible reason paraphrases</p> <p><i>I'm now looking at the article 'chemical dumping witnessed' and reading that article now....gentleman is an observer of nocturnal wildlife"...people are dumping at night by</i></p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*the sound of it...so, do they need to have staff at the tip at night?.... Once again asking for the community to come forward...*

Locate Evidence

Radio report – Chemical disposal policy outlined - reads - paraphrases - suggests possible remedies to problem

*Now might go into the radio tapes...in the Tanundra region... chemical disposal policy... might go into linked media for that also....there are storage pits at the tip but people have not been using them...reading....so local groups want council to review its waste policy and it's probably an idea if the community is involved as well...so large amounts of chemicals should be placed in pits for treatment ... so you have to wonder if these pits allow the chemical to be leached into the soil anyway... there an alternative there... interviewer is worried about the site of the tip being so close to the river ... so it is a problem with liquid waste being poured directly on to the tip with leaching and also when there's rains with the hazardous waste going directly into the river...OK, so there's obviously a problem with paying for the waste removal....um.... they're saying it's the responsibility of the local industry but obviously maybe the costs are too high so that's why they're dumping so the government should give them assistance which may mean they won't do it anymore....what can the residents do... OK, if as individuals they put their dangerous chemicals there it could be a problem so there should be fines for individuals and some education as well...individuals when they are coming to the tip there should be some control of them....*

Locate Evidence

Radio report – Chemical dumping radio campaign– linked media

*Going to the next one... this is an advertisement....OK, so this advertisement outlines that people believe that everything gets treated at the sewerage plan...so once again its education... and everyone believing their little bit of rubbish is not going to make any difference ...so that's a good promotion...advertising through the radio... I'm just scribbling on my paper here...*

Locate Evidence

Radio report – Tip poisons nearby river – linked media - reads - paraphrases - forms opinions

*...looking at next article... tip poisons nearby river...tests of the ground-water beneath the tip ...so they've done some tests and it does indicate chemicals that are being stored and disposed at the tip are making there way into the ground-water and then get into the river... its got here the tip has been positioned in an area that once was a wetland so it not a good spot to put it on in the first place ....so, perhaps they may need to look long term and actually move the area where the tip is....it says the residents want to close it down but obviously they need to put it somewhere....*

Locate Evidence

Radio report – Tip chemicals kill fish– linked media – cross referencing with other articles – using reasoning skills to apply to problem

*... another report... this one indicates that empty agricultural containers have also been left at the tip so it seems that a few people are dumping or not disposing of their waste properly.... See what this says...*

*OK, so insecticides have seeped into the river ... so this is saying the fish kill would be a result of that...so, obviously they have been taken to the tip without having being rinsed*

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*and sealed ... and so there needs to be some sort of processes at the tip being sure that has been done so some sort of stamp or seal put on them to show they have been properly rinsed first....*

*So that's all the media ones... let's listen to what the people have to say...*

Hints	Wrong guide - reselects
Hints	Peter - (check media reports) ... recognises a repeat of info <i>... he's just repeating what he has already told me ...</i>
Hints	Tatiana - wrong guide - reselects
Hints	Peter - (filing cabinet - farming , disposal of waste) - acts on advice
Locate Evidence	Filing cabinet – reads list of articles – made correct choice of related articles – reads & paraphrases - evidence of reasoning /thinking about problem in verbal record - notes in workbook - recognises previous articles <i>... haven't yet gone out of the research centre at all ....opening the filing cabinet... looking under farming....just have a look at agricultural run-off and the use of pesticides...OK...so cotton farming are big earners ...so perhaps they should spend some money towards dumping problems ... lots of chemicals at all stages of the farming process ...so they discharge it to natural water policies.... Surface run-off... just want to see if there is anything else under farming practises that I think might be of help to me....that's the same thing I was just reading... OK, I might just go back to see what Peter was saying ...</i>
Hints	Peter again - (preparing report - farming) - acts on advice
Problem Selection	Read problem outline - looks through own notes and strategy booklet <i>Ok' I'm just going back now to have a look at the critical thinking strategy just to sort of ... quickly write out what I feel is going on here...</i>
Problem Solution	Begins to prepare solution - reviews notes - periods of reflection - <i>...what I believe to be the problem... um... so there's illegal dumping and there's problems with... um...</i>
Question	What are you doing now? <i>... I just sort of summarise what I've ... go through the strategy as I've just been writing lots of scribbly notes everywhere...um... I probably could investigate... go back and check zone 3...</i>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan CT 9 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem I’ve just clicked into chemical pollution...
Problem selection:	listened – grabs problem - read - brief notes in workbook <i>O.K. so I need to find possible reasons for the fish kill and prepare a report that details the findings. ...as well as any procedures the community might adopt to fix the problem.</i> Goes to Region - random exploration <i>I’m just going to find some,...click various parts of the screen to see what I can come up with.</i>
Locate Evidence	Newspaper – acid burns school boy - Read & made notes in wkbk – analysed & highlighted small sections <i>“Just reading an article about acid burns school boys at tip ... ”just writing about this article that the dump at the tip... now I’ve lost it...dumped at the tip face instead of the large storage pits... which could be a reason... I’m just going to click somewhere else to see anything else ...</i>
Locate Evidence	Radio – Tip chemicals killed fish – linked media – made notes <i>...read about the tip kill fish ,select media report ... empty agricultural containers left at the tip... just taking some notes down that may help...which could be part of the problem....</i>
Locate Evidence	Radio – Chemical dumping to be fined – linked media – selected ‘bits’ & ‘grab’ – verbalised ideas <i>... media report...chemical dumping to be fined.....muttering ?.....just highlighting some things that I think might be important for this news report....</i>
Locate Evidence	Radio – chemical dumping campaign – linked media <i>...looking at a chemical dumping radio campaign radio advertisement... back to the ‘homestead’ ...see what I can find over here...</i> Returned to WRC
Locate Evidence	TV reports – linked media – selected & ‘grab’ bits <i>....just going to look at TV report on fish found in river... may have looked at before... just check...”</i>
Locate Evidence	TV report – Resident’s call for tip closure -clicking through information - (reading/analysing) <i>...look at chemical dumping...just to see...residents call for tip closure...quick look at this...looking for anything helpful...</i>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>TV report - Chemical dumping witnessed — reads - highlights &amp; 'grab' of sections that were considered appropriate</p> <p><i>... just highlighting some interesting reports and I'll just investigate them ... just having a look at chemical dumping witnessed ... may have looked at already... (clicking through) ..seen toxins ... might highlight that in case its helpful...</i></p>
Locate Evidence	<p>Radio - Chemical disposal policy outlined – reads &amp; 'grab' – comments on checking reports – appear to be the same.</p> <p><i>... just have a look at the radio reports and see what's in this...clicking/analysing....just looking at all reports ... seem to be same ... looking in case there is something I've missed....</i></p>
Locate Evidence	<p>Radio – Tip Poisons nearby river - Read &amp; 'grab' – comment on gathering info &amp; making sense of it later</p> <p><i>...highlighting everything and when I've got a few things will see what I can make of it...just going to have a look at... um....OK, I'm just going to have a look at...the files to see if there are some things in the files that can help then I'll test the water to see happens from there...</i></p>
Locate Evidence	<p>Filing Cabinet. – read , made notes and 'grab' selected 'bits'</p> <p><i>...just have a look in the water pollution...hazardous waste and environment ...have a look.... Pause, clicking/reading...still reading the article about disposal of chemical containers from the water authority .. see what that says...(examining article)...pause...just..clicking...just took a little piece about rinsing of containers to see if I can use it later...checking urban runoff... reference to tip....</i></p>
Hints	<p>Checked Peter again...returned to region &amp; checked for more info</p>
Locate Evidence	<p>water testing – took measurements from 'bottom' to 'top' of screen</p> <p><i>.... just do some water testing I think....check to see if I've got everything.... Check for pH level... pesticide levels... bacteria .....asked me what turbidity was... algae....OK...mutterings.....bottom of the river (screen) checking water levels and making my way to the top of the screen... checking.... pesticides... not much of a difference as I'm going up from the bottom of the screen .... checking for pesticides... seems to be the same ... change in...near dump....just interesting, they are saying that all these fish have been killed but it doesn't seem to be any pesticides from up stream.. down stream... no pesticides at top of screen at river but as I come down river pesticides low, ph levels still on 5... just trying to see if there is something causing but doesn't seem to be pesticides.. quite low really, but its interesting... just seems to be one spot that's low but right next to it.... Bacteria very high....nothing there....just checking to see if there is anything more to check.... Just check just in case... possible problem outside the tip....strange, in a matter of a couple of metres it's low in pesticides ...it changes,low pesticides, turbidity high.... Just about it...feeling that „pesticides low all the way down, hits the tip pesticides medium...problem there, coming from the tip ... because if it was coming from upstream I think it would be higher there.... Fair distance from the ... farm house there, its got low pesticides...as you get in to tip still low ... possible problem</i></p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*starting with the farmhouse, dumping small amount... something entering river from up, there.. as it gets outside the tip ...*

#### Problem Selection

checks problem outline and notes

*I'm just going to have a read of the notes I've taken, what I've highlighted...*

#### Problem Solution

summarises ideas - then expresses uncertainty.

*... I definitely think there is a problem starting about halfway down the river... before there is any sign of pesticides towards the tip pesticides get higher may be getting in the river above the tip and other runoff from tip ... fish dieing down stream not upstream... water bit dirty up there but not enough to kill fish.....*

*Clicking through notes in PDA (reviewing & checking)*

*... OK I've gathered most of my information and I think now I'm just going to basically analyse it all and try to put something together... but how I do that??... interesting... because I've never had to do a report like this before...all new to me .. so I think um.. I'm going to base a lot of it on what I've found in the water because its hard to sort of... test the land ... couple of problems mainly coming from the region near the tip.....solution to the problem is to stop pesticides being dumped for starters um... don't think it should be dumped in local tip unless containers washed first... possible runoff from heavy rain because it said that after heavy rain is when fish are found dead... strange... can't see where else it could be coming from.... Don't really know...*

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Action Plan CT 27 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	listened – grabs problem - reads - headings in workbook <i>...reasons for fish kill....resident’s opinions....ramifications?...</i>
Hints	Peter again – acts on advice - goes to zone - random exploration <i>... look for evidence for pollution...</i>
Locate Evidence	Radio – Chemical dumping radio campaign - listens – made notes in wkbk
Locate Evidence	Newspaper –Keep out of river - read – made note in wkbk – <i>... this just supports initial problem....</i>
Locate Evidence	Newspaper – “industry killed fish”, says worker - reads – highlightessections while reading - made note in wkbk <i>...a possible cause of the problem....</i>
Locate Evidence	Newspaper – acid burns school boy at tip - reads – makes note in wkbk <i>... Problem with illegal dumping at tip...need to try to identify a solution..... so far there’s problems with the tip and sewerage treatment.....</i> Back to WRC
Hints	Peter - listens
Locate Evidence	TV – Chemical dumping witnessed - views/listens <i>...another reason to look at....</i>
Locate Evidence	Radio – Tip chemicals killed fish - reads – ‘grab’ of sections from linked media
Locate Evidence	TV – Fish found dead in river - views – linked media – makes note in wkbk <i>...foreign chemical...another reason....</i>
Locate Evidence	Radio – Tip poisons nearby river - listens – makes note in wkbk <i>...another suggested reason to look at....</i>
Locate Evidence	Radio – Chemical disposal policy outlined - made note in wkbk <i>... council aware of illegal dumping... greater fines..</i>
Hints	Peter again (filing cabinet) - acts on advice <i>... go to filing cabinet...</i>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence                      Filing cabinet –farming reports - agricultural runoff – reads – highlights sections and ‘grab’ to PDA - Then proceeds to select articles at random for general reading – river irrigation, Nardoo catchment, sand and gravel extraction, Logging industry – ‘grab’ on section on runoff – then water pollution – disposal of farm containers – highlights sections and ‘grab’  
Returned to Zone

Locate Evidence                      began chemical testing - Tested sites along river – ‘grab’ in PDA  
*...check chemical pollution in the river....ph.... pesticides, ....oil... salinity... coliform bacteria....*

Problem Solution                      discusses thoughts - vague generalisations - no support from evidence accessed and/or collected.

- Note:**
- **tape recording faulty – no further audio transcript**
  - **no apparent strategy used**
  - **no referral to strategy outline**
  - **aspects of critical thinking approach? Some highlighting and some analysis of media articles.**
  - **little verbalisation of thinking processes**

**Participant frustrated with own inexperience with mouse, selecting info, etc – commented never used a computer until this year.**

## **NOTE**

1.            check each participant for reasoning skills and thinking strategies (define these)

Action Plan CT 16 - Problem 1

STEPS	REFINEMENT PROCESS
Introduction	views/listens to guide – selects problem
Problem selection:	listened – grabs problem - reads <i>... alright I'm clicking on the grab button.....um...I'll go outside and look around...</i> Goes to Region - random exploration
Locate Evidence	Radio – chemical dumping radio campaign - reads <i>...I'm still in the outside area...muttering...</i>
Locate Evidence	TV – Chemical dumping to be fined - views/listens - then reads from linked media - highlights relevant sections <i>...Clicking on linked media reading the script ...then highlight what I think is relevant....clicking/reading article....then I clicked on another area outside...</i>
Locate Evidence	Newspaper – acid burns schoolboy – highlighted bits - ‘grab’ – typed into PDA <i>...then I just grabbed a section of the article and I'm just writing a note next to it on what it is....</i>
. Locate Evidence	Radio – Tip poisons nearby river – linked media – highlighted sections – ‘grab’ <i>...Clicking linked media and highlighting again... I'm going back into the resource centre and looking in the filing cabinet under water pollution ... highlighting and grabbing....</i>
Problem Selection	reads problem outline & notes collected <i>...I'm going back to my notes and looking at the problem again so I can be more specific in what I'm looking at ... and reading ... and refer back to what I've got in my notes....alright now I'm going to look at the... animals to see what sort of things kills the fish...</i>
Locate Evidence	Animal & Plant Book – reads through selection of fish information (10 in total) <i>OK, I'm just going to my notes now and writing a brief note about the fish and what causes problems with them...(types into PDA)..</i> Opens database to search for articles
Locate Evidence	TV - Chemical dumping witnessed – from database – views/listens, then linked media - evaluates and rejects evidence <i>... I'm not going to use that...I'm still in the database and going to look at another report</i>
Locate Evidence	Radio – Tip chemicals killed fish – listens, then linked media – highlights and ‘grab’ bits

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*...I'm highlighting this and grabbing...*

**Locate Evidence**

TV – Resident's call for Tip Closure – views/listens – linked media – highlights sections and 'grab'

*OK, I've just grabbed some information from that report...*

**Locate Evidence**

Radio – Chemical disposal policy outlined - Listens – linked media – highlights sections and 'grab'

*... I'm getting out of the database and just going to look at my notes again....*

**Problem Selection**

Reads problem outline & reviews notes collected

**Problem Solution**

Begins analysing data collected - reviews process for action steps taken - reading and checking....asks question.....my reply.... Types into PDA

*OK, ... alright I've collected all the evidence as I went through and I've revisited the problem... question ... a few times to see what I was specifically looking for and um that was like the chemical pollution in the river...and I looked at...in the reports .. the news reports and um the television reports and that and grabbed the information that I thought was relevant and developed or seen how a pattern was developed in the reports which was the leaching from the tip ... and , then I looked at the fish the information on the fish ... to see what environmental problems could cause their death and ...um... I looked at the residents opinions on the matter and what they proposed to do as a solution... and then in my report I would sum up those ideas and make a general conclusion about what I thought would be the cause of the problem...um...that it would be the tip and the leaching after heavy rainfall because the fish death occurred after heavy rainfall and the solution to the problem would probably be in the general idea of regenerating the area with vegetation...um... having stricter rules in the tip ... maybe not having chemical waste being dumped there... mainly relocating that sort of thing to another area away from the river where it is a health hazard... that's about it.*

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CT 14 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	<p>listened – grabs problem - reads</p> <p><i>So I went straight to chemical pollution and just get information... um I think I might just go straight to the ...site and ... have a look around .. click on stuff...and go to the television, radio and stuff....click on media</i></p> <p>Goes to Region - random exploration</p>
Locate Evidence	Radio –Tip poisons nearby river - replays intro of tape - listens– made notes
Locate Evidence	<p>Newspaper - reads - outlines early strategy - (Big Picture?)</p> <p><i>...I'm not really into gathering stuff at the moment...I just like look at everything first... like pictures and television clips and stuff....to find out what I'm really looking for first....</i></p>
Locate Evidence	<p>TV – Chemical Dumping to be fined - makes notes in wkbk</p> <p><i>...OK, now from TV and radio announcing I kind of know what its more bout so I will probably go back to the ... house ... and look around for evidence for water pollution in the area...if this is the right way to do it...</i></p> <p>Returned to WRC</p>
Locate Evidence	<p>filing cabinet – water pollution folder – water pollution article - pesticides/chemicals - writes short note in PDA</p> <p><i>...this article is about farming and pesticides and stuff ... so that's not really...I guess you could write that down as part of the problem maybe....but now that I've watched TV and the radio I am more inclined to think its about...um...the chemicals .. so I don't think I need to go in there anymore...I prefer to just go straight to something rather than look around in...it might tend to make me a bit more confused...</i></p>
Locate Evidence	<p>Data base search – becomes confused</p> <p><i>... I'm typing chemical dumping and see what I can find...I don't think its found anything so I will go to something else....no, I can't find anything....um....no... I'm a bit confused on this one...I don't think it can find anything...OK, ...so I've got to put in my key words and click on them.</i></p>
Locate Evidence	<p>Clicked into wrong zone/region(earlier in time) and listened to radio report on poor water quality due to sand extraction</p> <p>Realised error and returned to WRC</p> <p><i>OK, I've returned to the resources centre and found the TV reports and there's four here and I'm going to go through them to see what they say...</i></p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	TV – Chemical Dumping to be fined – stops <i>...seen that one so I'll go to the next one...</i>
Locate Evidence	TV – Resident's call for tip closure – made short note in PDA
Locate Evidence	TV – Chemical dumping witnessed – views then revisits task and read
Locate Evidence	Checked animals and plants book <i>...just going to the fish of the Nardoo... I don't know if this will have anything to do with it ... no, its jus tall about the fish so its got nothing to do with the dumping or nothing like that... so I don't need that ...</i> Begins rechecking media reports <i>.... then radio reports. ... don't need to listen to...then newspaper reports (audio reference)</i>
Locate Evidence	Newspaper – Industry suspected of dumping acid - read & analysed – selected sections & 'grabbed' to PDA - discusses evidence <i>...so, if I guess that in a school they were trying to solve this problem on a computer which I don't know if they are or not...you'd be getting close with stuff like this because they are talking about industry estate, the clues and...like I might highlight this bit and ...um...and highlight some industries in the estate create biproducts like heavy metals and other chemicals like acids in the manufacturing processes ...and just save that and go to... this one... go to grab and put it down in there so I've got something from there...and here's another one that's got released the type of businesses... zinc , painting, detergent... battery... don't know whether that would be that important b ut I'll highlight that as well...just from the ...</i>
Locate Evidence	Newspaper – Industry kills fish, says worker – highlights sections & 'grab' <i>...there's a newspaper article here... but that's pretty much what I already know from the TV programs.....golf...OH, I heard that... they want to make it into a golf course...but here they've um... there must be a golf course nearby as well because they've said greenkeepers have extensively fertilized the course etc.... this could be part of the problem as well so get some ideas...because I know that...um... there is something contaminating the water but it could be a couple of things... that has lead me to believe... ok...that's it there...I don't need that... that's a house thing...</i> Returns to Zone
Locate Evidence	used chemical tools to test – ph & pesticides near dump region – then upstream <i>...I might go to the source bit and do some testing but I'm not really sure where the dump is... is that it... so the dump is around here ... I'll take some samples but I'm not really sure what I'm looking for ...pesticides...and ph levels... so I think its around the tip... I got 4.5 and medium but I don't have any idea how that would ... its all pretty much 4.5 although about here its 4.5 and low...upstream so that might have something to do with the flow of water or something....Downstream its medium... upstream it has no pesticides so... put that in to... so the pesticide medium is around... isn't the golf course around here though... that's the tip... is their a location map around here</i>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*anywhere?...alright so I've got those results in the... I can't go in there can I...so I'm inclined to think its ... um... I probably will go back into the house again and...*  
Returned to WRC

Hints	Peter again – reference to media reports - Appears uncertain
Strategy Outline	Review strategy outline - summarises data collected <i>... I'm just trying to think where else I can look for stuff...I know I can look in the filing cabinet but I think that's just all,..um, information about stuff so I probably won't go there 'cause I would have to read something.....nup.. doesn't look interesting... go back to the guy and see what else he has to say...</i>
Hints	Peter (media reports) - listens <i>...he suggested I go to the media reports but I've been to all of them...</i>
Hints	Peter again <i>...well I know there 's fish that have been killed...find possible reasons for the fish kill...looks at notes... well...alright so I'm going to try the poster strategy and work through that...</i>
Strategy Outline	Reviews framework <i>...OK, so I see there's a problem with they're all trying to find the reason for this chemical pollution so I figure the problem is either in the tip or from the golf course um... the most important problem is the fish dying and people getting sick and I've got newspaper clippings from that and like key paragraphs from stuff in the house thing and if I brainstorm possible solutions... I don't know, like this program I sort of feel there might be hidden stuff in this whole thing somewhere that's why I feel I need to check everything out...no answers are wrong well that's good...I will go back to this man...guy in the resource centre 'cause I reckon I 've found most things...</i>
Hints	Peter <i>... he's no help...</i>
Hints	Peter again - filing cabinet - rechecks
Locate Evidence	Checks filing cabinet – farming – agricultural runoff – reads, highlights sections and 'grab' – <i>...so he's told me to go to filing... I wouldn't have thought to go to filing any other way, but... unless it has to do with pesticides and stuff... agricultural runoff...I don't think I need anything on irrigation...</i>
Hints	Peter again <i>...I just remembered he said something about a radio report ...</i>
Locate Evidence	Radio – Chemical dumping radio campaign - listens – makes notes in wkbk <i>...um... I'm just trying to remember which ones I've listened to....</i>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Locate Evidence

Radio – Tip poisons nearby river - revisits – listens – makes notes

*... I was just thinking from that radio... um.. thing it said that the tip was allowed to go over a wetland area and if I went back and looked at a radio report from before if there's one ... you might find out why they put in on a wetland area... I don't know whether these go back in time...*

(asks about going back in time... my response...)

*.... Click house and I'll go to... TV...or is this...OK...*

## Problem Solution

Begins to outline solution to problem based on evidence collected

*... with all my information and everything I'd like I've written some down.. in a flow, map, mindmap kind of thing...about "'ive' got ...um ...the tip is contaminating water ... chemicals from tip...was a natural wetlands... I guess I could research more ... refers to research in library.... I also think chemicals coming from the golf course....pesticides...possible solutions... regular patrols ... my own personal recommendation...fix the dump...*

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Action Plan CT 26 - Problem 1

STEPS	REFINEMENT PROCESS
Introduction	views/listens to guide – selects problem
Problem selection:	listens – grabs problem - reads
Hints	Peter - listens Goes to Region - random exploration of zone
Locate Evidence	TV – Chemical dumping fined – linked media – reads, makes notes in wkbk <i>...chemicals in the rubbish tip...council’s going to impose fines... trying to track it down would be impossible.... OK, what’s this here...</i>
Locate Evidence	TV – Chemical dumping witnessed – linked media - reads, makes notes in wkbk
Locate Evidence	Newspapers – acid burns boy at local tip – reads – makes note in wkbk <i>...pollution in the tip...here...what’s this...it has to be coming from somewhere..</i>
Locate Evidence	Radio – tip poisons nearby river – linked media – makes note in wkbk <i>... so its seeping from the tip... into the river...container of chemicals...tip sited on wetland... not just flowing its seeping...moving tip .... not sure where we are .. definitely away from the river...muttering.... clicking...come around the bend....got the tip...the pollution (testing??)... clicking ... .. muttering....all stems from the tip... don’t think its coming from up here.... muttering.... radio campaign...</i>
Locate Evidence	Radio – Chemical dumping radio campaign – reads – makes note in wkbk <i>...just common sense you don’t detergents or chemicals put down the sink so they are reinforcing that...so... its not just the tip... muttering.... so have to comment on this... Encourage people to deal with rubbish...</i>
Locate Evidence	Newspaper – ‘Industry kills fish’, says worker – reads
Locate Evidence	Radio – Chemical disposal policy outlined - listens
Locate Evidence	TV ..... <i>... council ...spillage...paint is a council problem... chemical dumpers... chemical paint thinners...no fines...doing the right thing here... all boils down to this corner...(refers to notes)... planning...planning to do a major overhaul with using advertising.. really think it needs to be pumped through households and schools councils need to be part of it...TV’s, radios... what am I thinking....well major... moving the dump... without moving the dump or tip think this is major problem here... where would they put it... this needs to be discussed through council and committees throughout the community... there’s enough evidence I think to prove that most of the pollution is coming through the</i>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

*tip which is sitting on the wetland its not just draining into the water its seeping into the soil so its destroying soil as well.. so advertising encouraging the local community to get right in there I think...but where to start... council tips... kids are important I think... using schools... getting kids to have a look around... letters to council...think overall the pollution is pretty bad...contaminated water is not just killing fish but people have to drink from the water ...maybe take in some testing... actually get testing done further than the water,... you could actually ...um... I don't know how you would do it. You would have to get an industry I suppose to go further down and get samples from the bottom of the river...do chemical analysis of all that... chemical analysis of dead fish and surrounding wetlands...OK, makes it pretty hard to actually catch anybody... but if you get proof of the chemicals and what they are you can go back to the source...*

Hints

Peter again – returns to zone for final check – comments on solution  
...OK, I have looked through media reports...

Locate Evidence

CHECK - expresses opinion

*... its not just looking at the dead fish its looking at the water ....a little boy was burnt from a chemical spill at the tip... so its just more than one thing here... its actually an acid burn... how many kids go to the tip... so there alone there has to be a balance of some sort and go back to the industry, the main source and say "hey guys its just not good enough"... clicking... chemical disposal policy... common knowledge the little boy has burns...(reading article aloud)...*

Locate Evidence

CHECK

*...so, there's a campaign to encourage correct disposal of hazards...clicking... I'm reading now through councillor Saxby... I must agree with it... and again... households need to be aware of what they are putting down there drains... councils need to be on their toes all the time...so...pressure, pressure and pressure I think...clicking...just have a look around...there's also uproar over residents calling for immediate closure of the tip .... I believe it is the councils ...but have to find somewhere else to move it... overall I believe the tip is the main source ...industry being able to dump as they wish ... and if we could find another suitable spot move the tip and have industry responsible for their dumping*

Possible Solution

outlines solution based on evidence accessed - generalisations - no support from evidence

*...the solution ... not an easy one actually.. it all comes down to money, time placement.... number one I think industry should be responsible for costs involved in moving and cleanup of the river... council backing and removal of the tip...clicking... ok... there is also an article about children becoming sick after playing in the river.... ok... the evidence is all here in the media reports... how would I evaluate it...(muttering as reflecting on evidence gathered)... it all stems from this bend of the river which is totally the tip... industry having free reign to the tip makes it difficult also... what I would do now is get an action group together with council members, parents students, to see about fining those people involved, also finding looking for a new area for the tip... it might need to be closed down, dredged out, soil removed, the expense should go to the*

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*person who has been tipping the chemicals...above all put a perimeter around...children should be warned not to swim ,not to go near the tip, just stay right away until it was chemically free ...that could take years... use the radio, TV,.... some highlighting - analysis of articles*

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Participant Action Plans



## Problem 2

Action Plan CT 1 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	listened – grabs/reads - - highlighted words/phrases on reread (clarifying problem?) Goes to Region – random exploration
Locate Evidence	TV – Cause of algal growth found – viewed
Locate Evidence	Newspaper – logging linked to weed growth – read – h/g sections(bits)
Locate Evidence	Radio – Logging linked to weed growth – listened
Locate Evidence	TV – River choked by wild willows - viewed
Locate Evidence	Newspaper – Weed Eradication program - read Returns to WRC – TV (6-8), Radio (9-11)
Locate Evidence	TV – Weed growth distresses residents – viewed
Locate Evidence	TV – cause of algal growth found – started/topped
Locate Evidence	TV – River choked by wild willows – started/stopped – linked media – h/g small sections to PDA
Locate Evidence	Radio – weeds cover river ,killing fish – listened – linked media – h/g small sections to PDA
Locate Evidence	Radio – Logging linked to weed growth – started/stopped – linked media – h/g small sections to PDA
Locate Evidence	Radio – Expert warns against weed invasion – linked media – typed in PDA ‘David Abernathy etc..’ – h/g sections
Locate Evidence	Accessing animal/Plant book – random searching/reading – (alligator weed, willows read) – no clear pattern
Locate Evidence	Filing cabinet – water plants/weeds folder – reviews all articles – h/g sections on weed control – reviews own notes and task Returns to region – types into PDA (next to ‘willows’ heading)
Problem Selection	– reviews own notes and task

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>Takes measurements in river – P, N, O, turbidity – top, level with camp, bottom – compares readings – records in PDA (in this order) – goes back in time zone and checks similar positions – repeats forward in time.</p> <p>....well, the evidence is the fact that the logging's occurring and they won't stop logging because they have a five year contract and he doesn't want to put people out of work...find alternative jobs and you can see by taking the measurements of phosphorus and nitrogen over a period of time you can see that it has changed....</p>
Question	<p>So what do you think the logging company is doing to the system?</p> <p>....polluting it by putting all the nutrients into the river from the logging, the weeds and the willows...</p>
Question	<p>Are there any other causes of the problem, or do you think the logging company is the main problem?</p> <p>...just check my notes...the logging company....ummm... the weeds, willows planted... seeds regenerating them...they tried poisoning them but that only causes more pollution of the water....</p>
Question	<p>I noticed you didn't talk through the process</p> <p>...(laughs) ...no, because I was too busy thinking and I thought if I start talking I'll confuse myself and lose my train of thought</p>
Question	<p>So, you think the talking takes away from your train of thought?</p> <p>..yeah ...</p>
Question	<p>The strategy that you were using...what do you do? What strategy do you use in problems like this to help you come up with an answer?</p> <p>...my own strategy, I look for key words...key things....I group them all together and go back and revisit ....the question and revisit what I have grouped together and see what's irrelevant and just take out what's not and make an opinion from that.....</p>
Question	<p>Do you think the critical thinking strategy helps you in clarifying your ideas?</p> <p>...I didn't look at the book, sorry.</p>
Question	<p>I just see that you are doing things that resemble that strategy.</p> <p>...oh' right ....after the information gathering process, I analyse it.</p>
Question	<p>Do you think about the process as you analyse the information? What do you do when you are thinking about those things?</p> <p>...well, I think about the question, making sure that I'm analysing what the question says rather than going off on the wrong track...sort of constantly revisiting the question to make sure I'm on the right track.</p>
Question	<p>When you were highlighting and grabbing sections, what was the purpose of you doing that?</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

...they were little key things just so I could go back to later to revisit.

Question

Were they little sections of supporting evidence?

Yes

Question

So, when you had an idea coming into your head you took sections to support the ideas?

Yes, that's why I also got the persons name who said the statement

Question

So, you could reference it later

Yes

Question

Is there anything else you wanted to add?

No

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CT 6 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Strategy Outline	brief review of critical thinking strategy booklet
Introduction	views/listens to guide – selects problem
Problem selection:	Tatiana - listened – grabs/reads - notes key points in workbook ... just going to see if she has anything else to say ...
Hints	Tatiana (measurements/fisherman) - acts on advice - note in workbook Goes to Region - random exploration
Locate Evidence	TV – Cause of algal growth found - Linked media – read aloud – note in wkbk. ...got a media report ... fisherman has identified a possible cause of the problem....weeds are greener near the logging area.... Waste water coming out...
Locate Evidence	Newspaper – Weed effort Fails - reads & paraphrases ...residents are trying to clear the weeds... that's one solution they've tried....spent two days clearing it....already growing back... Looks like there are a lot of them along the banking area.... spreading elsewhere... they've actually been introduced.. not native... erosion....more problems...
Locate Evidence	Radio – logging linked to weed growth - Linked media – analysed/note in wkbk - poses questions ...just now reading the article logging leads to weed growth ... this logging operation is linked to the spread.... So they're willing to help... so they've done some water quality tests... below camp contains more nutrients than above....so they've put there main camp facilities near the river... got the sewerage draining directly....question is whether they are the only cause....they're not going to stop their logging.... going to be employing more people.... Does that mean there is going to be more facilities therefore they need to start thinking where they might put these facilities?... alternative ways to deal with the sewerage so it is not going directly into the... if they are going to be there for fifty years...
Locate Evidence	Newspaper – logging linked to weed growth – read – note in wkbk ...reading another article logging linked to weed growth... scientists has got some findings ... samples of water and weeds from the worst effected areas... he believes the logging company has contributed to the growth...excess nutrients below the site...phosphorus and nitrogen....present in higher than normal concentrations (note in wkbk)... so his suggestion is that these chemicals have to be prevented from entering the river....he wasn't able to determine the actual source of the nutrients....so, in thinking of a solution that is one of the first things you have to do because that is what is going to determine a cause of action....

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence	Radio – Weeds cover river– linked – notes in wkbk Reading another article.. weeds cover the river killing the fish...muttering.... So up river it's thinning but the river is muddier... I don't know if that is significant at this stage...
Locate Evidence	Newspaper – Farmer doubts beetle solution – read ...there is a suggestion of a solution here about the beetles...just eat all the weed... concerns about introducing something.... Always related problems later.... Initially solve the problem but create more in the long run... another person suggesting spraying.... While other methods of controlling the weed are available.. the beetle is the choice favoured by the government... you have to question why... is it cost related?... spraying... there might be other problems with doing that... Back to the hut now... Returns to WRC
Hints	Tatiana (measurements/fisherman) - recognises prior access ... I've spoken to the fisherman ...
Hints	Tatiana (filing cabinet- animal/plants, archives) – acts on advice
Locate Evidence	filing cabinet – reads articles on weeds - note in wkbk - reads & paraphrases ... found along stationary and slow moving water...duck weed is an indicator of high nutrient waters.....
Locate Evidence	Checks TV reports – wrong region – recognises & corrects ...go back to ....I'm in the wrong region here....Merrimurra....actually a variety of weed species... just going back to find out what weeds they were...
Locate Evidence	Checks TV listings – rereads sections - paraphrases Cause of algal growth found...river choked by wild willows.... Logging company planted those willows.....mistake to use those...logging company is going to be expanding over the next five years they definitely should not be planting any more of those and even be taking measures to remove those that they have already planted... just going to zone 2 to see what .... Reads ... . Not relevant to what I want.....cross into zone 2... .no....
Hints	Tatiana (journal/presentation) - not relevant, so ignores advice
Locate Evidence	checks radio reports - reads ...got all of these.... solution to the alligator weed... check machinery ... alligator weed and salvinia...controlled by weed .... no point attacking the weeds if you don't deal with the problem that's making them grow ...
Hints	Tatiana (measurements/fisherman) - ignores advice (not relevant?)
Hints	Tatiana (filing cabinet - plant/animal book) - acts on advice

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>Filing cabinet – animal/plant book – checking information on weeds</p> <p>...filing cabinet....just ....the alligator weed to start with....so...biological control...chemical spraying... limiting nutrient flows.....salvinia....growth in slow water... lots of nutrients....</p>
Possible Solution	<p>Begins analysing evidence from personal notes in wkbk - develops a solution</p> <p>...solution... need to define extent of problem...possible causes... does it need intervention... possible control measures... cost... short and long term effects....</p> <p>Harvesting the weeds....water level management ... so does that mean if they manage the water level it will be free flowing so the weeds won't grow there because they like stationary water....before entering that area they might have to prohibit the area for a while.... Biological control needs a lot of research...to attack the problem the water species... (notes in wkbk)....a control could be permanently biological....don't want any biological...we can manipulate the water and nutrient levels.. physically remove the weeds... improve the flow of the water....</p> <p>....associated with any of the solutions you came up with... increasing the flow can cause erosion of exposed and weakened banks....use of herbicides could contaminate the ground water....problem here with alligator weed and salvinia that's because of the nutrients especially ....muttering.... that problem where the nutrients are coming from...the willows have been introduced by the logging site... machinery may have the weed... the logging site are prepared to help...so that's good.. but they wont be cutting down on the logging and possibly expanding... so solution... relocate facilities so they are not pumping sewerage in the river and when they expand they should build them elsewhere... pumping system where sewerage gets taken away... look at the cost of moving the willows... investigate the use of native plants to stabilize the banks with no long term negative effects... now...( looking at notes)....if they deal with getting rid of the nutrients then they can physically get rid of the weeds again...that should help....I'm not so sure about... they could set up a study to determine the effectiveness of the beetle....(notes)....also just need to determine that its just actually the sewerage that's causing the phosphorus and nitrogen...is there anything else at the logging site that's causing it....(notes).....muttering....clean their equipment....muttering....finishes..</p>
Question	<p>What do you think the problem is?</p> <p>....I think that obviously the problem is the weed and they are growing abundantly and choking the area and my feeling is that one the nutrients (nit much higher than normal and that seems to be related to the logging site....</p>
Question	<p>I noticed you never actually took any measurements, is there any reason for that?</p> <p>(Short laugh) ...yes, there is a very good reason for that...on the first day that we actually played with this I spent the whole hour taking measurements ...(short laugh)...and I just didn't find it an effective use of my time ...I was hoping that I could find through read ... if I didn't find what those nutrients were through the</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

printed media then I would have to go back but I was avoiding doing that straight away because I knew I was wasting a lot of time doing that ....so I find I learn much better with written information...

Question

Is this the way you normally go about solving problems?

....um, yes I think ...yes I don't think I would do anything differently...just gone with what I'd do anyway, even though I've read the critical thinking.. I've just reverted back to what I would normally do anyway.

Question

Did the strategy help you focus your ideas better or clarify the problem better for you?

...yes, I think that ...really the strategy just clarified how I should go about it and that's why I kept going back to sort of look at how I should start.

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CT 9 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Tatiana – selects problem – reads aloud – note in wkbk ...just going to write this down – main causes and actions to reduce growth Goes to Zone – random exploration ...just having a look at the location in river
Locate Evidence	TV – Cause of algal growth found – linked media read
Locate Evidence	Radio – Weeds cover river, killing fish - linked media – reads & paraphrases ...interview with Mr Sam Chang ... so Sam Chang has noticed weeds....greener and very matted... growing wild...rereads... ...in the stiller areas weeds are more of a problem ...up the river they notice a thinning of the weed and it is more muddier....upstream more muddier and thinning (note in wkbk)... something possibly happening and moving downstream... I'll look up top of screen....just checking to see...
Locate Evidence	Newspaper – Weed Effort fails – reads sections ... weed effort fails residents ... moved from one area and grow somewhere else... in the area where its been cleaned it is already growing...
Locate Evidence	Newspaper – Farmer doubts beetle solution - reads ...someone has introduced this plant and they want a beetle...just going to look at the TV reports... Returns to WRC - wrong region – begins reading article recognises mistake selects correct region....
Locate Evidence	TV – Weed Growth distresses residents - linked media - reads ...scientific testing of water samples could pinpoint the problem....that's my opinion as well... muttering (reading)
Locate Evidence	TV – River choked by Wild willows - linked media - reads ...wild willows - -see what this has to say....weeds were originally planted by logging company.....Reads article aloud.....what she's saying is right...maybe they are breaking off and spreading... now radio reports....
Locate Evidence	Radio – Weeds cover river, killing fish – started/stopped – linked – read
Locate Evidence	Radio – Expert warns against weed invasion – linked - read .....muttering (reading)...where did it come from.....South America...how did it get there... reading aloud.....ideas from David...so, there's a few theories there...continues to read ....just going to see...

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Hints	.Tatiana (measurements/fisherman) - ignores advice
Locate Evidence	<p>goes to filing cabinet – first four articles accessed and read  ...just having a look in the file to see what is says... look at the water weed identification.. start with what it is....weed control...</p> <p>...just sort of looking around to trying to find out as much as I can about these weeds... what it is ... and then look have at the water ... see if I can find out if there is anything in the water that is causing it...thinner upstream then it is something going on upstream and bringing it down....look at these water plants...</p> <p>...Close this ....go and have a look and do some water testing to see if I can find anything...</p> <p>Returns to Zone</p>
Locate Evidence	<p>measurements - selects tools – begins moving down river from top of screen  ...test for coliform bacteria, pesticides...don't want to look at that..., nitrogen, oxygen, ...those levels are up... salinity, algae, river flow rate, check them all....</p> <p>Tape corrupted/faulty ???no recording for remainder of session – remainder of data based on observer notes</p> <p>Top – gradually moves down – looks at changes in readings – records in PDA – makes visual comparisons  Creek intersection(camp) – moves into creek (audio reference to algal count/nitrogen levels)  Downstream – comment on algal count – ‘roughly the same...’  Creek intersection – comment on flow rate ‘river flow slowing’ – ‘algal count and nitrogen high’ – makes comparison between readings  ‘little difference in river flow and algal counts together’ ... ‘go back upstream to check’ ... ‘lower readings’ ....(above camp)  Returns to WRC</p>
Locate Evidence	Animal/plant book - brief look
Locate Evidence	TV – cause of algal growth found – 2 <sup>nd</sup> time – reads linked media ...‘maybe that’s why....etc’
Locate Evidence	Animal/plant book again – comment on finding the right plants ....‘just checking something’ ...
Locate Evidence	rechecked TV media reports
Hints	Tatiana (measurements/fisherman) - ignores

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Problem Selection	<p>checks task &amp; quick look at own notes</p> <p>'I'm trying to find out what weed it was...'</p> <p>Returns to Zone</p>
Locate Evidence	<p>Checks some measurements again - makes inferences about camp and cause of problem based on measurements</p> <p>... just checking ....closer to those little houses ...</p>
Problem Solution	<p>checks own notes and begins to outline solution</p> <p>...I think the problem is ..etc...'</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan CT 14 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	listened – grabs/reads - rereads & highlights sections of text ..... just identifying the problem and writing down what I need to find ... the main problem and the actions needed to reduce it....go and have a look at the TV reports.....
Locate Evidence	TV – weed growth distresses residents – viewed
Locate Evidence	Radio – weeds cover river, killing fish – listened – note in wkbk
Locate Evidence	Filing cabinet .....just have a look in the filing cabinet...weed control options.... Define extent of problem....determine the possible causes..... financial cost involved... quite costly...
Hints	Tatiana (measurements/fisherman) ... go into these other areas.... Goes into Region – random exploration
Locate Evidence	Newspaper – weed effort fails – read
Locate Evidence	Newspaper – logging linked to weed growth – read – note(s) in wkbk ... just writing down the main cause...what I’m trying to see is the main cause of the pollution and stuff....articles on algae and weed ... logging company has something to do with it....excess level of nutrients has contributed to the growing of weeds... I guess I could take some samples in the river...P & N...just write down logging increases P.....
Locate Evidence	TV – cause of algal growth found – viewed – note(s) in wkbk .... he said... with the weed ...its due to the sewage from the house...
Locate Evidence	Newspaper – farmer doubts beetle solution – read – note(s) in wkbk ...I’m just looking at a possible solution... beetle could help...spraying is expensive...I’ve got a couple of ideas...at the moment the beetle is favoured by the government...
Locate Evidence	Measurements – P/N/algal counts – audio reference to Poster strategy I might take some quality control things...P, N, ...top of the river...50/150 ...middle...around the logging camp...170/700...about the same...might also check bacteria and algae...algae counts are the same....bacteria high around the logging and algal count increase dpwn the river...100 at the top...500 around middle of river...guess if I was going through the poster strategy there are a few

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

problems and the most important of them is that the camp seems to be the problem....I guess I'm up to the solution part now as I've gathered most of the information I think..... might go back to the house thing...

Returns to WRC

Hints

Tatiana (plant/Animal) - acts on advice

Locate Evidence

filing cabinet – waterplants

I'll have a look at the water plants because that's what she suggested...she actually said that water plants are important but another possible problem might be its not the water weeds that ....creating the problems...

Reference to poster strategy

...it says here that ...about the solutions ....several times that spraying is too expensive...and this beetle...I don't know that I'd introduce a beetle without extensive testing.....might go back to the region and have another look...

Problem Selection

Refers to Task outline - rechecks own notes - reflects on data for short time (approx 2 minutes)

Returns to Region

Locate Evidence

Re check of media reports in area

....also in here .....another point is that they were trying to pull out the weed and was only making a bigger mess....don't know whether pulling out the weed is the thing to do...

Problem Solution

Begins to outline ideas

....I...guess on the program the media and that have given you a few options as to how to approach the problem.... Identifying the strengths and weaknesses of each way in dealing with the problem...spraying too expensive.....shall I keep working through this?

Question

Do you think you have all the information to solve the problem?

Well...like I could make a guess..

Question

Who do you think is the main culprit?

...I guess the logging company...

Question

What's the main problem?

... the way the weeds growing around their area and downstream

Question

what's causing the weeds to grow quickly?

... is it the housing...the sewage runoff...

Question

You also did some phosphorus and nitrogen tests, but there are some additional or associated problems with that. You mentioned possible causes and remedies...you mentioned the beetle. Were these important?

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



I think I said that wasn't a very good idea just bringing in a beetle and just pulling out the weed doesn't seem a good idea...

Question

Do you normally go about solving problems of this nature in the way you have done?

Well...I like having this here (indicates critical thinking strategy) ...you mean the strategy? .Y eah, you could have a look at that and think ...oh, yeah, I'll write down some possible problems and then think about the solutions whereas I'd probably sit and think "what questions do I need to ask?" and what do I need to do? ...

Question

So you think that strategy has helped clarify the problem for you...

Yeah, so when you are looking at a program like this and there are different solutions. but no one(solution) that you should go for like there's ...I think its easier to follow something like this and just see where.... none of your ideas are wrong to write them down and see what you think...

Question

If you didn't have that strategy in front of you how would you go about this anyway?

...I think I'd be a bit lost because I'd be looking around , writing things down ...probably get stuck and probably not got to a solution ...I probably wouldn't try to get a solution myself whereas it says here to select one and try it....so, I guess I'd select...pick one like spraying and go back to that and say no that's too expensive and may not work.. it sort of encourages you to keep on going with it....

Question

I notice that when you started you did some general looking around in the Water Research Centre, is there any reason for that?

I didn't want to go straight out at first because it's a bit...you get a bit bogged down...and you can look at things all over the place, whereas if you look at things in the WRC you know what you've looked at...

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan    CT 16 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem selection:	read - grab
Hints:	Tatiana - acts on advise
Locate Information:	Plant & Animal Book – looked through list - background reading?  "First, I'm going to go into the plants & animals...just have a look through the folder and see how they reproduce.... what sort of things that can cause plants to grow quicker...O.K... now I've read a few of them I'm going to go to the river..."
Locate Information:	Region – takes several measurements  "...I'm going to test parts of the river....in different areas of the river....pH all around seven...now the temperature....now the phosphorus, nitrogen, oxygen and salinity of the water so I can compare the results in different parts of the river ... top of river before development begins ..... the amount of phosphorus, nitrogen, oxygen and salinity is lower...the oxygen is 100%...so, the quality of the river as you go downstream gets worse...I guess that's because of the development and the growth of plants and weeds in the water...I'll go back to the centre and look at the TV reports.
Locate Information;	TV – Weed growth distresses residents – viewed – linked media – h/g sections  " ....put that into my notes so I can refer back to that.....the thing that stands out is that there are different types of weeds so its going to be hard to control different types of species....."
Locate Information:	TV – Cause of algal growth found – viewed – linked media – h/g sections  "...I'm going to grab that too....some of the stuff Sam Chang said about the weeds...I'm highlighting that...."
Locate Information:	TV – River choked by wild willows – viewed  "...don't really think that's part of it....."
Locate Information:	Radio – Weeds cover river, killing fish – listened – linked media – h/g  "... I'll highlight the bits that are most important....densely covered areas of the river fish and eels found dead.....near camp river muddier...I'll grab that...."

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Information: Radio – Logging linked to weed growth – listened – linked media – h/g

".... I'll highlight this... a few important bits I think... Water quality tests have shown that the river below our camp contains more nutrients."

Locate Information: Radio – Expert warns against weed invasion – listened – linked media – h/g

"....I'll highlight things he said and grab it... ...now that I've got these news reports I'm going to go through them for the different species of plants that were named in the area of the river ...and then go to the plants and animal book again and look at the type of habitat that they best survive in and see if I can find any linkages...

**Problem:** reads - reviews notes

"...alligator weed... salvinia... "

Locate Information: Animal& Plant Book – reads

"...alligator weed...I'll highlight this and grab it....there's salvinia, I'll grab that....I've grabbed a few species that have been mentioned in news reports now I'm going to check the habitats....all these plants show the same sort of characteristics... all live in slow moving bodies of water with high nutrient levels...all fast reproducers...can cause death to fish and other organisms and lower the water quality.....I'll go back to the 'map'(Region) to see the causes of high nutrients in water.. "

Returns to Region – random exploration of media

Locate Information: Newspaper – Weed Effort Fails – reads & evaluates

"... says here the residents tried to clear the area themselves but I don't think that's very effective because plants produce really quickly if there are one or two bits left in the water...."

Locate Information: TV – Cause of algal growth found – started/stopped

"...I've listened to that...."

Locate Information:: Radio – Logging linked to weed growth – started/stopped

Locate Information: Newspaper – Farmer doubts beetle solution – read

"...just discusses using a beetle to eat the alligator weed ...I'm going to grab that....residents against it ...related to the cane toad...I think there's a problem with it because it says ,in a radio announcement I think it was, that its a really

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

complicated problem because to kill of one species another species could take over"

Locate Information: Newspaper – Weed Eradication program – read

"...single node can start an outbreak...."

Locate Information: Rechecks several media elements – TV, Radio, Newspapers

Hints: Tatiana(x3) – (measurements/fisherman), (animals/plants),(presentation guide)

Possible Solution:: discusses ideas for preparing sol'n

"... well, after checking all the media I'd probably start writing notes about....to start categorising the common things, like the problems with the local residents...what they think is the problems and I'd talk about the solutions they are trying to come up with and what they have done and the faults with them and why they haven't worked...then I'd look at the types of species found in the area and the type of habitat they are found in....to try to kill them off, probably look at ways of changing that environment so eventually they die off... that's probably it....as for whose responsibly, I'd refer back to the media and look at the logging and house sewerage problem and look at the results of the tests in the river, like the pH levels and all that sort of thing.... and see how there related to where the development is and compare them with results up the river where there is no development.... Probably make the conclusion that the development and the outfall in the water is causing the weed to grow rapidly because its causing ideal conditions for the weed to grow..."

Question: Is this the normal way you go about solving problems such as this?

" Probably, I don't solve many problems like this ..."

Question: Do you think the ideas associated with this strategy have helped you in clarifying the problem better?

'Yes, because you go back over it...you collect all the evidence, review it, check the problem again and see how it relates to the main ideas..."

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan    CT 26 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem selection:	views - grabs task - reads - goes to Region - random search
Locate Information:	Radio – Weeds cover river, killing fish – listened – note in wkbk
Locate Information:	TV – Cause of algal growth found – viewed – note in wkbk
Locate Information:	Newspaper – Weed effort fails – read
Locate Information:	Radio – Logging linked to weed growth – listened – note in wkbk – linked media – note in wkbk
Locate Information:	Measurements – P, N, O readings taken from top to bottom – general scan and visual comparison
Locate Information:	TV – River choked by wild willows – linked media – note in wkbk Returns to WRC
Hints:	Tatiana – introduction again
Locate Information:	Checks Newspaper reports – general reading
Locate Information:	Radio – Expert warns against weed invasion – listened – note in wkbk – linked media – note in wkbk
Problem:	Refers to task then goes through own notes and adds to them
Locate Information:	Animal & Plant Book - water plants /weeds folder – alligator weed – read – note in wkbk
Problem:	Refers to task again – reviews own notes (clarifying/summarising ideas? - writing in wkbk)
Hints:	Tatiana - returns to Region
Locate Information:	TV – Weed growth distresses residents – linked media – note in wkbk Returns to WRC
Locate Information:	Newspaper – Logging linked to weed growth – read – note in wkbk Reviews own notes Indicates completion of problem.

NOTE

1.        check each participant for reasoning skills and thinking strategies (define these)

**Possible Solution:** ideas for preparing sol'n

Question: "Just finding out where it (problem?) is ..like problems, contributors come from the narrow channel....cutting down the trees, all the nutrients are getting released...can't stop that because you can't stop progress...what you can do is look into research on how we can prevent all the nutrients getting into the river So you think the main problem is from the nutrients released from the logging camp?

"Well, its not just the logging its also the fishing boats carrying the weed up and down the river...its really a big problem...you need to look at everything and try to prevent it before it happens.. "

Question: Why didn't you talk through the process today?

" I don't like that machine (the taperecorder) ..."

Question: Why, is it a conscious thing?

"Yes, it is...I usually talk as I am writing but I knew it was there...if it was behind a petition I might have been a little more open...

Question: When you are solving problems of this nature on your own, is this the normal strategy you would use?

"I do like pen and paper...I do like to read through everything that I can find and just jot things down and go back to my draft and do a concept map and work out my conclusion....

Question: Do you think the critical thinking strategy helped you?

"Yes, very much so... because you really need to think the why, what, when, how ..."

Question: So you think the strategy helps clarify or clear up your ideas?

"Yes, definitely...."

#### **NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan CT 27 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem selection:	listens - grabs problem - read - note in wkbk
Locate Information:	Database – weed species –brief review - note in wkbk - goes to Region - random exploration
Locate Information:	Newspaper – Logging linked to weed growth – read – note in wkbk – reread – h/g sections
Locate Information:	Measurements taken Nitrogen - scan from top to bottom of river – general comparison of figures Phosphorus - scan from top to bottom of river – general comparison of figures
Locate Information:	TV – River choked by wild willows – viewed – note in wkbk – replayed – note in wkbk – read linked media
Locate Information:	Newspaper – Farmer doubts beetle solution – read – note in wkbk – h/g sections Returns to WRC
Locate Information:	Radio – Weeds cover river, killing fish – listened – note in wkbk – linked media – reread
Hints:	Tatiana – (measurements/fisherman) - acts on advise
Locate Information:	Filing Cabinet - water plants/weeds folder – reads articles on identification, weed control, waterplants, alligator weed – h/g sections from each Logging industry folder – runoff, environmental impacts - reads
Locate Information:	Newspaper – weed effort fails – reads – h/g sections
Hints:	Tatiana – (animals/plants) - acts on advise
Locate Information:	Filing cabinet – waterplants - reads
Locate Information:	Animal & Plant Book – random search
Problem:	Refers to Task - rereads
Locate Information:	Radio – Logging linked to weed growth – linked media – reads  "Seems to be the logging company planting trees,...willows...and the sewage from the camp... "

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

<b>Problem:</b>	Refers to Task - rereads - reviews own notes ( both PDA & handwritten)
<b>Possible Solution:</b>	<b>outlines</b> ideas for solution
	"I think there is a couple of causes....there's these willow trees that they plant...also when the branches break off it creates more problems....
<b>Question:</b>	So you think the main cause was the logging company?
	"Yep, for sure...."
<b>Question:</b>	What evidence is there for that?
	"They've actually planted these trees....plus , ...the guy talked about where they have established the logging camp and possible problems with runoff...he's more interested in getting his quota for trees... ... in regards to controlling it, the government wants to use a flea beetle but a lot of people are scared of that and may have to resort to pesticides which would be worse."
<b>Question:</b>	Is this the normal way you would go about solving problems or trying to solve problems like this?
	"Normally I'd get information from all sorts like the newspapers, radio and television but sometimes newspapers and media make their own stories up... "
<b>Question:</b>	Did you find the critical thinking strategy helps you in clarifying the problem?
	"Yes...I just...you have to think laterally about a lot of things but it depends on what your thinking... "
<b>Question:</b>	You weren't talking through the process as you were working through it, is there any reason for that?
	"There was a conflict between thinking about something and talking about it at the same time... reading and trying to navigate and talking about it at the same time was difficult...."

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)





# Problem 1

Action Plan    SH 2 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem Selection:	listens - grabs - lists key points in workbook
Hints:	Peter 2 <sup>nd</sup> time – made note in wkbk - comments on process Goes to region - random exploration
Locate Evidence:	Newspaper – Industry suspected of dumping acid – read – note in workbook
Locate Evidence:	Newspaper – Acid burns school boy at local tip – read - continued exploration of the zone
Locate Evidence:	Radio – Tip chemicals killed fish – listened – note in wkbk - pauses (thinking?) ..‘hmm’...
Locate Evidence:	TV – Resident’s call for tip closure – viewed – made note in wkbk
Locate Evidence:	Radio – Chemical dumping radio campaign - linked media - read - highlight key points and 'grabs' in PDA - comments on tip umm,... the tip's down stream ...
Locate Evidence:	Radio – Tip chemicals killed fish – listened partly - recognises previous access ... I need to go back and find what my task was again ... I'll go back to the WRC and perhaps save it in my notes...
Problem Selection:	reads - refers to notes (PDA & workbook) - checks 'hat' strategy
Strategy Outline	brief check - reviews own notes  ‘ umm, I’ve got a few bits of information just by going around the site and clicking ... some reasons why the fish are dying and also ideas to stop it. I’ll go back to the filing cabinet in the Water Resource Centre. Returns to WRC
Locate Evidence:	Filing cabinet – water pollution - disposal of farm chemicals – note in wkbk "... water pollution... OK ... disposal of chemical containers...that’s one of the reasons they think the fish are dying... I’ll read this ..." pause - (reading, talking to oneself)
Locate Evidence:	TV report – Fish found dead in river – viewed/listened

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence:	TV report –chemical dumping to be fined – viewed/listened
Locate Evidence:	TV – resident’s call for tip closure – viewed/listened
Locate Evidence:	TV – witness to dumping – viewed/listened – notes in PDA - reflects "Hmmm" – thinking?
Locate Evidence:	Radio – council waste policy – listened briefly, then moves on.
Locate Evidence:	Radio – Tip poisons nearby river - listened
Locate Evidence:	Radio – Tip chemicals killed fish - listened
	"They've sited the tip in the wrong place... I don't know... I'll go into the tip to do some testing.. the tip's around here isn't it? - returns to Region
	Asks me confirmation of where tip is – talks about uncertainty in what to do.
Strategy Outline:	brief look at 'strategy'
	"O.K. ... I want to put this into my notes... do I click.. will I test the pH for acid levels? ...I don't know what high or low pH means ... what's turbidity? Is that water movement? ... cloudy? ... do I look at all of these...I don't know.... Don't know. I'll look at them all then... alright, I don't know what I'm supposed to be looking for with water testing ... OK, I've got some evidence to suggest that the tip site is probably not very well placed...."
Possible Solution:	begins typing solution into PDA. Refers to notes in PDA & workbook. States causes for fish kill and procedures to rectify situation
	"O.K. ...um.. so I've gone into my notes ....just a conclusion on why I think fish are being killed ...O.K. .. um...can't spell.... Um....(typing)... (reading notes) ... (typing) .....(reading notes).. ...typing.....um.....typing.....etc....(repeated process several times)....can't remember who suggested it...um...can I save this and go back to where I found it ... I think it was a lady... ...water resources centre, I'll go there."
.Locate Evidence:	TV - Resident's call for Tip Closure - views - replays
	" ... regenerate the site..."
Locate Evidence:	TV report – residents call for tip closure - views - continues typing in PDA - indicates completion of task.
	"... is that alright? ... I don't know.... I think I'm done ..."

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan SH 3 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem Selection:	<p>listens - grabs - reads</p> <p>"OK so I'm now clicking on the grab button like he said and having a look....pause...OK so I'm going out to zone 3 Tanundra... so I'm going to go down the banks... and see where I might find some information in the centre... just get rid if that first...could be where the kids are.....and I'll listen to the TV...."</p>
Locate Information:	TV Report – Fish found dead in river
Locate Information:	<p>Newspaper – acid burns school boy at local tip</p> <p>" OK ... I've clicked on the screen and I've looked at a media report that talks about students being burnt by acids at the tip and it talks about illegal dumping after hours .... I wonder.. if I look at areas around the tip and see what around it and test it..."</p>
Locate Information:	<p>Radio – Tip poisons nearby river - listened and made note</p> <p>"OK, so the site of the tip obviously isn't suitable either because of the ground water seeping underneath and that's causing pollution... OK, going further down river..."</p>
Locate Information:	<p>TV Report –fish found dead in river</p> <p>"OK, so probably it would be interesting to do tests on the different areas that are effected... I'm sinking here ...seeing I have no science background here this is really , .....O.K. pesticides might be a good one ...so I'll start... that's the township...I wonder where the kids were exactly ... can you find out where the kids were fishing from or have I actually found that out because I have a feeling it was around this area near the dump.... I'll just scan down here to see where the pesticides are strongest ...ok...they start a little bit below the township they're low oops as you are going down it changes does it ok... adjacent to the dump its medium .. medium level.... ... is that some sort of mining that's going on there...is that some sort of mining?..... you're not going to tell me are you!... if its medium level pesticides from...adjacent to the dump.....and using my red hat what are my feelings about this...well I'd straight away think it's the dump especially from the report that said water is leaking from underneath... water is seeping underneath the dump site... unsuitable site... however seeing that it starts upstream... although that could be from the town as well....from just runoff in the township.... OK. ... they are noticing an increasing number of dead fish so... whatever is happening is on the increase ....</p>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

**Problem:** Looked at notes/task in PDA –

"OK, Using my green hat what is possible?....

Using my white hat what is the information? Well the information is...looks like the dump is in the wrong place and the green hat would be to find a suitable place to relocate the dump if that is at all possible ... can't relocate a dump to somewhere there is wildlife...what's over in this area...

Dumps are always a problem in any town ... sewerage plant there as well...could be another.... O.K . As you move further down the river you find other areas that could be the possible cause. However if I look at the pesticides, readings low... medium, ...ok, seeing the other pesticide readings start at medium around the dump it would be more likely if the rivers going this way that it would be coming from here or maybe its both. ...Um... I don't know... totally lost... ok, now what I'm going to do is go back because they said if you need help go back here and .....um... is this the fellow?

**Hints:** Peter - listens - acts on advise

"That's just what I've done...ok..that's the secret....ok, if I go back...where was I Peter again... how do I get back?....so... I fell into the trap of finding some information but then I'm lost with the information I've got so I decided to go back to the ...um... home place... and ask for help and he suggested going through the media reports ...ok, alright, so I'm going to go back to the home and going to .... wallaway, no tanunda...um... ok, so this ..."

Returns to zone 3

I'm now into... so I should probably look at all the reports..."

**Locate Information:** Newspaper – Keep out of river – read – referred to notes

**Locate Information:** Newspaper – Industry suspected of dumping acid – highlighted sections – note in PDA

**Possible Solution:** verbally outlines solution based on gathered evidence

"O.K ... (reading/muttering)....ok so I'm going to write down from these reports the different causes... the first one was illegal dumping after hours... more reading/muttering...that's coming from ... suspected in coming from a nearby industrial estate ....ok, so one possible solution would be to educate the industrial estate on safe disposal of their waste and to police it more to have heavy fines for illegal dumping.....reading/muttering....ok, so perhaps education and ...um...of waste management might be a solution... ok.. so some industries are licensed to discharge volumes of waste into the sewerage system but concentrations (reading article) of pollutants in the waste cannot exceed licensed levels...ok , the wastes are tested on a monthly basis to comply with license conditions except if there are only tested on a monthly basis the that leaves a big gap in between ...maybe they need to test more regularly when there is a problem like this...and again the next article talks about the golf club

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

being fertilized... so even in the township that could be a source of the problem as well because... um... you know like with the golf course water seeping through and the water finds its way down to the river so there's a whole pile of different problems

Using the red hat my gut feeling is it's the dump because... usually dumps are formed at the beginning of when a settlement occurs and its often not in the best place and I don't think a dump next to a river that has a drainage problem is in the best place.... that's what I think the solution is ... "

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

**Action Plan    SH 4 - Problem 1**

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem "I'm clicking on the investigation board to find the proper area for chemical pollution."
Problem Selection:	listens - grabs - reads "I'm making a note that I'm looking for a cause why the fish were killed... now... I'm reading the notes and using my white hat to gather information
Locate Evidence:	TV report – fish found dead in river – viewed/listened ... ok so that just tells me that fish were killed so I need to go into the zone and, still on my white hat, gathering information... Goes to Region ... going into the current area.... and listening to TV report."
Locate Evidence	TV - (Sandra Vickers) - views/listens "I'm looking for more clues in the area, still collecting more information... listening to the news ..."
Locate Evidence	Radio Report – Tip chemicals killed fish – listened "OK, I'm still collecting information in the area.....that was about some of the birds in the area....."
Locate Evidence	Newspaper – 'Industry killed fish', says worker - read - note in wkbk OK, ... they're blaming the local industry for discharging higher volumes of waste...
Locate Evidence	Newspaper – Keep out of river – read ... ok....still gathering information.....
Locate Evidence	Newspaper – acid burns schoolboy at local tip - read OK, ... teenager received acid burns in the tip ... "I am going back to the discovery centre to check the newspaper, radio and TV reports to see if I've gathered all the information ... Returns to WRC "...I still have my white hat on gathering all the information I believe... I don't think I've got passed that... be in the right region... ok... news report..... fish killed....I'm checking the TV reports ... and radio reports....."
Locate Evidence	Radio - Tip poisons nearby river - read - note in wkbk OK, now I think I'm switching to my blue hat because I'm thinking about what I need to do next....I think I've gathered enough information.....and now I think

**NOTE**  
1.        check each participant for reasoning skills and thinking strategies (define these)

I'm going to do some testing .....um.... So going back to my white hat and gathering more information about what the testing shows.  
OK, I'm clicking back to the man in the discovery centre ...

Hints: Peter (x3)- listens - expresses confusion about hints - asks for clarification - repeats & acts on advice.

Locate Evidence checks newspaper reports - analyses and paraphrases  
"OK, I'm going back to check the newspaper reports and analyse some of these.....I'm putting on my black hat to see what's wrong with this newspaper report... it says at least one student was ill by eating fish caught from the river or from contact with the polluted water but it could be either... so I'll go onto the next one.....  
This is about boys being burnt from drums in the tip..... and they look like acid burns.... so what's wrong with this article ..... the facts say they found some drums and were burnt by something that looks like acid.....ok I still don't know the source of the acid but it came from the tip they do know that.....ok that's about fish being killed in the water..... the local industries.... Now I'm going to check the TV reports to see if I've got all of those"

Locate Evidence: checks TV reports - reads introduction to confirm previous access - views/listens to some reports  
"I've got those ... Now I'm checking the radio reports to see if I've got those."

Locate Evidence checks radio reports - reads introduction to confirm previous access - listens to some again  
"I think I've got all the information ... now I'm thinking and putting on my blue hat thinking about what I need to do ... and I think I'm going to do some testing of the area ... to see what the chemicals are in the river...

Locate Evidence Measurements - phosphorus, pH, pesticides, oil, coliform bacteria - scans up, then down river, checking change in readings  
"I'm not sure how to do this ... phosphorus seems to get higher the further downstream you go...., so that would be something to check out... it increases further... total pesticides, is that what I'm checking? ... checking for pesticides... pesticides also increases... no pesticide top of the river but further downstream is a small amount and increases along with oil..... so thinking about what we need to do is check what type of pesticides they are exactly.....and then.....ok, so we see in this part of the river there is higher pesticides so what we could do with this information is find out what type of pesticides they are and see who manufactures them... now where do I go from here...

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Action Plan SH 5 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem Selection:	listens - grabs - reads
Hints:	listens - NB: student didn't pick up on clues from guide
Locate Information:	<p>filing cabinet – farming practises</p> <p>"I'll just trying to get some background information on zone 3 Tanundra ...um....mumbling... this will come under the white hat ..gathering information...and getting chemical data"</p> <p>Long pause ... planning strategy?</p> <p>"OK, I've now looked in the filing cabinet and now going to have a look in the zone...I just had a look at the farming practises too as that was a suggested hint on how to solve the problem ... also they about mention salinity... which is the salt content... now it would be a good idea to test for that and I'll be using the white hat again....."</p> <p>Goes to Zone 3 – begins random exploration</p>
Locate Information:	Newspaper – acid burns school boy at local tip – read – 'grab' of selected bits
Locate Information:	Newspaper – 'Industry killed fish', says worker
Locate Information:	radio – tip chemicals killed fish – made note in PDA
Locate Information:	radio – tip poisons nearby river – linked media – made note in PDA
Locate Information:	begins chemical testing – samples a full range of tests (12) moving down river from bridge - many tests irrelevant
Problem:	<p>refers to task outline - reviews notes in PDA - summarises progress</p> <p>"I'm just looking at ...um... the sort of target arrow thing (mouse icon)... that's given me a bit of background information ..... some new articles... there's been a variety of suggestions... this would also fall under the white hat.....</p> <p>Returns to WRC</p> <p>"Now I've just returned to the house ... I'm just going to find some more information ... to see if it can help me in my process of determining the solution to the problem</p>
Hints:	<p>Listens - acts on advise</p> <p>"The fellow just suggested to look at the media report so that's what I'll do... if I can't find more information I'll come back and ask him for some more help....</p>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

I'm just now entering... I'm in the right region and getting the TV reporter to explain what's happening

**Locate Information:** TV report – fish found in river

**Locate Information:** report – chem dumping

**Locate Information:** TV report – residents call  
...(mumbling)... sort of got this stuff."

**Locate Information:** Radio – chemical disposal policy  
"Alright.. now I'm just going to click on the man that provides the information  
... I believe this could help me solve the problem"

**Hints:** listens - repeats sequence four times

**Problem:** rereads task - checks notes in PDA  
"I've just entered into my notes and it says find possible reasons for the fish kill...I've determined those however I've not determined yet which one is the major one .. the reasons are the farming practises... associated with this is pesticide use and,.... The salt use and .... There's also the dumping of acids that I've come up with .... that's about it.....

**Possible Solution:** **checks notes in PDA and workbook**  
"Alright now I'm just going to look through my notes using the yellow and black hat's determine the strengths and weaknesses of each of the bits of information I've gathered.....  
Looking through my results... um... one of the problems suggested was salinity was the cause.. but .. um... I don't believe this is so as all of them measure 800... this could work both ways but I highly doubt it ...so I'm saying salinity is not the cause....  
Um... farming seems to have a reasonable argument...as pesticides as we know are used ... so what's happening is that the amount of pesticides is higher around these areas than other areas....  
Um... the oil could also be a cause... the drums that burst... so that's looking with the yellow hat... a strength...  
Um... the news reader has stated " quote..." ...so that's a case for the tip being a possible cause.....

Looking at my results I would say it is a combination of the dropping of the oil and the rubbish tip... that's about it.... I don't know which one

#### **NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

**Action Plan    SH 7 - Problem 1**

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
<b>Introduction</b>	views/listens to guide - selects problem
<b>Problem Selection:</b>	listens - grabs - reads aloud while analysing task – made list in workbook of three main points from task analysis - these points formed basic focus of participant's strategy. "I'm going to click back on him..."
<b>Hints:</b>	Peter - listens - acts on advice? - goes to Region - random exploration OK, ... I'm using my white hat to gather information ...
<b>Locate Evidence:</b>	Radio – Chemical dumping radio campaign – linked media - note of main points in PDA – yellow hat reference "I'm highlighting sections that support the problem... that's the yellow hat... I'm highlighting sections that I think are important ...
<b>Locate Evidence:</b>	TV Report – Fish found dead in river – viewed/listened - linked media – read - note in PDA "...now I'm just doing the same thing... finding bits of information about that support reasons why the fish are dying and ....I'm also doing things that could be used as procedures for the community to adopt and I'll put it in my notes ... ... so, I'll just classify the information I've got.....(reviews notes) .... I'm just clicking through other bits that I've highlighted...
<b>Locate Evidence:</b>	Radio – tip poisons nearby river - h/g key points in PDA "....I'm again just looking for bits that support reasons why the fish are dying.. so that using the white hat, no yellow hat, so I'm looking for information so that's white hat as well.....ok, test so far seems to be the tip ...ok, so obviously must be water ....tips at that area... near wetlands.. move where they stood ....running down the banks after rain .... Ok, so ..."
<b>Locate Evidence:</b>	Radio – Chemical dumping radio campaign - starts - recognises previous access & stops
<b>Locate Evidence:</b>	Newspaper – 'Industry killed fish', says worker – read - highlighted key points & 'grab" to PDA
<b>Locate Evidence:</b>	Radio – tip chemicals killed fish (containers) – selected 'good' points - h/g to PDA – reference to chemicals "OK, so ...I'm again looking at text to try and find information.... so it stills looks like being the chemicals... just trying to sum up what I've got so far..."

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	TV report – chemical dumping witnessed .....just highlighting parts of the story....ok, now I think I've done all of the background information bits .... so now I'm going to do something with the water...
<b>Locate Evidence</b>	Makes selection of tools (pH, pesticides, oil) - types sampling points in PDA ... so I'll do upstream then ... just labelling the sampling points ... Now ... now I'll do one near the tip ... ok, so I've got some information here now and now I'm going to go back to the hut thing and get some information....." Returns to WRC
<b>Hints:</b>	Guide - listens briefly & cuts short – muttering
<b>Locate Evidence:</b>	TV Report – residents call for tip closure "...as I'm going through the different things ... I'm just writing down a few points that will help later....."
<b>Locate Evidence:</b>	TV report – fish found in river – revisit (checking)
<b>Locate Evidence:</b>	TV report – Fish found dead in river – revisit (checking) ".... Ok, reading/muttering... go to radio..." - examining list
<b>Locate Evidence:</b>	radio – chemical disposal policy outlined
<b>Locate Evidence:</b>	radio – tip poisons nearby river – started then linked media ".... I'll go through text it will be a bit quicker..."
<b>Locate Evidence:</b>	TV report – chemical dumping to be fined – highlighted bits & 'grab' "...now I'm just looking for things that will fill in my report." .....muttering/examining notes.....
<b>Locate Evidence:</b>	radio - Tip chemicals killed fish - starts then stops...goes to linked media - h/g key point to PDA. "OK, I think I'm almost ready to do my report....."
<b>Possible Solution:</b>	Outlines possible solution to problem - refers to notes - writes ideas in workbook ..... Ok so I... just go through my information and see whether I've labelled it 'a' or just reasons for the fish dying... obviously its chemicals.... Its blue hat... chemicals from the sewerage and from the tip... sewerage.....primary treatment....um.....fish killed by chemical substance during heavy rain period.....muttering... so that confirms the chemical thing ... so I'll relabel that 'b' ... just go along.... So tip from agricultural containers....and .... Personal dumping... licenses .... Muttering.... Clicking through PDA.... Just checking because I've doubled up on information and I'm just deleting it.....ok, so other reasons that the water is getting in apart from the heavy rain is tip ...where its situated.. so now move on to be which is to report detailed findings which is

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

what I've done so move on to ... this is the good bit.. we just have to suggest possible procedures the community might adopt so.. we could logically go through why its happening in the first place then suggest ways we could counteract the problem... so, firstly we could suggest an upgrade to do.... Pause, muttering... I'm ticking them off as I go... tip could be moved, closed, area regenerated. ....um.... ok,....as for the council it could..... get some.. new dumping policy... review dumping procedures for that policy.... Um.... It could mount regular patrols.... On the river... keep a lookout for... frequent testing of the water and impose heavier penalties....dumping....ok....so.... checking notes.... Find.. I don't know what else I can do about fines... and they could produce an education campaign to encourage the community.... They could also ... I just thought provide incentives ..... I'm done.....

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan SH 10 - Problem 1

### STEPS

### REFINEMENT PROCESS

<b>Introduction</b>	views/listens to guide - selects problem
<b>Problem Selection:</b>	<p>listens - grabs - reads - goes to Region - no obvious initial strategy</p> <p>"OK, going to click the grab button to bring up what I'm looking at –</p> <p>OK, so that seems zone 3 Tanunda. I checked to see what region its in and that way I can direct all my investigations to that region....."</p> <p>Returns to WRC.</p>
<b>Locate Evidence:</b>	<p>TV report – Fish found dead in river – viewed/listened – linked media – read - made assumptions – suggested testing – highlighted &amp; grabbed 'good' points into PDA (yellow) – comment on white hat.</p> <p>"OK... what I gathered from that is that there is a chemical substance in the fish.... and that could be something I could look at ...maybe I could go and test the water.... Mumbling .... At the moment I'm using my white hat still looking for more information on ..um... what the problem is....</p>
<b>Locate Evidence:</b>	<p>TV report – Residents call for tip closure – suggested problem with tip – highlighted 'good' points while reading - no written/PDA notes made</p> <p>"OK, seems to be a bit of the problem with the tip... obviously one of the solutions would be to move the tip away... but ... the lady was right in saying it would not be a good idea to move the golf course in straight away because the toxins are still there ..so.. it points towards the tip as where the toxins are coming from...."</p> <p>Went to Zone 3</p>
<b>Locate Evidence:</b>	<p>TV report – chemical dumping witnessed – viewed/listened</p> <p>"OK, um.. I think this is green hat... new ideas ...perhaps, maybe its coming from the tip but its not the tips fault ...um... perhaps its got something to do with people outside the tip taking part in putting the chemicals that are damaging...."</p>
<b>Locate Evidence:</b>	<p>Radio – tip chemicals killed fish – listened – reflective comment</p> <p>OK, just looking at where the tip is.... it seems to be further downstream so I don't know if the fish have been effected up here so if it was anything there's something that points to it maybe not being the tip but coming from further upstream, that's what I think... I'll have a look up further ..."</p>
<b>Locate Evidence:</b>	Radio – chemical dumping radio campaign - listened– checks notes
<b>Locate Evidence:</b>	<p>Radio – Tip poisons nearby river – listened – expressed confusion</p> <p>"... hmmm... bit confused what that's trying to tell me....</p>

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

OK, here it says in a media report that some local industries have discharged some waste and sewerage into the water.... And that has nothing to do with the tip... the problem is figuring out where its coming from .....(asks me question)....  
 ..... clicking.... (Asks me question )... ok I've just tested the water and I have some results but ...using my red hat... I have absolutely no idea about what they mean so I'm pretty confused at the moment and I don't know how this is going to go towards my investigation...I'll put those in my notes anyway and ...go back to the centre...  
 ... clicking ok, now I'm... how do you test to see if there normal levels and stuff – right I've got those levels, ... but I don't know what they mean....  
 Returns to WRC

**Hints:** Peter – listens - acts on advise

**Locate Evidence:** filing cabinet - locates article - reads  
 "OK, just looking at farming practises and runoff and use of pesticides "

**Locate Evidence:** Newspaper – Industry suspected of dumping acid - read  
 "OK, it says here in ... in... disposal of chemical containers that effects of failing to dispose of chemical containers properly can go undetected for years so maybe even this could have happened a long time ago and they're only discovering it now, I'm not quite sure....

**Hints:** Peter - listens - acts on advise  
 "So the guys' given me a clue as to where to look so.... "

**Locate Evidence:** Radio report – chemical disposal policy – linked media - reads

**Possible Solution:** reviews notes - outlines solution to problem  
 "...um... still don't know who it is but.... Ok from my... um.. from my findings... I'm going to ...I figured from this that... possible reasons for the fish kill.. this is my blue hat... um... ok. A lot of fingers have been pointed at the tip but even from the conversation in the households ... its possible that even the local residents are dumping their pollution ... small amounts of pollution down the sink and that's adding to it as well and local industries seems to... um....are not taking responsibility for their waste and some of them are dumping it into the river instead of taking it to the tip because they don't want to cover the cost of the waste.... Um....so...the community will have to ... no the government will have to start promoting more awareness in the community about what they can do to help towards the problem personally and should have bigger fines on companies that do not dispose of their waste properly... and maybe the tip should be moved further away from the river....."

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan SH 30 - Problem 1

### STEPS

### REFINEMENT PROCESS

<b>Introduction</b>	views/listens to guide - selects problem
<b>Problem Selection:</b>	listens - grabs - reads - note in workbook of task analysis. "OK, I'm just writing down the points about the investigation that I will know the main things in it. I went to the region...." Goes to Region - random exploration
<b>Locate Evidence:</b>	TV – Fish found dead in river - viewed/listened – linked media – ‘grab’
<b>Locate Evidence:</b>	Radio – Chemical Dumping radio campaign - listened
<b>Locate Evidence:</b>	Radio – Tip poisons nearby river - listened – linked media – read – ‘grab’ of highlighted section – selective "Now, ... go back to the resource centre to look at different information... I'll go to the newspapers" Returned to WRC
<b>Hints:</b>	listens (x2) - doesn't act on advise - random searching
<b>Locate Evidence:</b>	Newspapers – “industry killed fish”, says worker. - read – highlighted sections while reading – ‘grab’ "... went to the filing cabinet and go into farming
<b>Locate Evidence:</b>	Filing Cabinet – farming - reads - rejects evidence ...don't want to go to that... now I'm going back to the region Goes to Region – began random exploring again
<b>Locate Evidence:</b>	Newspapers – Keep out of river - read – highlighted specific sections – ‘grab’ " ... took some information for the report from the teacher... now I'm going back to look at the newspapers" Returned to WRC – looked through notes in PDA – referred to task again - some audio – newspaper reports
<b>Locate Evidence:</b>	Newspapers – acid burns school boy at local tip – read
<b>Locate Evidence:</b>	Newspapers – Industry suspected of dumping acid - read " ... now I'm going back to use the tools to test the water" Returns to Zone 3 – began exploring again with tools

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence:	<p>Took readings along river starting above bridge then moved downstream passed dump to sewerage treatment –observed changes in pH, pesticides, temperature and oil – checked results collected in PDA</p> <p>" ....now back to the resource centre"</p> <p>Returned to WRC – some audio – Peter(x2) – checked media reports</p>
Locate Evidence:	<p>TV – Chemical Dumping to be fine - viewed/listened – linked media – ‘grab’ on selective information</p> <p>" ... now I’m going to get some more information"</p>
Locate Evidence:	<p>TV – Resident’s call for tip closure - viewed/listened – linked media – selective ‘grab’ of information</p>
Locate Evidence:	<p>TV – Dumping witnessed - viewed/listened</p> <p>... now I’m going to the computer....</p> <p>Opened database</p>
Hints:	<p>listens (x2) - comments - doesn't act on advise - appears confused</p> <p>"... I went back to the region....</p> <p>Returns to Zone 3 – general exploration - no pattern</p>
Possible Solution:	<p>OK, ... like I’ve probably now got the red hat on... on account of now I’ve got this information and don’t know what to do.... or compute... but I would go to the yellow hat and analyse and write down and.... go through my information and go through the strength of finding that.... write down the points I find relevant to the investigation as a whole and similarly I would put the black hat on and do the same and go through the weaknesses of the things I don’t really need ...that I would mainly focus on the strengths I’d mainly have on the yellow hat.....</p> <p>participant then indicated completion of the task</p> <p>NOTE: little direct evidence of analysing and comparing information to investigation</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan SH 29 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide - selects problem
Problem Selection:	<p>listens - grabs - reads - note in workbook of task analysis - no further entries made in workbook to support problem</p> <p>" I'm reading the problem at the moment and I'm going to write down the task which is to find the reasons for the fish kill .... And I'm going to click on one of the people to see if they can point me in a direction to go..... (clicked on Tatiana) that didn't work, so....</p>
Hints:	<p>listens - follows advice</p> <p>"So, he told me to go to the river so I'm going to go there...</p> <p>Goes to Zone 3</p>
Locate Evidence:	<p>began systematic exploration starting with river – looking at fish – read – typed in PDA</p> <p>"I'm going to grab the environmental issues relating to the carp and put it into my notes.... and now take ..., freshwater cat fish...."</p>
Locate Evidence:	<p>TV – Fish found dead in river - viewed/listened – linked media – highlighted and 'grab' of specific sections</p> <p>" ... just grabbing some information out of the media report and putting in my notes..."</p>
Locate Evidence:	<p>Radio – Tip poisons nearby river - listened – linked media – highlighted specific sections and 'grab'</p>
Problem selection:	<p>checked task outline and notes- typed in PDA – then rechecked notes</p> <p>"... just notating my...the things I've grabbed and put into my notes.....ok... so, some of the chemicals are coming from the groundwater that flows beneath the tip...(continues typing in PDA)...</p> <p>Returned to WRC – referenced media reports</p>
Locate Evidence:	<p>Newspapers – Keep out of river – read</p>
Locate Evidence:	<p>TV – Chemical dumping in river - viewed/listened – linked media – highlighted specific sections &amp; 'grab' – typed in PDA – reviewed notes</p>
Locate Evidence:	<p>Newspaper – Industry suspected of dumping acid - read – highlighted sections &amp; "grab" – notes in PDA</p>
Locate Evidence:	<p>Newspaper – 'Industry killed fish', says worker - read – highlighted and 'grab'</p>

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	Newspaper – acid burns school boy at local tip - read – highlighted sections & “grab” – notes in PDA
<b>Locate Evidence:</b>	Radio – Tip chemicals killed fish - started – linked media – highlighted sections & ‘grab’
<b>Locate Evidence:</b>	<p>Radio – Chemical dumping radio campaign - listened - analyses – highlighted specific sections and ‘grab’ – typed into PDA</p> <p>“... Um... I’m just taking out the points that are valid... um... like the local plant is only able to deal with primary treatment... so... paint and so on that goes down people’s sinks ends up in the river through stormwater....ok,, close that up and annotate what I’ve grabbed ... so (typing in PDA).. and look for anything else that’s available...</p>
<b>Problem selection:</b>	<p>revisited notes in PDA &amp; referred to task - Returns to Zone 3</p> <p>OK, ... so far I’ve done... looked for places in the river and then I’ve looked for places on the far side of the river and now I’m looking for places on the left side of the river...”</p>
<b>Locate Evidence:</b>	<p>begins testing water</p> <p>"OK, ...now I’m going to test the water along the river to find where the pollution occurs...what am I going to test... I’ve got... pesticides, I’ve got ... oil.... acids....just reading my notes to check for the things I need to check for in the river....acid and heavy metals... ..insecticides....phosphorus and nitrogen content....ok, so I’m going to test for phosphorus, nitrogen, pH, pesticides and oil ..... top of the screen.... Ok, that’s better... I’ll annotate as I’m going... just below the bridge..."</p> <p>(types positional headings in PDA as water testing proceeds)</p> <p>"OK, ...just annotating what the trends were of the .... ..pollutants in the river...."</p> <p>Refers to notes and compares figures – types in PDA</p>
<b>Problem solution:</b>	<p><b>reviews evidence - eliminates</b></p> <p>" What I would do now is put it all together to see if there is any relationship between the pesticides and the pollutants in the river to the fish kill.... and so far there seems to be a trend ....and there is... definitely for pesticides, phosphorus and nitrogen content and.... As to where it comes from... mainly the tip area...."</p> <p>Participant then indicates completion of the task....</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



## Problem 2

# Action Plan SH 7 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction:	views/listens to guide
Problem Selection:	listens – grab – reads - main points in workbook <i>"I'm just writing down just what we actually have to do so I don't have to go back to the PDA"...just click on her again to get some information on what to do..."</i>
Hints:	Tatiana – (measurements/fisherman) – note in wkbb - acts on advice. <i>"OK, so I'm going to go to that actual site an gather some general information...this is the white hat."</i> Goes to Region – random exploration
Locate Evidence:	Radio – weeds cover river, killing fish - Listened
Locate Evidence:	TV – River choked by wild willows - Viewed/listened – note in wkbb – linked media – read - highlight/grab selected bits to PDA <i>"I'm clicking on linked media and I am going to go through and have a look to information that supports the problem we want ... which is the yellow hat...and take out the information I don't want ...which is the black hat... (analyses article)...keep going and get more general information...."</i>
Locate Evidence:	TV – Cause of algal growth found - viewed – note in workbook – linked media – highlighted/grab selected bits <i>" Now I'll just take the information that I think is good,,, that's the yellow hat.....and just add out what I want to do again....thinking of other...well the willows are one and now weeds and algae are the other...I think that's green hat..."</i>
Locate Evidence:	Newspaper – Weed effort fails - Read – highlighted/grab sections to PDA <i>"Just going on and finding more information...that's the white hat....so that would help in the possible solutions.....muttering...clearing...so it's the weeds.....or perhaps not solution because the weeds came back.....now I'll just go down to others that I haven't seen yet..."</i>
Locate Evidence:	Newspaper – Weed eradication program – read
Locate Evidence:	TV – Weed growth distresses residents - viewed – note in workbook – highlighted/grab sections to PDA <i>"So this is a possible reason for the weeds and what can be done about them .....so this is solutions (refers to own notes)... So water samples would be ... I'll do that next....so I've still got my white hat, then yellow hat, black hat...collecting information and analysing for good bits and bits I don't want...."</i>

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence:	Newspaper – Farmer doubts beetle solution - Read – highlight/grab sections <i>" ... another solution is to release the beetle.....so another solution would be spraying....."</i>
Locate Evidence:	Radio – expert warns against weed invasion - Started – stopped – linked media – read – highlight/grab sections <i>....so its half the weeds? .....now I'm going to take tests of the river"</i> Goes to Region
Locate Evidence:	selects tools - (oxygen/turbidity/pH/flow/algal count) visual comparison of readings - collects to PDA <i>... I'll take it from above the logging site...and I'll take it just below...that's the difference between the two...big jump in the algal cell count...now I might go....now I'll just make my....think I've got enough information ... so , I will go through and add up what I want overall.... which is my yellow and black hate again... so I guess one thing that is probable... OK, I might just go back and clarify the problem "</i>
Problem selection:	reads task outline - reviews own notes - identifies supporting evidence - analyses and rejects evidence <i>"... main causes are willows, ....weeds and algae.... so one is that people have brought in something....that is supported by .....using my yellow hat ....just go and take out the bits I don't want...it might be easier... so that's black hat .....</i> (I stopped student removing data from PDA – student then verbalised strategy for completing task)
Problem Solution:	participant outlines solution(s) to problem <i>".. well, I think that the logging area would have.. has a big impact on it because if we have a look at the test just before,,, above the logging area in the river the algal cell count is only 120 and after the logging area, just below, the algal cell count is 450...that's a big jump and even further down its 500 still... so that would seem a key reason for the growth of the weeds... solutions for that would be ....notes....it said earlier that people can't empty the water in their boats out ... and the other thing is the willows and the algae... the people are doing that from their boats..... alligator weed... so solutions for that would be the spraying,,, they have cleared it out but that no good as it comes back straight away... release the beetle... but if they release the beetle to eat the weed it would be too much for the ecosystem as it is an introduced animal.....so the main causes are basically people from either the logging area or them spreading the weeds down the river...</i>
Question:	I noticed that in search etc...nitrogen and phosphorus... above and below the river... Reply - check!
Question:	Just thinking about the strategies that you use ... is this the normal strategy you would use?

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

*" ... well, not really....it would be, because last time when I thought about it , because I didn't use the hats at all really last time, out loud ....but when we talked about it afterwards I realised that I do think that way but not really systematically ..it sort of happens all at once...."*

**Question:**

Does the hat strategy help you make things more systematic and help you clarify your ideas better?

*" ... yes it does definitely ....I found it easier to use this time, once I've actually...because I'm more practiced in it but .. it does, but it has taken me a while to get it in my brain...this is how we do it.."*

**Question:**

How would you usually do that?

*" ... usually I would basically get the same thing....get the problem.. clarify the problem... find exactly what I would need to find ....like what I need to look for... go get all the information and basically pick out the bits that support, or what I need to look for... so, its basically the same thing except I don't actually write anything down..."*

**Question:**

Do you think you would normally do an information gathering process?

*"yes..."*

**Question:**

And then do some editing of that?

*"yes..."*

**Note:** participant missed articles on Logging Company involvement

## **NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan SH 5 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction:	views/listens
Problem Selection:	Tatiana – grab – read
Hints:	Tatiana (waterplants/weed, fisherman) – note in wkbk "I'm just basically gathering information at the moment..."
Hints:	Tatiana (animal/plants), Tatiana (journal) – note in wkbk "I'm using the yellow hat at the moment just looking at some positive information...coming from the filing cabinet."
Locate Evidence:	Filing cabinet – water plants /weeds – first four articles (quick read) - h/g small bits – note in wkbk – audio comment (assumptions) " ... again I'm using the yellow hat ....which may help with the problem ...just going to an article on causes of weed infestation which may give me some more background information...." " ... seems as though the habitat plays a big role in it... it says here.... (reads from article) – h/g small sections – note in wkbk " ... benefits of plants are obvious...so I'm going to grab information on that...this is how the problem is identified in the first place....foreign invaders...unnatural inhabitants are a major cause....and problems associated without the water plants are ..." " .....control of water flow, destruction of habitat, decline in water quality.....suggestion about agriculture (logging ???), so I'll test around the agricultural areas soon....and the major things to look for are nutrients and pesticides...h/g small bits...the major effect is on organisms that live in the waterway so its obvious the problem has to be solved to provide a natural habitat."I'll go to the region now and do some chemical testing especially around the sites where they suggested, mainly the agricultural regions but I'll need to check as a control , other areas....." Goes to Region
Locate Evidence:	measurements – (P, N, O, pH, pesticides) – scans top to bottom several times, comparing each data set "Just doing the testing...the ....pause... agricultural site?...the logging camp doesn't seem to be contributing all that much to it.. seems to be gradually getting worse going downstream and the logging camp is no big contributor to that so there is other factors involved...."
Problem selection:	Looks at task/notes in PDA – refers to wkbk and makes another entry "Now I'm just going back to the house (WRC) to try and confirm what I think...." Returns to Water Resources Centre

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence:	<p>filing cabinet</p> <p>"Now, the suggestions are that.....to fix the problem, ....harvest the weeds , manage the water levels and reduce use of herbicides,.... clean machinery that has been in that area....now I'll go to the TV reports ."</p>
Locate Evidence:	<p>TV – Cause of algal growth found – viewed – linked media – h/g small sections – note in wkbk - paraphrases</p> <p>" Mr Chang suggested a few reasons why this was occurring ... he believed that the vegetation was different in the still parts ... they were worse near the logging area... the waste water near the jetty was polluted and the water smells near the huts... when the huts indicated shower and toilet usage..."</p>
Locate Evidence:	<p>TV – River choked by wild willows – linked media – read – note in wkbk</p> <p>"...the next interview with Alice Butler, .....she believes the willows are choking Possum Creek and personally I think the same thing... so that's my answer to the problem....and I say that because as a naturalist she obviously has a lot of background knowledge and history in that area</p>
Problem Solution:	<p>outlines solution to problem</p> <p>"...now the main causes of the problem are,... the willows, ....land clearing, draining, introduction of foreign species, and development of conditions which promote weed growth... the main offenders....would have to be those that involve those kind of practises....obviously the logging is involved... that's the land clearing.....draining, they would have something to do with that....introduction of foreign species,....development of conditions....extra use of pesticides, herbicides...to fix the problem cut out the logging, ...that has a big effect.....stop use of herbicides and pesticides.....</p> <p>Indicates completion of problem</p>
Question:	<p>Do you think the logging camp is the main offender?</p> <p>"Yes."</p>
Question:	<p>In terms of promoting the weed growth?</p> <p>"Possibly, they would have to use some form of poison to get rid of the vegetation to clear the land....."</p>
Question:	<p>I noticed you made a couple of references to the hat strategy but didn't make great use of that, What sort of strategy do you normally employ in solving problems like this?</p> <p>"Well, with this one (problem 2) I've gone around and around to find things ..."</p>
Question:	<p>When you go around and around, what do you find?</p> <p>"Solutions to the problem...just like a science experiment you've got your aim, method...</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

- Question:** You gathered information from going mainly to the filing cabinet, you didn't get much information from the media elements, is there any reason for that?  
"Not really but the media aren't always correct, ...."
- Question:** You gathered that information and then I noticed you taking small pieces of information. Why did you do this?  
"Just grabbing the information so I could form a conclusion about why it happened and what can be done to solve the problem."
- Question:** So, were the bits of information you were gathering providing some support for your line of development  
" ... yes & no... at first I thought the logging company wasn't doing anything but then after reading what was provided I changed my mind....."
- Question:** Do you think the hat strategy helps clarify your ideas better?  
"I wasn't thinking about the hat strategy that much...."
- Question:** Do you have problems talking about what you were doing?  
"Yes."
- Question:** Do you have to think consciously about doing that?  
"Yes"
- Question:** Is it taking you away from the problem solving?  
"Yes, I think it was... "

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan SH 4 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction:	views/listens "...putting my white hat on now because I'm gathering information to find out what the problem is ..
Problem selection:	Tatiana – grab – reads – heading in workbook .....reading the background notes...I'll go into different parts of the centre and collect some other information...here's some video...
Locate Evidence:	TV – Weed growth distresses residents – linked media – read "...so they're going to be doing some testing of river samples ... another video
Locate Evidence:	TV – River choked by wild willows – linked media – read "... I'm putting on my green hat....I think one of the causes is the wrong species...of plant was planted originally...they should have used native species....possible solution is to remove the willow trees that are there now with native species.."
Locate Evidence:	TV – Cause of algal growth found – linked media – read - paraphrases ...there's another report...I'm still gathering information with my white hat but I'm coming up with some causes...possible cause could be waste water from up river...so I'll do some testing....some of the huts are used for showers and toilets...so the waste water may cause the plants to grow wild...so a possible solution to that would be ....using my blue hat now ...is to ensure waste water is not getting into the river and by making sure the huts are not used for showers and toilets.... Back to the hut to look at some radio reports ...
Locate Evidence:	Radio – Weeds cover river, killing fish – read – white hat reference "...more changes in the weed...and fish and eels are coming up for air...still investigating with my white hat...gathering facts ..."
Locate Evidence:	Radio – Logging linked to weed growth – read – note in wkbk – white/red hat reference ... still gathering information with my white hat ....logging operation linked to spread of weeds....sewage is draining directly into the river causing nutrients and weeds to grow....putting my red hat on now ...there's a bit about the timber....if the logging is causing the weed problem, well the timber company is saying they cannot reduce the logging activity....they employ workers and have a responsibility to their jobs...that could be a big issue .... they may have to look at reducing their logging but that's an emotional issue because losing jobs effects the whole area...I'm not quite sure why the logging would increase the weeds....still gathering information with my white hat..."

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	<p>Radio – Expert warns against weed invasion – read – Black hat reference – note in wkbk – -paraphrases</p> <p>....alligator weeds grow rapidly....they've been found in the river...difficult to get rid of...spread by boats...water hyacinth overwhelming native plants....putting on my black hat because a weakness in this ... a weak point, is that there is no point in attacking the weeds if we don't attack the problem</p> <p>...killing one weed can lead to a rapid growth in another....a possible solution is to remove all the weeds that are causing the problem"</p> <p>Goes to Region</p>
<b>Locate Evidence:</b>	<p>takes series of measurements - collects readings in PDA - expresses confusion</p> <p>"....testing water samples....I'm not sure what I'm testing for so I'll test for everything and compare them...testing upstream...testing at the beginning of the weeds....testing where the weed growth seems to be the most compared to where there is little....have a look at these.....analyse these...not sure what hat that is....got too many facts that I don't need ... algal cell count is going up....not quite sure what I'm getting here....pH seems to be about the same....phosphorus and nitrogen seems to go up....nitrogen is a lot less in the areas of the river where there is not weed.....I'm confused with these readings.... I'll go back to the centre ...see what I can find in the filing cabinet"</p> <p>Returns to WRC</p>
<b>Locate Evidence:</b>	<p>filing cabinet – water plants/weeds folder - reads &amp; paraphrases</p> <p>"....still investigating ...using my white hat ... willows seem to be the problem.....for flooding and blocking the stream, but I don't know if removing them would help the problem or not.....alligator weed responds to high levels of nutrients especially in fresh water....maybe that needs to be removed....water hyacinth is a noxious plant and grows where nutrient levels are high, which is here.....go to the newspapers and see what it says in there ..."</p>
<b>Locate Evidence:</b>	<p>Newspaper – Weed effort fails – read</p> <p>... gathering some more information on the weeds ... some residents have begun to remove the weed but it seems that there are new areas where weeds are beginning to grow, so that probably is not a good option...."</p>
<b>Locate Evidence:</b>	<p>Newspaper – Weed Eradication Program – read</p> <p>"....reading part of article... noxious weeds ... here's one about logging...."</p>
<b>Locate Evidence:</b>	<p>Newspaper – Logging linked to weed growth – read</p> <p>"....logging increasing nutrients causing rapid weed growth....phosphorus &amp; nitrogen present in higher than normal concentrations ...I think that's what my testing showed....coming from logging ... unless the chemicals are prevented from entering the river ... logging might need to be checked..."</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	<p>Newspaper – Farmer doubts beetle solution – read – note in wkbk</p> <p>".....don't know what effects the beetle may have ....what about spraying the weeds? .....I'm going to back to the area and look at the logging again..."</p> <p>Returns to Region – general exploration</p>
<b>Problem Selection:</b>	refers to task outline - checks notes
<b>Possible solution:</b>	<p>proceeds to outline solution(s) to problem</p> <p>".....O.K., I think I've checked all the information and now I'm going to put my blue hat on to see what is needed.....some possible suggestions...whose responsible, I think they need to check into the logging company...and possibly do a test and stop there operations for a certain amount of time to see if there is an effect on the nutrients in the water and if there is they might be able to prove that is the cause and if it is they may need to relocate or change their procedures to make a difference....."</p> <p>Indicates completion of task</p>
<b>Question:</b>	<p>In terms of your own strategy how would you normally go about solving this type of problem?</p> <p>"...probably the same sort of way but I got distracted verbalising it and I was probably more aware of this sort of thing...how I was doing it than doing it....so, if none of this was involved I think I would have been ...it wouldn't have taken me so much time....I was very thorough ... I found in vocalising...verbalising it and trying to put on these different hats I found it distracting...."</p>
<b>Question:</b>	<p>Do you think the hat strategy is of value for you in trying to clarify your ideas better?</p> <p>"...personally, I don't....but I think along these ways,....I'm very thorough... and when I do have a problem, I do gather all the information and think of all the good points and bad points and I like to see things on paper so for me to do anything on computer I still need to jot things down because I need to see the good points and bad points in front of me...so although I probably do most of these things anyway, when I've got a problem.."</p>
<b>Question:</b>	<p>You're referring to the hat strategy?</p> <p>"The hat strategy, yes...I would gather the information...I would pull out the good points, the bad points , how I feel about them and come up with solutions, but I wouldn't sort of think 'ok I'm putting on my green hat, my blue hat or I'm thinking creatively now'...I wouldn't be...consciously aware of the different steps...I think I'd do it but not switching from one to the other... I think I automatically do this but don't think so much about doing it.....(laughs)</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan SH 3 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction:	views/listens
Problem Selection:	Tatiana – grab – reads – task outline in workbook – no further use of workbook "She suggested measurements so I'll give that a go in the river... my gut feeling, using my red hat, is that it's a people problem..... Goes to Region
Locate Evidence:	begins taking measurements – systematic (top to bottom of river) "I'll just take some measurements....I want to make some notes....(types in PDA)....Phosphorus levels in the river, adjacent to the camp is 70 ...at the mouth of the creek the phosphorus further down from the camp is getting higher....and inside , going up further in the creek its getting higher still...the bends of the river are even higher but that could be due to how fast the river is flowing....so , phosphorus is definitely coming from the creek... Nitrogen, next to the camp is 650.....going down.....now above the creek... doesn't seem to be a huge....O.K., lets look at the oxygen which is good.....80.....total pesticides.....not using any pesticides.....which probably ...coliform bacteria .. so there is obviously a lot of sewage coming from the camp just at the mouth of the river...." Returns to WRC
Hints:	Tatiana - acts on advise "... I'll now look at some media reports...."
Locate Evidence:	Radio – Weeds cover river ,killing fish – linked media – reads article aloud ".....so there's changes occurring recently that could be making it worse...lack of oxygen... I wonder if it's the weeds that are taking the oxygen?"
Locate Evidence:	Radio – Logging linked to weed growth – linked media – reads aloud "... it looks like there've had an increase of people ...to fill the orders on time and that could have caused an increase in sewage....problem with the number of people now having an impact on the river..."
Locate Evidence:	Radio – Expert warns against weed invasion – linked media – reads aloud "... another problem.....maybe its not just one problem.....maybe its not just man made also there's a weed that's been introduced and removing it by normal process has made it worse...so the poor old river boat man may be making the river worse by pumping water into his boat and spreading it as he goes down..."
Locate Evidence:	TV – Weed growth distresses residents – linked media – reads aloud "...so this guy's saying it's the two problems as well... increase in nutrients and also that people are inadvertently causing the weeds to spread.....OK so where do I go from here?"

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	<p>TV – Cause of algal growth found – linked media – reads</p> <p>" ... if you were smart you would take water samples and pinpoint where the problem is.....I'm not real confident in that....I think the waste water comes from the huts...."</p>
<b>Locate Evidence:</b>	<p>TV – River choked by wild willows – linked media – reads</p> <p>"I'll go into the plants and animals book ... that might show me how you can get rid of the weeds ..."</p>
<b>Locate Evidence:</b>	<p>Animal/Plant Book</p> <p>"I'll have a look at willows first....(reads article)....alligator weed.....(reads article)....worse where the river is stationary....."</p>
<b>Hints:</b>	Tatiana – hints restart - (measurements/fisherman)
<b>Locate Evidence:</b>	<p>Filing Cabinet – waterplant/weeds folder – weed control options – selects different folders</p> <p>" ... it's a problem mainly focussed around logging area.....the possible causes are increase in humans...the nutrients from humans is causing a problem ...the use of the river, the river boats are causing the spread of the weed.....determine whether the problem warrants intervention or whether the habitat can cope with the weed infestation ...it can't cope...."</p>
<b>Problem Selection:</b>	checks task outline and notes - returns to filing cabinet
<b>Locate Evidence:</b>	<p>reviews articles on weeds</p> <p>"Consider the possible control measures...how do I find out that? ....consider the financial cost involved....huge costs but could be borne by the logging company.....consider the short and long term effects on the environment...disaster for fish life.....treating the symptoms...harvesting the weeds would be hard for if you break them up they spread.....maybe where the alligator weed is could be a no go zone for boats....release insects as control agents...alligator flea beetle... maybe we need to import these.....there is a biological solution instead of using pesticides... so its not an overnight fix....can't physically remove the alligator weed....any form of chemical control always posses some risk.... Got to cut off the nutrients so the camp has got to get a better sewerage system.....maybe the willows are blocking the channel which is stopping the water.....how can we get rid of the willows?"</p>
<b>Problem Selection:</b>	Checks task and measurements
<b>Possible Solution:</b>	<p>outlines solution to problem</p> <p>"I think the problem is that the people responsible is the logging camp because for several reasons they planted introduced species which causes the river to be sluggish which helps the alligator weed to grow...its also being fed by the</p>

#### **NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

sewage from the camp ....the alligator weed was probably introduced by boats coming into the area and being made worse by boats travelling in the area and causing it to go out further... to increase .. to reproduce...and I think to solve the problem they first need to look at their sewerage problem and get rid of the willows ....the areas where there are alligator weed needs to be a no go zone for boats and they need to invest in getting some of the alligator beetles in...its not going to be a quick fix and will probably take a long time..."

**Question:** Is this the normal way you go about solving problems...would you normally use this approach?

"....well, I didn't use the six hats, and....I didn't use the six hats even though I studied it recently.....but doing something like this I feel really embarrassed and the time frame...I like to have more time and Usually I would go through every single thing that I could find before making decisions, and I would write them down."

**Question:** Does the verbalisation put you off?

"Yes, a little bit... it does.. but then in some ways it can clarify things.. but I would usually write things down so I can revisit it"

**Question:** Do you think the six hats strategy helps you clarify your ideas?

"...I think with practise it would..."

**Question:** You started to use it at the start.

" ... yes, but I thought I haven't got time....but in a way I was using it because I was thinking what's good, what's bad, my gut feelings,, then I was looking for facts,.... The thinking about thinking....I don't know..."

**Question:** I was wondering whether this was part of your normal strategy or whether the revision of the six hats process has helped you in any way?

"I really haven't done enough with the six hats .... But, I think I basically do that."

**Question:** What, go through the process in similar fashion to the strategy?

"....yeah, I do....."

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



# Action Plan SH 10 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction:	views/listens
Problem selection:	Tatiana – grab – note in wkbk – read Goes to Region – random exploration
Locate Evidence:	Newspaper – Weed Effort Fails – read
Locate Evidence:	TV – Cause of algal growth found – linked media – read – h/g bits
Locate Evidence:	Radio – Logging linked to weed growth – read – h/g bits Returns to WRC
Hints:	Tatiana (measurements/fisherman) - acts on advice
Locate Evidence:	TV – Weed growth distresses residents – viewed Returns to Region
Locate Evidence:	takes measurements – P, N, algal count – starts at top of screen and takes several readings moving down river – makes comparisons between readings – random sampling Returns to WRC
Hints:	Tatiana (animal/plants) - acts on advice
Locate Evidence:	Animal & Plant Book – random searching – no apparent direction or strategy
Locate Evidence:	Filing Cabinet – waterplants/weeds folder – (weeds/weed control) - reads
Hints:	Tatiana (journal/comeback again) - doesn't act on advice (irrelevant at this stage)
Locate Evidence:	Radio – Weeds cover river, killing fish – read
Locate Evidence:	Radio – Logging linked to weed growth – listened – linked media – h/g bits
Locate Evidence:	Radio – Expert warns against weed invasion – read – h/g bits (types of weeds)
Locate Evidence:	Filing Cabinet – alligator weed – h/g bits
Hints:	Tatiana (measurements/fisherman) - acts on advice
Locate Evidence:	Newspaper – Farmer doubts beetle solution – read - returns to Region

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

<b>Locate Evidence:</b>	measurements again (above camp, level with camp, in creek) – more specific sampling – reviews readings in PDA – reviews and deletes some.
<b>Hints:</b>	Tatiana (animal/plants) - recognises repeat of hints
<b>Problem selection:</b>	Checks task again and reviews own notes – transfers data from PDA (after initial editing) to presentation guide – assembles report in PDA – reviews work/ideas regularly Indicates completion of Task. ".....that's it..."
<b>Question:</b>	What do you think are the main causes of the problem? "....that fact that some people are dumping weed into the river is one of them...but I thought that nutrients coming from the camp is contributing to the rapid growth...because it is obvious from the tests that the nutrients, P, and N, have increased ....."
<b>Question:</b>	You didn't talk through this particular problem , is there any reason for that? "I found it easier to do it..."
<b>Question:</b>	When you were just concentrating on doing the task you found it easier to just work on the task instead of doing both? ".....last time I was talking I didn't get as far..."
<b>Question:</b>	I notice because you were not doing any talking you didn't indicate whether you were changing hats through that strategy. Do you use the six hats strategy, or not? "...I tried to but I couldn't really quite identify which one ..."
<b>Question:</b>	So you had difficulty in switching between hats? " ... yes, it seemed like to me most of the time I was in white hat mode gathering info and then ..."
<b>Question:</b>	Do you think the hat strategy can help in clarifying the task and clarifying the problem? "I found it confusing at times...."
<b>Question:</b>	So you didn't find it helped you in identify the strengths and weaknesses of the information? "I can see where it can work in some ways.....I found it easier than the last task I did...half the time you are thinking about which hat and half, you have to do in the problem....it confuses you...."

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

**Question:** Was it becoming confusing trying to think of the hat strategy and which one you were applying at the same time?  
" ... yes, that's why I didn't say it because I wasn't sure which one I was using at the time.....

**NOTE**  
1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan SH 2 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction:	views/listens
Problem Selection:	Tatiana – grab – read – note in wkbk
Locate Evidence:	Filing Cabinet – waterplants/weeds folder – weed control options Goes to Region – brief exploration
Locate Evidence:	Newspaper – Weed Effort fails – read Returns to WRC – media exploration "....just go into the newspaper file...."
Locate Evidence:	Newspaper – Weed Eradication program – read
Locate Evidence:	Newspaper – Logging linked to weed growth – read – note in wkbk
Locate Evidence:	TV – River choked by wild willows – viewed – note in wkbk
Locate Evidence:	TV – Cause of algal growth found – linked media – note in wkbk "I'll go into the radio files to have a look at their articles ..."
Locate Evidence:	Radio – Weeds cover river, killing fish – linked media – read - note in wkbk
Locate Evidence:	Radio – Expert warns against weed invasion – linked media - read – note in workbook – repeated process "....have a look around...'
Hints:	Tatiana (measurements/fisherman) - acts on advice Goes to Region ".....just going into the actual area we're looking at and test around the logging company site because apparently the waste from their site is adding nutrients to the water the weeds are growing off them...."
Locate Evidence:	check for phosphorus, nitrogen, around the logging site– takes measurements – P, N, Col. Bacteria – above camp, level with camp, below camp. – visual comparison - notes in wkbk " ... should I check the temperature?....does temperature have anything to do with weed growth?... I'll check it anyway.....no...." Returns to WRC
Hints:	Tatiana (animal/plant) - acts on advice "I'll check the plant and animal book again....."

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence:	Animal/Plant Book – brief exploration/reading Indicates completion of problem
Problem Solution:	indicates answer to problem "...I found out a fair bit of information on how the weeds are growing and why.....I can't find a lot of information on the ways to get rid of them....."
Question:	Do you think you have found the main cause? " ... two main causes I think....the logging company is the main culprit I think...the waste coming from their site is adding nutrients to the water and weeds are thriving...and they have also planted some willows to make the area look nice but it is actually an introduced species and they are taking over everything.....so the logging company I think is the main culprit."
Question:	"Any ideas on what they may do to help reduce the problem? "...well....there were suggestions to take them out but that's been done and they are just growing back due to the nutrients already in there, so what can you do...they are just going to keep growing....do you ride it out until the problem goes away and in the meantime stop them logging?....stop them chucking their waste in the water?"
Question:	You've identified some causes and made some statements about how to go about reducing the problem. Would this be a short term or a long term thing? ".....no, a long term thing...."
Question:	What sort of weeds were the main problem? " ... lots of weeds,....the wild willows.."
Question:	You haven't been talking about using the strategy. Do you use a particular strategy? " ... its pretty much how I go about all my assignments....I get as much information as I can then make the best of what I've got ...I've gone in and looked at a bit of everything and picked up bits of information here and there...."
Question:	Do you try to apply the six hats strategy to enable you to do that? " ... not really,...not that I'm aware of...I just go to the different resources and try to grab as much information as I can and then put it all together, ....rather than having an idea ...like thinking about what I want to do and then looking for information to fit that..."
Question:	So, in your particular case you don't think that strategy works very well for you? "....in theory I think its an excellent strategy ...its just I'm set in my ways and it's a habit now.....its working alright ,its working well...I don't know...its probably a bit more work going in the six hats strategy, going through all the different hats...it would work, I can see how it would definitely work....you can get so much information and come up with a really good conclusion, ..."

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

**Question:**

So, you are still applying an information gathering strategy.

"...yeah, what's that...the white hat... I'm still using the hats, a little bit I suppose ...I'm using the white hat to get all the information I can..."

**Question:**

You seem confused with what you've gathered at the moment, do you think using the yellow hat or the black hat to help you analyse your info. If you thought about those two hats would you be able to analyse your information better?

"...yes, using the yellow hat...what are the good points....I would use the yellow hat to find out what I know...etc....the definite pieces of information that I know and the weaknesses...."

**Question:**

You didn't talk very much through the process. Is there any reason for this?

"....it doesn't bother me but its something that I'm not used to...I just forget...It doesn't make me feel uncomfortable....I just forget..."

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan SH 29 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction:	views/listens
Problem Selection:	Tatiana – grab – read – note in wkbk " ... just writing down what I need to find out.....now I’m going to use the hat...the blue hat ... and go to the area and find information from there..." Goes to Region – general exploration – thorough!
Locate Evidence:	TV – Cause of algal growth found – viewed half, then linked – typed in PDA (possible contributors’) – h/g sections – audio "...now, I’m working out what’s good and bad about each particular point..... now I’m first going down the river to find the bits of information I need and go from one bank to the other....."
Locate Evidence:	Radio – Weeds cover river, killing fish – linked media – read – h/g
Locate Evidence:	Newspaper – weed effort fails – read – h/g
Locate Evidence:	Newspaper – weed eradication program – read
Locate Evidence:	TV – River choked by wild willows – linked media – read – h/g sections (placed under ‘positive contributions’)
Locate Evidence:	TV – Weed distresses residents – linked media – h/g
Locate Evidence:	Newspaper – read – typed ‘alligator weed’ into PDA
Locate Evidence:	Radio – Expert warns against weed invasion – linked media – h/g sections relating to weed type & causes
Locate Evidence:	Newspaper – Logging linked to weed growth – read – h/g – note in wkbk
Problem Selection:	Looked at Task again – reviews notes in PDA – audio "...now I’m going to test some water to find out some more information...in the river, start at the top...."
Locate Evidence:	Takes series of measurements – full set (12) – above camp, level with camp, mouth of creek, in creek, south of creek, first bend, bottom of screen - visual comparison of readings – entries in PDA "...I’ll go back to the previous time zone to check what the water quality was like then....." Goes to previous Time Zone to check readings

- NOTE**
1. check each participant for reasoning skills and thinking strategies (define these)

<b>Problem Selection:</b>	Examines PDA records - checks task – indicates completion
<b>Problem Solution:</b>	<p>outlines possible cause/solution</p> <p>".....just looking at the information I've gathered to find out what I think the causes might be....</p> <p>".....OK, from the evidence I'd say the logging camp is contributing to the nitrogen &amp; phosphorus levels in the river which is causing growth of algae in the river.....there's algae been introduced from other places, .....like alligator weed and the willows causing most of the problems...</p>
<b>Question:</b>	<p>So, you think the logging camp is the main problem?</p> <p>"...yes, from the water testing you can see the difference...up here the levels are same as before any logging began...</p>
<b>Question:</b>	<p>I noticed you started to talk about the strategy in terms of the hats you stopped. Is this the normal way you go about solving problems of this type?</p> <p>"...yes it is...I try to find all the information and go from there..."</p>
<b>Question:</b>	<p><b>Why did you</b> mention good points and bad points?</p> <p>".....I pick out the bits of importance to the issue.....and bits of information you need and discard the bits you don't...."</p>
<b>Question:</b>	<p>Do you think the hat strategy helped you in clarifying the problem, or in helping you direct your thoughts towards solving the problem?</p> <p>".....mainly to understand the way I'm thinking about things....yes, it helped to clarify the way I was working to solve the problem..."</p>
<b>Question:</b>	<p>You don't seem to want to talk through the process. Does it bother you or are you just uncomfortable in this?</p> <p>"...probably because it doesn't come naturally...I like thinking in my head more than verbalising things..."</p>
<b>Question:</b>	<p>Do you think having to talk about the strategy as you go as well as trying to solve the problem detracts from solving the problem?</p> <p>".....yes, a little bit distracting....."</p>

#### NOTE

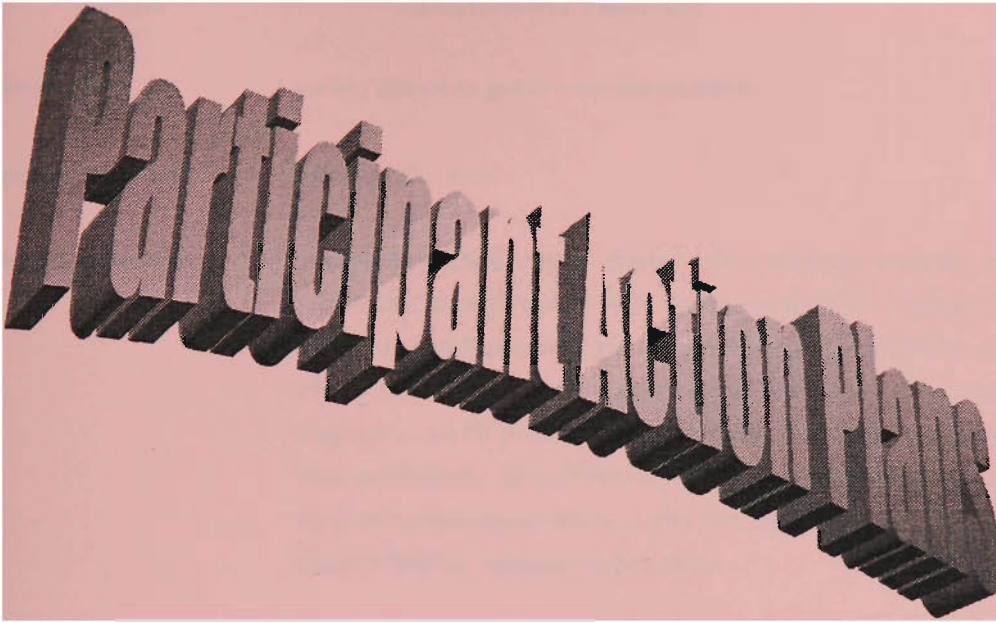
1. check each participant for reasoning skills and thinking strategies (define these)



**Action Plan SH 30 - Problem 2**

Withdrew from study – cited pressure from other commitments

**NOTE**  
1. check each participant for reasoning skills and thinking strategies (define these)



# Problem 1

Action Plan VD 8 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter– grab – read
Problem Selection	read problem/task again – started a flow diagram in wkbk - returned to WRC ...first, the strategy would be to figure out what the problem is...sussing out what the chemical problem is ... read through the inform to get a general idea what I have to do...to get to the solution I'm the sort of person to have a flow diagram ... so I'll put the problem up and work out a plan from that to get to my final conclusion...go and find some background information on the region... to see if there have been any recorded facts of it... Goes to Region - random exploration
Locate Evidence	Newspaper – 'Industry killed fish' says worker - read – highlighted sections & 'grab'
Problem Selection	referred to task again - types note in PDA .... So, I'll make a little note on that newspaper article... just do a cut and paste... just write down the point ...that sewerage was a problem....
Locate Evidence	TV – Fish found in river - viewed/listened – note in workbook OK, ... so now were narrowing it down to a couple of things... we've got the sewerage , we've got potential chemical....so the fish down the river had something to do with chemicals ... look at maybe what chemicals could be put in there...
Locate Evidence	TV – Chemical dumping witnessed - viewed/listened .... conformation of the chemicals being dropped in... check out things in the radio....
Locate Evidence	Radio – Tip chemicals killed fish - listened – note in workbook - lists possible causes of problem ...now I'm starting to gather the major points on the reasons for it.. we've got sewerage, chemicals, the tip, poor cleaning of equipment, maybe poor dumping sites as well....just have a closer look at where things are being dumped... to see whether they're effecting on the river
Locate Evidence	Radio – Chemical dumping campaign – listened – rejects evidence ....OK, that's just a campaign really, so I don't need that...

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>Radio – Tip poisons nearby river - listened – note in PDA – linked media – highlighted &amp; ‘grab’ – referred to own notes in PDA</p> <p>....just recording down... the tip and water flow underneath...ok, what else we got.... Now, I’ll probably go out and do some tests myself.. try to figure out if its true or not...</p> <p>Returns to Zone 3 – begins random exploration of the area</p>
Locate Evidence	Radio – Chemical dumping campaign - started to listen – stops and continues
Locate Evidence	<p>TV – Fish found in river – viewed/listened (2<sup>nd</sup> time) types in PDA</p> <p>...ok, now I’ll find out where the tip is and do some tests myself ... newspaper article ...</p>
Locate Evidence	Newspapers – acid burns school boy at local tip – reads
Locate Evidence	<p>Begins water testing – pesticides – up/down river comparing figures – records readings in PDA</p> <p>...just trying to find differences in readings to justify what’s going on.....</p> <p>wonder if temperature means anything.... don’t know enough about this stuff to figure out what I need to look for...the only big difference is the pesticides go from low to medium.... .. doesn’t mean too much at the moment... but maybe that’s...ok, so there’s a significant increase in bacteria,,, which means potential poisoning I guess... I’ll take another sample below there.... Do a little bit more research on..... try to look for more confirmation of what I’ve found....</p> <p>Returns to WRC</p>
Locate Evidence	<p>filing cabinet - checks several articles</p> <p>... water pollution – land fill , waste disposal, disposal of farm containers...</p> <p>obviously the issue would be chemicals being dumped at the wrong spot...</p> <p>maybe...so there’s more information on the chemical so I can use that as well....</p> <p>could also add in a bit</p>
Problem Solution	<p>outlines possible causes of problem</p> <p>... if I was gonna make a report add in what the impacts were.. use more of the resources again .... So in the report I’d have a ....<i>refers back to task</i>...brief introduction to what was going on.. the potential reasons... outline the reasons....talk about the sewerage, possible chemicals from the tip, water flow under the tip, poor drainage in the area, positions of the tip and back it up with what I found here... add in some tests showing significant differences, taking one upstream one downstream, and compare that to justify findings and try to add some impacts of it as well...</p> <p>Indicates completion of the task - Outlines personal strategy</p> <p>..so one of the things I do when I’m planning, instead of doing it on the computer, would be to do a flow diagram so I’d have my problem ... being chemical pollution... and I’d separate it when I started findings things out into</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

the different areas so that the four different potential problems ... what background information I have for each one and where I got it from so I'd keep a list of where I was and then make a plan out of it as in 4 or 5 major headings with the different points under each one that I want to talk about and from that plan you can look at it and say well if I don't have enough information on it you can go back and find more.....

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 11 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem I’ve got the information and the task and I’ll go out and look at that section of the river....
Problem selection:	Peter– grab – read - went to Zone 3 - brief look at scenario Returns to WRC
Problem Selection	(read task again) .... Have a look at the newspaper reports....
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker - read aloud – highlighted sections & ‘grab’ ...dead fish... sewerage treatment plant....etc...take this part out....muttering.....
Locate Evidence	TV – Fish found in river - started video, then linked media – read – note in wkbk .....fish are going to be tested and the water is going to be tested    need to test water and fish....
Locate Evidence	TV – Chemical dumping - started video – linked media – read – note on wkbk ..... pollution inspectors .... etc... more dead fish....industries.....licence.....illegal dumping.....chemicals.....
Locate Evidence	TV – Resident’s call for tip closure - started video – linked media – read – note on wkbk ....chemicals leaching from the soil in the tip....what else...
Locate Evidence	TV – Chemical dumping witnessed - started video – linked media – read – note on wkbk .....someone has witnessed the chemical dumping.....muttering (reading report)..... deliberately dumping... ..chemicals...
Locate Evidence	Radio – Chemical disposal policy outlined - linked media – note in wkbk ..... illegal dumping goes into the tip near the river ... also contribute to the problem.....residents also dumping... als o contributes to the problem
Locate Evidence	Radio – Tip poisons nearby river - linked media – note in wkbk ... chemicals are leaching into the groundwater under the tip.....muttering....

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Radio – Tip chemicals killed fish - linked media – note in wkbk ... chemical containers left at the tip.....muttering..... Returned to Zone 3
Locate Evidence	chemical testing – comparison of figures from top to bottom of river ...I'm taking water samples and testing for the water quality... so far I've got... as you come further down the stream the levels are getting higher until the bottom of the screen they are at their highest level..... at the top of the screen is the lowest level so as you are going through its gradually getting higher..... 800... I'm not sure what all these things mean... the temperature is steady , the salinity is steady, the flow rate is steady,,,, .... Bacteria has gone up, algal cell count has gone up, phosphorus is enormous, nitrogen has gone up and the oxygen is going down,,,,, so we've got increasing levels of phosphorus.... ph level has gone from 7 at the top of the screen and acid.... The pesticides... has gone from 0 to medium...gone from 5 to 7 ... there's a problem seems to be coming from the garbage or the dump...or in the area of the dump rather than the factories.....there is some coming from the factories... going up a little bit... 0.5 ....acids starts ...high pH must be alkaline then.....so if it starts off at seven and goes down to 5 .....and up to 6 so there some coming out of industry and down to 4.5 ok the biggest problem is the tip and pesticides.....0..0..0...low...and down to medium at the tip.... Still coming from the tip.....and.....muttering.....
Problem Selection	reads investigation and task again – made notes in wkbk – used venn diagram to clarify ideas – checked info gathered in PDA .....move the tip... community education.....relocating .....chemical dumping areas....away from the .....increased security....separate cleaning facility.. for chemical containers...I think the way to clean the water up is to stop the chemical dumping... the way to solve for the future not for now....wetlands ...muttering,,... artificial wetlands.... (reading through notes)
Hints	Peter again – then returned zone 3
Locate Evidence	Radio – Tip poisons nearby river – listened ....I'm not sure where else I can go now..... Returned to WRC
Hints	Peter – filing cabinet – agricultural runoff – read aloud Returned to Zone 3
Locate Evidence	compared saline figures .....muttering (comparing figures)...
Problem Solution	started to review data collected OK, so going through all of that it seems to me that with the acid figures increasing from top to bottom and the pesticide level increasing in the same area

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

that seems to be the main problem ....and that looks as if its mostly coming from the dump with the chemical containers and the illegal dumping and the community dumping of small lots as well so its increasing both acid levels and pesticide levels in the water so its killing the fish and burning the children ....um.....really the only way of getting around that would be increased community education and increase the security around the tip to try and prevent the illegal dumping... the chemical dumping areas need to be relocated away from the water table... and the cleaning facility for chemical containers that's the last one that's right so you don't have them sitting around....I think that's about all.....

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)



Action Plan    VD 12 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem            (no audio track?)
Problem selection:	Peter– grab – read - went to Zone 3 .....I'll have to go there first.....(referring to zone)
Locate Evidence	Made chemical tests of water returned to WRC
Locate Evidence	checked 'fish info' in animal/plant book – made note in wkbk – wrote a venn diagram in wkbk
Locate Evidence	TV – Fish Found dead in river - viewed/listened – linked media – highlighted sections & grab
Locate Evidence	TV – Chemical dumping witnessed - viewed/listened
Locate Evidence	TV – Residents call for tip closure - viewed/listened – made notes in wkbk Returned to Zone 3 – random exploration
Locate Evidence	TV – Chemical dumping to be fined - viewed/listened
Locate Evidence	TV – Returned to WRC
Hints	Peter
Locate Evidence	Newspaper - 'Industry killed fish', says worker – read
Locate Evidence	Newspaper – Industry suspected of dumping acid - read – made note in wkbk – appeared to be more selective with information gathering Returned to Zone 3 – random exploration
Problem selection	reviewed task and information in PDA .... going over my notes..... listing possible causes for the fish kill.....
Locate Evidence	Newspaper - Chemical dumping radio campaign – read & made notes
Locate Evidence	Newspaper - 'Industry killed fish', says worker – read & made notes

NOTE

1.        check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Began chemical testing – examined data and made comparison between points – each test compared individually in initial stages – then sampled all items and collected in PDA Returned to WRC
Locate Evidence	filing cabinet – farming folder – read list
Hints	Peter again – acts on advice
Locate Evidence	filing cabinet – made careful selection from list – runoff, pesticides – made notes in workbook Returned to Zone 3
Locate Evidence	TV – Chemical dumping witnessed - viewed/listened – linked media – highlighted sections and grab
Locate Evidence	Newspaper – Industry suspected of dumping acid - read – highlighted sections & grab Returns to WRC
Hints	Peter -
Locate Evidence	anima/plant book – silver perch – rechecks headings of newspaper reports
Problem selection	reviews notes(wkbk) and task in PDA
Problem Solution	indicates completion of task
	NOTE : Participant appeared to be a 'silent'(reflective) thinker

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 13 - Problem 1

## STEPS

## REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem (no audio track?)
Problem selection:	Peter– grab – read - reread sections while highlighting words/phrases in text went to Zone 3
Locate Evidence	TV – Chemical dumping witnessed - linked media – read – highlighted sections & grab
Locate Evidence	TV – Resident’s call for tip closure - viewed/listened – typed in PDA ....my idea is better management of the tip.....
Locate Evidence	TV – Chemical dumping to be fined - viewed/listened to mid tape – linked media – highlighted & grab
Locate Evidence	TV – Fish found dead in river - linked media – highlighted & grab
Hints	Peter again – then Zone 3
Locate Evidence	began chemical testing (uncertainty with tools – some advise given) – typing into PDA – verbalises thoughts – (extensive use of tools without researching media support – appears to be off track with testing?) – some results in PDA ... I’m testing in the river... moving downstream from the dump....results are pretty weird.....don’t really understand.....now I’ll try for something else.... Returns to WRC
Locate Evidence	filing cabinet – water pollution ....farmers use phosphorus....I’ll need to recheck that.... <ul style="list-style-type: none"><li>• Pilliga Crossing Industrial estate – read – grab</li><li>• Hazardous waste in the environment – read &amp; grab</li><li>• Sources of sewage</li><li>• Landfill</li></ul>
Locate Evidence	Newspaper – Keep out of river - read aloud – highlighted sections and grab – makes comparison with previous data collected ....that information goes with the news report from before.....
Locate Evidence	Newspaper – acid burns school boy at local tip – read aloud ...more support for possible causes....look at all my information to see what links I can find.....

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Newspaper – Industry suspected of dumping acid – read ..... industries are a problem.....
Problem Selection	Examines PDA notes and rereads task – indicates that data collection is sufficient to generate a solution but expresses confusion with what some of the data means and uncertainty in what to do next to finalise session.... Tape finishes

**NOTE:**

1. participant made no use of wkbk, choosing to do all note taking in the PDA
2. no use of venn to define strategy
3. expresses lack of understanding at end of session – comments 'I probably should have used the circles to help.... not a strategy I am familiar with'.

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 17 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter– grab – read - wrote heading/questions in wkbk - opened TV listing and scanned titles then checked in more detail
Locate Evidence	TV – Chemical dumping witnessed – linked media – read
Locate Evidence	TV – Resident’s call for tip closure – linked media – read – highlighted sections & grab ...just going into linked media to find what information I can get from the TV...
Locate Evidence	TV – Fish Found dead In river – linked media – read – highlighted sections & grab ...grabbing some information that says.... Councils at fault of dumping chemicals... that’s from Sue Walters.....just seeing if I can find more on this .... Um.... Locals seem to think the tip is to blame but we have no evidence as yet...from this news it says from laboratory tests ..container...prove that it contains a foreign chemical... that’s the fish but more tests need to be done...go to radio to see what they have to say...
Locate Evidence	Radio – Tip Chemicals killed fish – linked media – read ....residents say the council is to blame for the river being contaminated from the tip ... they’ve apparently done tests.... .....they’re tests which involve drilling and water sampling confirm the chemicals have found there way into the groundwater.... And the water table is close to the surface so obviously the groundwater is seeping into the river.... ....going to the filing cabinet to see what that has to say
Locate Evidence	Filing Cabinet – looked at folder titles then went to zone 3 to explore ..... Might check the river first to see what industry its got there as well Goes to Zone 3 – random exploration – media reports – chemical testing
Locate Evidence	Radio – Tip poisons nearby river - linked media – read – highlighted sections & grab – analysed ‘on the fly’
Locate Evidence	Newspaper – acid burns school boy at local tip – read ... the pollution entered the river during recent heavy rain....
Locate Evidence	TV – Chemical dumping fined - linked media – read – analysed – made note in wkbk

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Problem selection	checked task and notes
Locate Evidence	Radio – Chemical dumping radio campaign – linked media – read ....we might do some testing on the river o see what chemical there is
Locate Evidence	Begins chemical testing – P,N,O, salinity – comparison of figures ... just see if there is a difference in the water closer to the tip and further upstream....the water taken near the tip compared to the water upstream is a lot higher in... um... phosphorus, nitrogen, ...and has less oxygen... have a look downstream...its higher again....have a look at the pH , temperature and the river flow rate.... also the turbidity... (continues checking)....ok, the turbidity is actually lower near the dump, pH is lower, temperature is 2 degrees higher...(types into PDA – compares figure – continues to type in PDA) ...we might see if I can get some help from the team in the centre... Returns to WRC
Hints	Peter – acts on advice
Locate Evidence	filing cabinet – farming folder – selects articles(runoff, (read) landuse (read), farming practises(opened then closed) ...I've had a look at TV and radio, so I'll go to the file....going to have a look at runoff ...said that groundwater was ????.... and the salt table was close to the surface.... .....might have a look at flooding since they said the fish were found after the floods....
Locate Evidence	Flooding occurrences(read), flood plain siltation (read), groundwater (partially read, then closed) ...just having a look at some other avenue that might have an effect on the river such as mining...underground mining that I know has had some effects on the rivers around Sydney, so I'm having a look at that....
Locate Evidence	TV – Coal Mining – linked media – read – highlighted sections & grab ....just having a look at the environmental impacts to see if they relate to the results I got from the tests.... ....just go back to the area to see if there is actually any mining in the area... Returns to Zone 3 – explores zone again
Problem Solution	... I think the tip seems to be the cause ...of the problems in the river and the dead fish obviously there is no mining in the area ...or other industry...and the results from the tests definitely show the levels are different near the tip compared to upstream.....(looking through PDA notes)... with the evidence we might approach the tip and maybe see.. to get evidence that it actually the tip we need to see what chemicals ... (looking through PDA notes)... that there the

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

same chemicals coming from the tip that were finding in the river and to see what other effects its had on the land.....um....the info we've got we might take it to the media so they can publish it and the council might close down the tip.....

Tape finished

**NOTE: no venn strategy used**

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 18 - Problem 1

STEPS

REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	Peter– grab – read ...so I want to find out the cause of the pollution... so get articles and take my own measurements... Went to Zone 3 – began random exploring
Locate Evidence	some animals/plants – reads briefly
Locate Evidence	chemical tests
Problem Selection	reread investigation/task again
Locate Evidence	Newspaper – Keep out of river – read
Locate Evidence	Radio – Tip poisons nearby river – linked media – read ... I want to find out where the area is where they fish so...(continues exploring)....
Locate Evidence	TV – Chemical dumping fined – viewed/listened – made note in wkb
Locate Evidence	Radio – Tip chemicals killed fish – listened
Locate Evidence	TV – Fish found dead in river – viewed/listened – made note in wkbk .....I'm just going to test where I think that article came from ...that news report that they are talking about...
Locate Evidence	Took more chemical tests in the river – compared tests individually – checked results in PDA then edited and deleted some readings ...ok.. I want to look for the article on that...um... eels and silver perch ...so I'll just....
Locate Evidence	Radio – Tip poisons nearby river – starts then stops after introduction – continues to search
Problem Selection	Read problem outline and notes again, then made decision to solve the problem
Problem Solution	....um.. I think I'd... I know what's causing the problem... insecticides being dumped at the tip... there not being stored properly and when it rains the runoff is going into the river....um.... and what's happening is they're getting dead

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)



fish... the silver perch and eels... um... making it dangerous for fishing but its also dangerous for kids swimming in the river as well... so.. if the insecticides were stored and... properly... um... the chemicals treated properly... you wouldn't be getting a runoff but because you are getting a runoff you need an environmental cleanup...  
.(checking notes again)....

**NOTE: no venn stategy used**

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 19 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter– grab – read - made note in wkbk – reread task <i>... first I'm going to write down the problem... killed large number of fish....</i> Went to Zone 3 – random exploration
Locate Evidence	Newspaper – Industry suspected of dumping acid - read – highlighted sections & grab to PDA - suggests possible cause <i>... looking at the article I found out its possibly acid....</i>
Locate Evidence	Newspaper – acid burns school boy at local tip – read <i>....um... local tip...go back and test the water for acid...</i> Returns to Zone 3
Locate Evidence	Measurement tools - selects pH and checks near dump...records reading in PDA <i>... reading is 5....go back to article ...</i>
Locate Evidence	TV – Chemical dumping to be fined - linked media – read – highlighted sections & grab - suggests possible cause <i>...and gathering information up....and highlight this part about chemicals in the river ...put in my report ... and put that information up into my notebook... and possible cause of why the chemicals leaked into the river.. that information is ... so found a possible cause is chemicals leaking into the river from the local tip and its supported by the boys being burnt by the acid....certainly the acid.. and there was acid being in the river...and...going to have a look at other areas to see if there is another problem and not just the tip....</i>
Locate Evidence	Radio – Tip poisons nearby river - linked media – read – highlighted & grab <i>...OK, ... More information that the chemicals are leaching into the groundwater... bit further down the river....</i>
Locate Evidence	TV – Fish found dead in river - linked media – reads <i>...I'm just going to go back to the problem and have a look at the first question... ... the problem...</i>
Problem Selection	revisited task in PDA – checks own notes
Locate Evidence	Begins further testing in the river - pH only - records readings in PDA <i>.... looking further upstream in the river....and...bit further... further up....test the water further up to see what the pH is.....and... best to get the area with the highest reading....</i>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Radio- Chemical dumping radio campaign - linked media - read <i>....there's more information about pollution further upstream....and there's two causes of pollution in the river so far...</i>
Locate Evidence	Newspaper – Keep out of river - read – highlighted & grab <i>... I'm now in a newspaper article ... put that information into my notebook ...</i>
Strategy Outline	examined assigned strategy
Problem Selection	checks information gathered – checked task <i>...and look any further up the river...and , so where the problem is...pollutants from industry on the land, ... on the edge of the river .....</i> Returned to WRC
Possible Solution	consults notes in PDA <i>....I'll go back and find ways of fixing the problem....back to the top task....and to answer the task...(begins to type in PDA).</i> <i>.possible reasons.... Found... runoff...from local industries.....into the river... finding the evidence to support the causes....</i>  Participant continued to prepare a solution and indicated the information gathering process was completed....  No Venn Diagram used.

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 20 - Problem 1

## STEPS

## REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	<p>Peter– grab – read - filing cabinet - changed mind</p> <p>...ok first I'm going to investigate what this is all about....alright there were fish floating around...dead fish floating around.. possible reasons... ok... well....I'll just go to the files first....might go back too this guy...back to the area first</p>
Hints	<p>Peter - listens</p> <p>Went to Zone 3 – Began exploration</p>
Locate Evidence	<p>TV – Chemical dumping to be fined - started then 'linked media' – read – note in wkbk</p> <p>... reading it is easier....ok, so there's evidence of chemical pollution ... its been illegally dumped...doesn't really say where its come from....(some confusion in navigation)</p>
Locate Evidence	<p>Newspaper – read</p> <p>... ok, this is just a report about the dead fish.....</p>
Locate Evidence	<p>Radio –Tip poisons nearby river - linked media – read</p> <p>... go back to the centre and I'll look at water pollution</p> <p>Returns to WRC</p>
Locate Evidence	<p>filing cabinet – water pollution</p> <p>....well this just talks about the pollution of the water and what causes it.... What am I trying to do?.....</p> <p>Selects 'Hazardous waste in Environment' – read – made notes in wkbk</p> <p>.....now I'm totally lost I'll start....</p> <p>Returns to Zone 3</p>
Problem Selection	looks at 'task' again in PDA
Locate Evidence	<p>TV – Fish found dead in river - linked media – read – note in wkbk</p> <p>.....we've got dead fish floating...huge amount of them....um...possible reasons....dumping of chemicals....contaminated water from rubbish tip.....leaking into the river....also got an ??? of student caused by....(just write it down)....there's also dead eels... the fish contain a foreign chemical... just been tested</p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Newspaper – Industry suspected of dumping acid – read ... in another area there's a newspaper clipping... acid being dumped at the rubbish tip....where's the rubbish tip?....ok, well the tip ,is suspected but the manager says they have a disposal program for it... I'll just go to .....
Locate Evidence	Radio – Chemical Dumping radio campaign – read OK, ... Um. What's this... chemical dumping... just advertising... factories dump there rubbish because they think its going to get treated... well this plant is able to manage all its dumping apparently... Returns to WRC
Hints	Peter – acts on advice
Locate Evidence	filing cabinet – farming - agricultural runoff – Farming practises – reads both ... OK, I needed a few hints... I forgot what he said... ok, pesticides...I'll just go back to this guy to help me
Hints	Peter again - listens ...O'K.... I have no idea on what chemical comes from where...what chemicals could be in the water... toxins, I guess I should check on that... go back to my area and check for toxins... Returns to Zone 3
Locate Evidence	moves mouse from upstream to down checking measurements ...don't know what these figures mean... medium pesticides in this area... downstream... there's none at the top... just take that...pH level...pesticides down here and there's dead fish in that area... what chemicals...so we've got the tip dumping these chemicals which are finding there way to the river... how do we prove what chemicals they are...back to my friend
Hints	Peter again - listens ...I'll read this... hazardous waste... there's chromium for leather tanning and I think there was a factory that did that... just take this...lead coming from...I think lead is in paints... the rubbish tip is dumping...O.K we've got arsenic, pesticides.. oh, my goodness, carcinogenic...domestic waste copper comes from domestic waste...what does it do... its not very toxic....don't have to worry about that...mercury.... ...I'll look at water pollution again because I don't understand what can cause the death of fish
Locate Evidence	Filing Cabinet – selects and reads articles – paraphrases - Hazardous waste (copied bits on heavy metals) – Water pollution – Pilliga Industrial estate (read & grab) – Impacts of landfill waste (read) ...phosphorus... causing....that's not very helpful... the industrial state ... lets have a look... tannery...(muttering as reading).... Oh, battery acid....so we have suspects... the tannery because they use chromium which is toxic to animals, I

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

think....ok, it doesn't say anything about being toxic, just a pollutant.... Wood products and paper.... Use....might just write that in....just fix my notebook....there's a mill that discharges....chlorine....food chain....there's another factory so what do they use that could be potentially hazardous... cyanide...battery manufacturing .. produces lead which we found wasn't poisonous to the fish....well, all of them put some chemicals in there ... or use chemicals which could possibly be going into the river... which one could be poisonous to the fish... chemical truck wash... soap and detergent, lead, phosphorus...muttering.... And ...impacts of landfill.....that's not going to tell me anything about the fish... go back to the guy again

Hints

Peter - listens

.....ok, I'll go to that radio report to see if there are any clues....

Locate Evidence

Radio – Tip Chemicals Killed fish - linked media – read – then reread  
... this is just pointing the finger at the....

Locate Evidence

Radio – Tip Poisons nearby river – second time – read  
...fish kill is the most obvious environmental damage.... Insecticide... just highlight that... grab it, so I don't forget it...

Locate Evidence

Radio – Chemical disposal policy outlined - linked media – read – highlighted sections & grab – refers to own notes – checking  
...OK, he's a scientist ,he might help me....its just the site.....poorly chosen.....doesn't say anything about the fish....  
... there is obviously a problem because they are going to mount a campaign... just highlight that and keep it....  
...ok, so it will be fixed by.....  
..... poisonous fish...dead fish .. which means there is pollution, toxic pollution... and we have the tip as our major... major contaminant... doesn't say pesticides ... lets go back to farming practise.....

Locate Evidence

filing cabinet - (reread articles in farming folder)  
.....ok...

Problem Solution

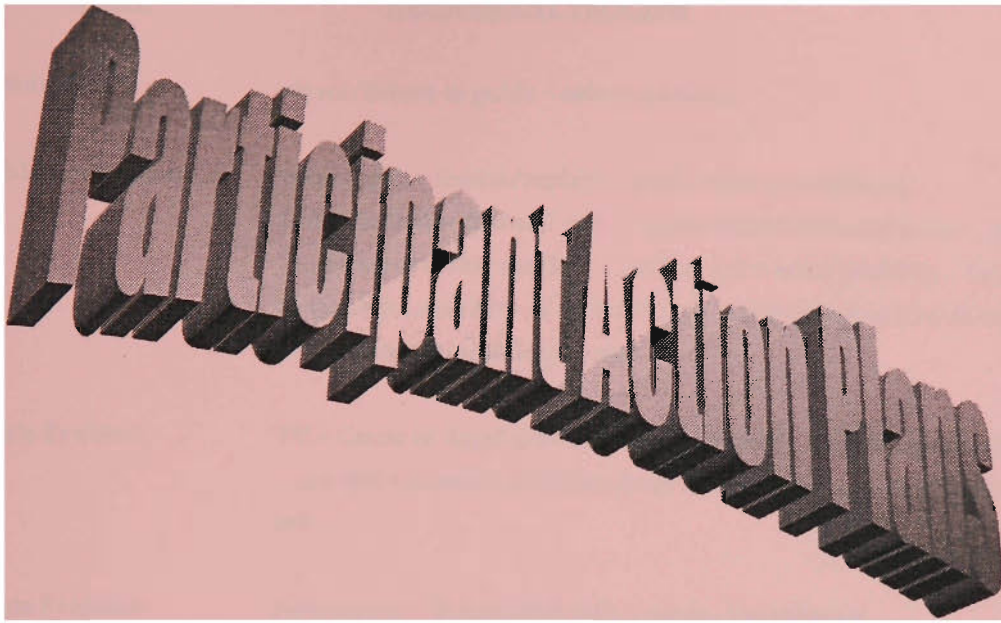
**participant then indicated completion of investigation**

**NOTE:**

- 1. venn diagram not used**
- 2. no clear (obvious) strategy used**

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)



## Problem 2

# Action Plan VD 8 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter– grab – listens/replays – grab – note in workbook. Going to replay that so I can ... figure out what I need to do ... weed problem ... ...weeds growing quickly .....so I've got a weed problem ...find out why it grew so quickly...and how to control it...get some background information... Goes to region – random search
Locate Evidence	TV – Cause of Algal growth found – listened – note in workbook .....so, got a possible pollution from house (camp) .....see what the next one has to say ...
Locate Evidence	Newspaper – Weed effort fails – reads - paraphrases ... reading information on how they tried to get rid of it.... originally tried to get rid of it by physically taking it out... that's not working.... Want expert advice on it ...
Locate Evidence	Newspaper – logging linked to weed growth – read – highlight/grab sections into PDA ... another article ... weeds ... gathering some more information ...
Locate Evidence	Radio – Weed covers river, killing fish – listened ..another possible cause....
Locate Evidence	Newspaper – Weed eradication program – reads - evaluates - types in PDA .....ok, not much there.....just writing some information on both of them....
Locate Evidence	TV – Weed growth distresses residents – views/listened ... from the background information my thoughts would be to do some chemical tests...try to figure out if I can pinpoint the specific problem....
Locate Evidence	Measurements – selection of tools (phosphorus, nitrogen, oxygen, algal count, flow rate - entries in PDA) – scans river looking at each test - making comparisons from above camp, camp, below camp. ... up the river its pretty clean....algal counts gets worse down river..... Continues exploration of region
Locate Evidence	Radio – logging linked to weed growth – listened – note in workbook .....got a big problem with the logging camp....what I've done is figure out what the problems are ... I've got two lists here (workbook) of what the potential

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)



contributors are and potential ways to remove it, ... I'll go back to the research place and find out any other information....

Returns to WRC

Locate Evidence

filing cabinet –reads a selection of articles – audio - checks  
...OK, got some causes on where you would....habitat has changed meaning the weeds can take hold....got some contributors ...poor quality of river below camp....weeds have been able to get established and certain weeds such as alligator weed can spread in other areas that aren't bad and that make the whole thing worse....so that's water quality again...look at some other stuff... just extending my list....

Locate Evidence

Checks TV reports, Radio – checks database – recognises previous articles  
..... same stuff I've looked at before.....

Locate Evidence

TV – River choked by wild willows – viewed/listened – note in workbook  
..... try and find some remedies...I've got some causes but I need to figure it out....so, ....

Problem Selection

Checks notes in PDA – revisits task – note in workbook - reviews evidence collected

Problem Solution

looks at evidence collected – talks through process  
.... Got two lists in front of me...figured out a few things... of contributors and potential ways to fix it up....so, I'd look at all the information I've got and try to summarise each column into ..sort of, under major headings.. so for contributors, one major problem would be the river quality which comes from ...below the logging camp and the stuff they're putting into the river... one from the fisherman saying sewage from "house" ...still water quality really.....if water quality bad weeds can get a hold ...Another big thing is the removal of weeds makes it worse ... different types of weeds can spread themselves that's a big cause.. and planting of non native species, like willows, up and down the sides of the river...three sort of main things there.... from fixing it up it comes from making people aware of the problem by putting a warning sign not to handle or remove weeds ... collecting samples to hand in... that's about it really.....

Question

Do you think there is a main contributor, any specific one?  
.....the river pollution from the logging...

Question

I noticed you do a lot of cross referencing is that the normal way you go about solving problems of this nature?  
.....cross referencing the information on here?...(referring to the subjects notes )....basically I went through everything on this to get a broad picture and went back to everything documented and found out it was the same... I wanted to

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

check if there was anything more that I could get... that's how I do things, get as many options as possible to see which ones funnel into each other....

While talking, the participant deleted the PDA measurements - indicates completion of task

Question

What was happening during the measurement phase of your problem solving?  
When reading the contents of the river I just dragged it all the way down river to see the changes in the readings ,,, noticed that the algal content was lower at the top half but after the logging camp it stayed at a constant high level so I did a reading at the top and one below it so if I needed to use them later to compare the two to try to show the logging bit was the problem

Question

I noticed you took the algal counts and you made a comment about that. Would you like to refer to some of the other things you were specifically looking at?  
....just quickly ran through the box of things ... the algal content, the salinity, pesticides, phosphorus, nitrogen, water flow rate etc ... tried to look at the actual nutrient differences ...

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 13 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem Selection	Tatiana – note in wkbk – grab – note in wlbl – reread – note in wkbk Goes to Region – random exploration
Locate Evidence	Newspaper – weed effort fails – read – h/g ....to reduce weed growth... Returns to WRC
Locate Evidence	filing cabinet – water pants/weeds folder - (1st article) – then animal/plant book (general look) ....I'm just trying to see what type of weed it was....
Locate Evidence	Radio – Weeds cover river, killing fish – listened
Locate Evidence	TV – Cause of algal growth found – viewed – note in wkbk
Locate Evidence	TV – River choked by wild willows – viewed – note in wkbk
Locate Evidence	TV – Weed growth distresses residents – viewed – note in wkbk
Locate Evidence	Radio – Logging linked to weed growth – listened – note in wkbk ..... I looked into the radio and TV and both told me two different accounts of where... the one I was just listening to was about the wood loggers and people have been blaming them....I think its got something to do with sewerage going into the water....and the fisherman that ....said there was a house up the river ... and it had wastage going into the river as well, and he's blaming it on that...I'm thinking so far that its got something to do with sewage waste going into the river.....and, what I've done is written out white river in the first place...and there's also an idea that the wild willow tree has been planted by loggers and that's not good for the river... I've got ...main cause the logging company and the sewage.... there's problems with their boats and they are willing to help in the problem...a scientist said he had an idea for getting rid of the weeds....go into the radio file....
Locate Evidence	Radio – Expert warns against weed invasion – listened – note in wkbk ... he said its alligator weed ...that's from ponds and he thinks people have thrown it out into the river... that sort of kills my sewage idea, but that's only one person.....

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>Filing Cabinet – weeds</p> <p>...just looking up causes of weed infestations.....this says that weeds grow in an environment ... this may include of damage through clearing....introduction of foreign materials...etc.. reads from article....maybe it is alligator weed because....its not really a very developed area....</p>
Hints	<p>Tatiana (measurements/fisherman)</p> <p>.....go to the area....do some testing</p> <p>Returns to Region</p>
Locate Evidence	<p>makes selection of measurement tools &amp; tests river – above camp, level with creek, checks down river</p> <p>....sort of .....the water's pretty clean...no pesticides or oil....oxygen about 65%.....coliform bacteria.....looking for evidence of sewage in the water....there's a fair bit of nitrogen in the water....I'm just comparing the different bits of the river.....</p>
Locate Evidence	<p>Rereads newspaper article on weed growth – audio</p> <p>.....logging linked to weed growth.....its linked to the logging site...a lot of nitrogen and phosphorus in the water...higher than normal concentrations...reads from article to support....</p> <p>Returns to WRC</p>
Locate Evidence	<p>Rechecks media reports – rechecks wkbk notes</p> <p>.....animals gasping for oxygen and clean water....</p> <p>Indicates completion of task</p>
Question	<p>Who do you think the culprit is?</p> <p>...I think it's the logging...and also the alligator weed</p>
Question	<p>Would you normally go about solving problems of this nature in this way?</p> <p>.....yes, although I probably don't always do this, which I think is a good idea...</p>
Question	<p>You mean writing things down?</p> <p>....like categorising things,,, I don't always do that, I think I rush into things...but because you said to me ...and I knew from last time that.... I'll read it if it's on a piece of paper rather than the notebook up there...(indicates the computer screen)</p> <p>So, is that why you don't try to go back to the question, because you have to go back...you would rather see it on paper in front of you?</p> <p>...I just think that when I write it down I'm thinking about it and I'm going over it again and I'll tend to go back to a bit of paper....I think this (strategy) is a good idea doing it that way but I don't always do that...I just rush in...(laughs)</p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Question

You didn't use the venn strategy as such, do you think they could help you or you don't think it helps you at all?

...I think it could because I could have used the circles and have weed problems or causes in one bit and suggested actions in another bit ....and I probably would have found all the things would have come to the same conclusions...I know how it works but I probably wouldn't use them...I haven't used them before.....

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan VD 17 - Problem 2

STEPS	REFINEMENT PROCESS
Introduction	views/listens to guide – selects problem
Problem selection	Tatiana – grab – read – draws venn in wkbk (3 circles) – headings in venn – reread task
Locate Evidence	TV Reports – reads titles
Locate Evidence	TV – Weed growth distresses residents – linked media – read
Locate Evidence	Radio – reads titles
Locate Evidence	Animal/Plant Book – checks index – reads listings – selects ‘willows’ & reads
Locate Evidence	Newspapers – reads titles – note in wkbk Goes to Region
Locate Evidence	takes measurements – pesticides, pH, pesticides, nitrogen, algal count – mouth of river, above camp, below camp – note in wkbk Indicates completion of task ... do you want me to keep going?
Question	Can you answer the problem? ....I think so... I think what’s happened is they have logged all of that area and removed all the native trees and that’s caused erosion, especially around the river banks and to prevent that happening they have plated willows....
Question	Do you think that’s the main problem or do you think there are other causes? ...the algal growth is a lot higher around the logging areas...
Question	Do you think it’s the logging practices that have caused the high algae count? ...or the actual logging?, is that what you are trying to say...a bit of both.
Question	If you were going to solve this sort of problem , is this the normal way you would go about doing that? ...using a venn diagram?...
Question	Is this a normal strategy for you, using a venn diagram? ....no, I probably would just write it down in a bit of a list.. things I needed to find out...like, why was the weeds and water plants a problem....just questions I needed to ask myself then I knew where I was going....

NOTE

- 1. check each participant for reasoning skills and thinking strategies (define these)

Question	<p>Do you think the venn diagram helps you clarify your ideas any better?</p> <p>....it does a little bit...yes, just going off this helped me a bit....</p>
Question	<p>What surprised me a little was that you only looked at the titles for a lot of the radio, TV and newspaper reports. Any reason for this?</p> <p>.....I didn't go into depth....</p>
Question	<p>Do you think you got enough from the titles themselves?</p> <p>....yes..but some didn't tell me anything...but I thought I wasn't go and explore it further...some I could've gone in and read about it more...</p>
Question	<p>So you based your conclusions on the titles themselves</p> <p>...I think it really clicked for me...I 'm not sure ...I think it might have been in TV or radio, but it said how...about the logging...they had a rapid growth in willow trees and I went in and had a look at willow trees....and willow trees cause erosion</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan VD 18 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem Selection	Tatiana – grab – headings in wkbk ...I'm trying to find out why there's weed growth....I'll take some measurements.... Goes to Region
Problem selection	Rereads task – measurements then random exploration
Locate Evidence	takes measurements – random algal cell count – visual comparison of figures
Locate Evidence	Newspaper – Weed Effort Fails – read
Locate Evidence	TV – Cause of algal growth found – viewed – note in wkbk
Locate Evidence	Radio – Weeds cover river, killing fish – listened – note in wkbk – replayed – note in wkbk – linked media – read – h/g
Locate Evidence	Newspaper – Farmer doubts beetle solution – read
Locate Evidence	Newspaper – Logging linked to weed growth – read
Locate Evidence	Measurements again – random readings – coliform bacteria, nitrogen, phosphorus, - readings in PDA
Locate Evidence	Radio – Logging linked to weed growth – listened – note in wkbk Returns to WRC – checks media listings from wall of WRC
Locate Evidence	Newspaper – Logging linked to weed growth – read
Locate Evidence	Newspaper – Farmer doubts beetle solution – reread
Hints	Tatiana – (measurements/fisherman)
Locate Evidence	Filing Cabinet – water plants folder & logging industry Returns to Region – testing of river - no recorded readings – general
Problem Selection	Looks at task & PDA notes
Hints	Tatiana – (animal and plants) – acts on advice

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence	Animal/plant book – floating weeds – alligator weed – h/g
Hints	Tatiana – (journal)
Locate Evidence	Database – Radio Report – Logging linked to weed growth – relistened – note in wkbk
Strategy Framework	Reviews Venn strategy booklet – draws circles and makes entries Indicates completion of task
Problem Selection	.....I'm just trying to put together what I've found out....I've found out what the weed is ...it's the alligator weed.....I think it was said in one of the articles...it's a floating weed and grows in stiller waters....around the areas of thje river where the water was still up ...around the bends in the river...
Question	Is there any particular reason why the waterplants are growing so extensively? ...yes,...its from the logging company and the camp they have....the sewage is running off and also the soil running off into the water.... Ad, so that's extra nutrients for the weeds ...and the problem the weeds are causing is that they are using up all the oxygen in the water and the fish are dying....and also making it difficult for the fishermen to manoeuvre through...and there was that bug....that they could use to control ... the beetle's food source could be that weed....
Question	Is this the normal way you would go about trying to solve problems like this? no, like I woudn't do it in such a short time...I'd spend longer on it...
Question	How do you go about it? What's your own strategy? .....usually I try to understand the question a bit more.....dive in and read .....get an understanding about the whole thing and pinpoint the specific subjects within that ...that are to do with answering the question.....
Question	You started to use the venn diagram ideas? Do you think the venn diagram approach helps to clarify your ideas? ....I don't know....I think to get confused with the overlapping of the circles and that....I'm usually better off to write things out in point form and then link them with arrows ... I draw a diagram to help me....to remind me...
Question	I notice while you were working through the information gathering process you weren't talking through that process. Is that uncomfortable for you, or is there a reason why you weren't trying to verbalise what you were doing? .....I think I was trying to get a grip on the information that was there....because there was so many different types of information its hard to get it all together.... ...all this stuff that I looked up,... I didn't get it...because I'm better off writing it down...I need to write it down...draw my own links

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Question

So your more comfortable working on pen and paper rather than working on the computer?

...I can get ,,use it to get information, but then....by taking that information,.... printing it out and working on it.....

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan VD 19 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem Selection	Tatiana – grab – read – note in wkbk – audio .... <i>problem is... rampant weed growth...looking for the cause....</i> Goes to Region – random exploration
Locate Evidence	TV – Cause of algal growth found – viewed – linked media – rereads – audio – develops venn diagram – h/g sections .... <i>the contributor....is the wastewater...I'll try using the venn diagram ...problem... getting rampant weed growth ...and some of the contributors...maybe...the rapid weed growth is found in the stiller parts....and also maybe , due to the waste water.....I'll test the water..</i>
Locate Evidence	Takes measurements (all tools) – general scan of river observing changes in readings ... <i>start upstream ...look further down the river.....</i>
Locate Evidence	Radio – Weeds cover river, killing fish – listened – linked media – read – note in wkbk – venn comment .... <i>in that interview there was a common contributor...it was the stiller parts .....have more weed....further up the river it was less muddier and there was less weed.....for one part of the venn diagram we could use observations...so there is rampant weed growth in stiller parts of the river...and further up the river, where it is muddier , there is less weed....</i>
Locate Evidence	Newspaper – Weed Effort fails – reads – note in wkbk in venn – Checks notes in PDA ... <i>some action that's been taken.....trying to physically clear the weed ...</i>
Locate Evidence	Radio – Expert warns against weed invasion – listened – note in wkbk – linked media – h/g key points to PDA .... <i>a definite contributor ...due to an increase in level of nutrients entering ..places up here, such as the waste runoff....(indicates logging camp)</i>
Problem Selection	Rechecks task outline
Locate Evidence	continues random exploration – looks at headings on articles – no new data collected
Problem Selection	Rechecks task outline

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Problem Solution	<p>Begins analysing notes and ideas from venn - begins typing 'solution' to problem into PDA</p> <p><i>....possible main causes....have been firstly the introduction of foreign weed, alligator weed....which has been rampantly ....the waste runoff ....</i></p> <p><i>... actions .....begin physically removing the weeds ensuring that .....the stems and ...pieces are removed .....precautions....should be taken to stop the spreading.....</i></p> <p>Indicates completion of Task</p>
Question	<p>Who do you think the main culprit was?</p> <p><i>...probably the boat...</i></p>
Question	<p>What do you think is the main cause of the problem?</p> <p><i>...probably,....the waste water...</i></p>
Question	<p><b>Where's that coming from?</b></p> <p><i>.....from the place over there ...</i> (indicates the logging company)</p>
Question	<p>I noticed you tried to use the venn diagrams. Do you think that has helped you try to clarifying your ideas better?</p> <p><i>....yes, it did... it sort of gave me different sections to follow instead of looking at the whole problem ....it helped break it down into little bits ...</i></p>
Question	<p>If you hadn't used the venn diagram, how would you normally go about trying to find a solution to this type of problem?</p> <p><i>.....I probably would have looked at the whole thing and not try to look for a cause ...like what was actually happening....but I wouldn't have tried to look for a cause....just go straight through it ...</i></p>
Question	<p>So overall, you think the venn strategy has helped in clarifying your ideas better?</p> <p><i>....yes,....</i></p>

NOTE: missed articles on logging company contribution to problem

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan VD 20 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem Selection	Tatiana (x2) – grab – note in workbook Goes to Region
Locate Evidence	takes measurements – P, N, algal count – above camp, level with camp, mouth of creek, first bend, second bend, bottom of river – compares readings visually – readings in PDA Goes to Region - Random exploration
Locate Evidence	Newspaper – Logging linked to weed growth – read – note in wkbk
Problem Selection	refers to task – reads
Locate Evidence	TV – Cause of algal growth found – viewed(partially)– linked media – note in wkbk
Locate Evidence	Radio – Logging linked to weed growth – linked media – note in wkbk
Locate Evidence	Newspaper – Weed Effort fails – read
Locate Evidence	TV – Weed growth distresses residents – linked media – read
Problem Selection	Refers to task again - reads Returns to WRC
Locate Evidence	Filing cabinet - Water Plants & Weeds – waterplants (reads), weed control (reads, h/g, notes in wkbk) Logging – runoff (reads), techniques for limiting etc (reads, h/g sections)
Locate Evidence	TV – River choked by wild willows – linked media – read
Locate Evidence	Radio – Expert warns against weed invasion – linked media – read- note in wkbk – h/g sections
Locate Evidence	Radio – Weed covers river, killing fish – linked media – read Returns to Region

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>takes further measurements</p> <p>... it looks like the logging company is responsible...but there's no proof ....I don't know.....I'm stuck.....that's where the showers are...the camp....</p> <p>Indicates completion of task</p>
Problem Solution	<p>....alright basically what I've got...</p>
Question	<p><b>So you think the logging company is the main problem?</b></p> <p>...yes...</p>
Question	<p>I noticed you did some tests for phosphorus and nitrogen, what did that indicate to you?</p> <p>.....I did some tests earlier in time, before any building, and they were very low....I also did some at the top, above the camp where they were very low, and as you go down the river past the logging company they get higher and around the bends its higher...</p>
Question	<p>Is this the normal way you would go about solving problems of this nature?</p> <p>....yes,</p>
Question	<p><b>So you do just a random searching for information?</b></p> <p>...laughs)...it looks random, but I think I'm going in the right direction and then something else comes up and I get lost in it...but usually I try to get as much information as I can and then sort it out into ....the problem...how you can solve it...different perspectives...</p>
Question	<p>I notice you were getting bits of info from several articles, what was the purpose of that?</p> <p>...just to refer to .. there were some different bits ...the expert mentioned how he identified the particular weed.. the alligator weed ...and how it can be transported...and bits that I grabbed on suggesting ways to solve the problem...</p>
Question	<p>You didn't seem to use the venn strategy, was there any particular reason for that?</p> <p>basically I don't think I understand the concept ..and when you have a problem I didn't understand how to find something in common...and also I'm used to doing it this way ...it's a habit.... too hard to break...</p>
Question	<p>The other thing I noticed was that you didn't talk much in terms of what your strategies were. Any reasons for that?</p> <p>.....probably because someone's listening.....</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Participant Action Plans



## Problem 1

# Action Plan CM 21 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter – grab – reads
Hints	Peter (filing cabinet) - views/listens – follows advice O.K, I’ve got to investigate why ...
Locate Evidence	filing cabinet – water pollution ....going to the filing cabinet now and looking at water pollution...this would be the main reason why fish are being killed... because of the water pollution.... Why is the water becoming polluted?... Went to Zone 3
Locate Evidence	Newspaper – acid burns schoolboy at local tip – reads - paraphrases - gives opinion .....now were looking at the region ... article on acid burns...school boys at local tip ... so there’s a rubbish dump here not far from the river....says here that dangerous chemicals are stored in pits there, so they might possibly be leaking...we might keep... grab... put in there.... Moving upstream....
Locate Evidence	Radio – Chemical dumping radio campaign – listened – note in PDA - analyses as reading .....that’s more a solution to stop it happening in the future...not what caused it on its own.. its something to keep for reference later on how to stop it happening again... there seems to be a lot of tributaries too. So its not just straight down the river... feral cats... what’s that got to do with it... got nothing to do with river pollution...near the dumping ground...acid from industrial waste ... that’s close to the water to so that might be contributing as well ...
Locate Evidence	Newspaper – Industry suspected of dumping acid – read – highlighted and grab ... that’s near the dump too so that could probably be contributing as well...a local sewage... why are all these things close to the river... no wonder they’ve got problems... heres another article...
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker – read ... they’re saying the local industry has killed the fish but they’re not saying why...
Locate Evidence	Newspaper – Keep out of river – read – highlighted and grab ..... Just saying what we already know....we might do some investigation as to what causes..

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)



## Locate Evidence

Begins selecting tools for chemical testing

...so I would do.. that one...and oil if there near dumps....temperature, no... pesticides...yes ... algae... and do....upstream.... down river where we've got a lot of people there....phosphorus levels up there....not a lot of change... and when you get down here... wow... this is where the dump is.... Ooh...my goodness me ... down near the sewerage dump its got even more ... that's where it's the highest... around near the sewerage dump and fairly high near this dump here... so I might just....see if they've got some more information on the sewerage dump and this dump here....I might go back to ... need some more information on this area here... think it might be the thing I've already heard...

## Locate Evidence

CHECK ARTICLE

.look at that....says here what this used to be... where the tip is....was once natural wetland and the water table lies close to the surface.....so that's why the water was contaminated there...that's very interesting... so it goes on landfill as well.. they didn't put that in a very good area did they... ok I think I need to go back and get more information on landforms... why they put them there, if that's what's causing the problem ... go back to the office now and see if they can give me some more information on landforms before all these buildings were put here.....

Returns to WRC

... now I want to know ...past history of that land... cause landform must have a bit to do with water seeping in...

## Hints

Peter ( explore area/ browse media reports) – went back in time to, other zones (Big Picture view) – looked at TV report – took some readings in river .....so ....that's not what I want.....aha... look at that... if we go back in time we can see evidence of where the dump and everything is now.. this looks like a big swamp area ... look at it... all you can see goes straight into the river, its not high ground... a few years later you can see all these buildings on the wetland... look at that...

## Locate Evidence

TV report - earlier time zone - views/listens -

... this is the area here they turned into a dump....

TV report - views/listens

Measurements - takes several readings similar to those in time zone for problem

I might do a reading of the river now... right near the dump... do those ones again

- phosphorus is low... pH is very high compared to last time...no pesticides, no oil

Returns to WRC

## Locate Evidence

Radio – Tip chemicals killed fish – listened – highlighted and grab - paraphrases

...so that's been an ongoing problem for a while.....so they seem to think.. could be caused by empty containers... now TV reports.

## Locate Evidence

TV – Fish found dead in river – viewed/listened(x2) – made note in workbook

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	TV – Chemical dumping to be fined – viewed/listened
Locate Evidence	<p>TV – Chemical dumping witnessed – viewed/listened - paraphrases - relates and links evidence</p> <p>OK, so it looks fairly conclusive that someone dumped something near the tip site that caused the fish to die on a certain night and they're now going to do tests to see what those chemicals were... I just.... think I did this before....</p> <p>... this is the dump site here and it is slightly high and it gets higher as you go downstream ...so.. it seems whatever caused the fish to die is probably happening in this area somewhere because the levels are a lot higher especially coming downriver from the dump and the eyewitness saw a truck dumping some sort of waste there... definitely something around there....</p>
Locate Evidence	<p>Analyses information – looks in database – random exploration - recognises some areas don't support assigned task</p> <p>... what have I got here... so what results did they get....all I want to do now is prove...it looks fairly conclusive but how can I prove that somebody actually did that...we have an eyewitness report and all we can actually do is test that....go back to my little friend...</p>
Hints	<p>Peter again – (farming hint) - acts on advice</p> <p>.....ok, we've heard the radio reports so I'll look in the filing cabinet under farming....</p>
Locate Evidence	<p>Filing Cabinet</p> <p>I can't see what this has to do with the fish being killed ..... oh... agricultural runoff...see agricultural runoff has a lot to do with the pollution but not why they actually died on a certain day... can't see how... ongoing problem... can't see what that's got to do with it...</p>
Hints	Peter again (x2) – (reports on public opinion) - (writing report)- acts on advice
Problem Solution	<p>outlines strategy for report</p> <p>.....I've gathered all the information so now I need to write a report on what I think happened and in doing so I'll go back and have a look at the information I've gathered here and put it all together.... Have a look..... first of all ... have a look.....I would put down that fishing is enjoyed... and ... the I would give the readouts on the river after the fish were killed from up the top to below the dump site and then in mu report I would get the items from the radio and the news ....of the discovery of the dead fish and the reports of the eyewitnesses if the dumping... then I would look into how we stop this happening again... looking at the policies,,, to stop people doing this... but how can we stop them doing it....</p>

- NOTE:
1. No clear structure of concept map used
  2. No defined strategy obvious

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CM 22 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter – grab – read .....just going to check out the TV report.....have a look at chemical dumping....
Locate Evidence	TV – Chemical Dumping to be fined – viewed/listened
Locate Evidence	Newspaper – Keep out of river – read .....just going to have a look into the filing cabinet... under water pollution..
Locate Evidence	Filing cabinet – water pollution <ul style="list-style-type: none"><li>• Disposal of farm chemicals – read – highlighted sections &amp; grab</li><li>• Urban Runoff – read – highlighted sections &amp; grab</li></ul> ....just going to grab from ‘Disposal of farm containers’ and put into my notes...grab some information about runoff into creeks and dams....asks about getting to zone 3... Went to Zone 3 – random exploration of general area
Locate Evidence	Newspaper – Keep out of river – read – 2 <sup>nd</sup> time
Locate Evidence	Radio – Tip poisons nearby river - listened – linked media – highlighted sections & grab ^....I’m going to click on linked media....click on news reports...now I’ll do some chemical testing to see how much pollution in the water
Locate Evidence	Chemical testing – makes selection of tools, then checks points in river .....pesticides...phosphorus...oil...salinity.....muttering... some industry... I’ll see what they have to say about it...
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker - read – highlighted & grab .I’ll take some information from the local industry....
Locate Evidence	TV – Fish found dead in river– viewed/listened – stopped ....I’ll see what the house has got to say....
Locate Evidence	Radio – chemical dumping radio campaign – listened ....I’ll get off that one and go back to the information resource centre and go and find out some more information from that guy....

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

Hints	<p>Peter - listens - unsure about advice but acts on anyway</p> <p>...hmm...not much help... back to the filing cabinet again and go and check the....hmm...nothing for me there....check the data base....check 'chemical dumping witnessed'</p>
Locate Evidence	<p>TV – chemical dumping witnessed – viewed/listened</p> <p>... tip chemicals killed fish... check that out....</p>
Locate Evidence	<p>Radio – Tip chemicals killed fish – listened</p> <p>... go back and check the tip out...</p> <p>Returned to Zone 3 – begins exploring again</p>
Locate Evidence	<p>Newspaper – acid burns school boy at local tip - read – highlighted &amp; grab</p>
Locate Evidence	<p>Radio – Tip chemicals killed fish – listened to 1<sup>st</sup> half</p> <p>... I've heard that...</p>
Locate Evidence	<p>Radio – Tip poisons nearby river • - listened to 1<sup>st</sup> half</p>
Problem selection	<p>Revisited investigation and task – read and checked collected information</p> <p>Returns to zone 3 – explores for further information</p>
Possible Solution	<p>....go back reading my notes so I can make a report.....I am rereading my notes and go back over it to come up with a solution...</p>
Question	<p>Do you have a strategy for doing that?</p> <p>....do I have a strategy?....no, I've got my information now so I'll make a conclusion from what I've got....</p> <p>participant reviews notes and begins a summary of notes from evidence – session concludes</p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CM 23 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter – grab – read - goes to Zone 3 - random exploration ... ok so I’m going to go to the area.. and click on some of the places that highlight and read some of the information
Locate Evidence	Radio – Chemical dumping radio campaign - listened – linked media – read .... Ok so I’ve listened to a bit of that and linked it to my notes... going to have a look at some other sites...
Locate Evidence	Newspaper – Keep out of river - read – highlighted sections & grab – referred to task ....so I’m just grabbing information and then I’ll decide what I’m going to do WITH IT LATER....
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker - read – highlighted & grab
Locate Evidence	Radio – Tip chemicals killed fish - started – linked media – highlighted & grab – read task again ...I’m going back to the area previously before the industry is there so I can get some idea of what it was like previously ...and perhaps the water quality... Then proceeded back in time – took measurements – reviewed readings then deleted most – retested ....I can’t remember which ones I’ve done...I’ve got lots more than I thought I’d have ... pressed button too many times, or something....I’ll see what I’ve got to do now (reviews task)... so I’m going to look at my question again Returned to Zone 3
Locate Evidence	Newspaper – acid burns school boy at local tip – read ....and I have information on what could be killing the fish... but I need to get information on how to fix the problem....
Locate Evidence	Radio – Tip poisons nearby river - read – highlighted & grab – made own note in PDA ...continues to explore checking articles – looking for new information Returned to WRC
Hints	Peter - listens - checked Radio/TV reports – then database search – then Filing cabinet

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>filing cabinet - water pollution – read task again</p> <ul style="list-style-type: none"> <li>• impacts of landfill – highlighted &amp; grab</li> <li>* hazardous waste – highlighted &amp; grab</li> <li>• urban runoff – highlighted &amp; grab</li> </ul>
Locate Evidence	<p>TV – Resident’s call for tip closure – viewed/listened</p> <p>....I’m just trying to get some information on things they can do to rectify the problem I’m not sure what level I’m doing this report for... what age group... get some information from the TV reports...</p>
Locate Evidence	TV – Chemical dumping fined – linked media – read & grab
Locate Evidence	TV – Chemical dumping witnessed ‘ viewed/listened – linked media
Hints	<p>Peter again - acts on advice</p> <p>...filing cabinet – agricultural runoff...read</p>
Hints	Peter again
Possible Solution	<p>...um...do I need to do the report etc?.....My reply... I would start to put my report together and I’d be getting the information from the data I collected....to put the report together as a possible solution....apart from reading through the notes and taking out the information I thought would be relevant in correct order would be the way I do it... it’s a very long process, I don’t concept map... but this is the way that I do most of my work....and I know probably that its time consuming.....more than time consuming because there's information that I have to go over that may not be relevant...my comment (you sort and sift?)...that’s what I do.....</p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CM 24 - Problem 1

## STEPS

## REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	<p>Peter – grab – reads - paraphrases</p> <p><i>....so I'll start by clicking on the grab button and read what they've got here...chemical pollution ... so there seems to be a problem of water pollution ...which is effecting obviously the animals life in the river.. which also effects the human people because they are the ones that want to fish and there's no fishing if the fish are dead ....so we want to find out why it's happening, what he causes of it are and what we can do about it....</i></p> <p>Went to Zone 3 - random exploration</p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign – listened – note in wkbk</p> <p><i>...OK ... I thought that was a very good report....that just shows how much influence humans have and the impact they can have on our rivers... that's true ...you can take one person and it doesn't take much but if you take everybody it can make a big difference... keep that...have another look around....</i></p>
Locate Evidence	<p>Newspaper – acid burns school boy at local tip – reads</p> <p><i>.....its about boys being burnt while at the tip ...sad story ... but that's more in the tip ....that sort of ... to me that doesn't say anything about them actually...I don't know whether that ends up to be tipped in the water but it doesn't say anything in there about being water pollution...I'll look somewhere else...</i></p>
Locate Evidence	<p>TV – Chemical dumping fined – viewed/listened – note in workbook</p> <p><i>....I think the way to stop it is to bring in fines to stop water pollution... heavy fines are always an incentive to stop people...</i></p>
Locate Evidence	<p>Newspapers – Industry suspected of dumping acid – partially read - stops</p> <p><i>...already read that one..</i></p>
Locate Evidence	<p>Newspaper – 'Industry Killed fish , says worker – read</p> <p><i>....this is good...sounds like a good information section...actually a gentleman who used to work at the local treatment plant, so he would know what they put in the river ...so, they are allowed to put a little bit of waste in the water...good to see tests are actually completed and taken out continually to make sure these companies are actually polluting the rivers with only what they are allowed ...I'll try somewhere else..</i></p>
Locate Evidence	<p>Newspaper – Keep out of river – read</p> <p><i>...OK, this is about a principal in the local area ... he thinks they shouldn't be playing in the water ...community being worried about their environment ....that's a start at least</i></p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	<p>TV – Chemical dumping fined – viewed/listened</p> <p><i>...I think I have heard that already but I thought that was quite good information so I didn't mind listening again to make it sink in ...</i></p>
Locate Evidence	<p>TV – Resident's call for tip closure – viewed/listened – note in workbook</p> <p><i>...that was quite interesting ... so the lady seems to think the local tip has a lot to do with it and obviously a lot to do with the illegal dumping... so it was quite interesting to note too it was not quite as easy to fix it as the chemicals are already in the soil so its not as easy to fix....</i></p>
Locate Evidence	<p>Radio – Chemical dumping radio campaign – relistened – note in workbook</p> <p><i>...that's another point ...I have read this one before but I've just picked up on that one .. that some people are not aware what they can and cannot put down the drain because we always expect that the community will organise some areas where we can take the pollution out of our water before it enters our streams ...and also he didn't know exactly where he could put his paints ...</i></p> <p><i>... looked through most of this now....</i></p>
Locate Evidence	<p>TV – Chemical dumping witnessed - viewed/listened</p> <p><i>....appealing for public help....haven't given any incentive for the public to come forward ...look at water levels in the area...</i></p>
Locate Evidence	<p>measurements - selects tools - outlines sampling procedure - extensive readings in PDA</p> <p><i>... click on all of them - phosphorus, nitrogen, oxygen, salinity ,pH balance pesticides ... temperature ...have a look at all of them to see how they compare ...one at the top of the river ...I'll take four ...two towards the middle and one at the bottom...ok... just go and write that in case I go back later ... top of river ... look at my results.....wish I knew a little more about science to understand it.... Nitrogen 1600 ...Oxygen ...90%... not bad.... Phosphorus is 300. I'll name that top/middle ... nitrogen hasn't moved that much ...just name that lower/middle ... Lets compare that with the earlier reading-- continues to compare readings...pesticides...that's one of their concerns...pesticides are down towasds the bottom ... oxygen is decreasing...depending where you are in the river it changes ...maybe they need to have a look at obviously ..whereabouts in the river are these high levels and also how fast the river flows as that could indicate where it comes from....</i></p> <p><i>...look at stream quality ... that changes as you go down the river as well ... its good to be able to compare things like this ... seeing the change....get out of here...look ...see if there anything we've missed... might go and have a look what's in the Centre</i></p> <p>Returns to WRC – checks newspapers</p>
Locate Evidence	<p>Newspaper – Industry suspected of dumping acid – reread – comments on Tip Managers response</p> <p><i>...he is starting to blame...industries need to take more responsibility ...</i></p>

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence	TV – Industry kills fish, says worker - checks listing .....quick, look at the written text to see if I've read it....
Locate Evidence	Radio – checks listing – Chemical disposal policy outlined - listened – note in wkbk .... talked about fines... fines won't fix everything... I think we have to do more than that... have a quick look through them all ...
Locate Evidence	Relistens to all radio reports – re-listens to Tip Poisons nearby river(x2) ... I think I'll listen to that one again ...tests at tip show tip is causing a lot of the pollution and the groundwater underneath used to be wetland ... pollution will seep down into the water and probably down to the river,,, seems like this tip should be well away from the river....
Locate Evidence	radio - tip chemicals kill fish - listens ... these companies spend so much money on fines that they should spend some on fixing the problem in the first place ..
Hints	Peter ( measurements/media reports) ...I've done that...
Hints	Peter again - (radio broadcast/filing cabinet(farming)) - acts on advice ... OK, I'll check filing cabinet for farming....
Locate Evidence	Filing Cabinet – looks at titles - checks dryland salinity – other salinity articles..... paraphrases - some articles irrelevant to task ....what causes dryland salinity? .....once you start farming and doesn't soak up the moisture.....cause erosion as well... options for control ... vegetation management ... ...agricultural runoff, use of pesticides, herbicides .....seems to be ... changes brought about by how we deal with the land ... all the farming brings the salinity and pesticides we use ... seems to have a lot to do with industry ... I'll go back to the original question
Problem Selection	reviews task ... I'll go back and have a look at the original question to get a better idea,...I think I've pretty well looked at everything now and just see what the task was again... find possible reasons for the fish kill...

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Problem Solution

reviews ideas gained through accessing media reports - notes in workbook limited

*... well, reasons for the fish...mainly water pollution ....from mainly industrial...industrial waste... other areas were household waste ....people not knowing where to treat them ... ends up going into the sewerage ... the sewerage is not able to take all the contamination out of the water before it enters the river ... other possible reasons for the fish ... the farming ...big factor ... cutting down the trees as well ...*

- Continues to review notes, PDA notes and task – uses a simple concept structure to guide the report process
- thorough but not clearly focussed on specifics of task

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CM 25 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter – grab – read – made note in wkbk - goes to Zone 3 ... go to the region...
Locate Evidence	general exploring slowly from top left to right in specific pattern – animals and plants – made notes ...just testing the water... under the bridge...just below the bridge....
Locate Evidence	chemical testing of water from top of screen, near bridge – entries in PDA Return to WRC – checked media reports ....go to the newspaper reports...
Locate Evidence	Newspaper – Keep out of river – read
Locate Evidence	Newspaper – acid burns school boy at local tip – read
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker – read ....alright... I’m just taking a news report on fish being killed in the river...also taking the newspaper report ‘Keep out of river’ ....just reading a report on the algae in the water (found report from newspaper files – not related to investigation!)... just taking part of that report..... Returns to zone 3 – cont’d slow exploration of the region – animals and plants – notes in wkbk – grab of selected material
Locate Evidence	Animal/Plants ...just making .....taking some notes down...
Problem Selection	rereads investigation/task ....looking at a radio report...
Locate Evidence	Radio – Chemical dumping radio campaign – linked media – read – note in wkbk .....just jotting down some ideas....
Locate Evidence	TV – Chemical dumping to be fined – linked media – highlighted & grab
Locate Evidence	Radio – Tip Poisons nearby river – linked media – read .just reading through the radio report.. ...just reading through the radio report... just look up some more media stuff....
Locate Evidence	Newspaper – acid burns school boy at local tip – reread – highlighted & grab

**NOTE**

- 1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Newspaper – Keep out of river
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker – read – highlighted & grab ... taking part of that report.....muttering...fish...just grabbing some information....
Locate Evidence	Newspaper – Industry suspected of dumping acid – read – highlighted & grab ...just reading ‘ chemical dumping news report’ .....just comparing reports...industry suspected of dumping acid.....just reading another report.....
Locate Evidence	TV – Chemical dumping witnessed – linked media – read – highlighted & grab ...the report....checking some reports...muttering (thinking??)... .....muttering ...just reading a report....this one is on dumping of chemicals....here’s more information...
Locate Evidence	TV – Resident’s call for tip closure – linked – highlighted & grab ...I’ll take some water samples
Locate Evidence	Begins water testing again – entries in PDA ....above the tip...down near the next bend,...around the corner....now by the tip....back to the centre....filing cabinet Returns to WRC – filing cabinet – water pollution folder
Locate Evidence	filing cabinet ....look under water pollution.... Water pollution article – read – highlighted selections & grab ....just going to take some information from this report....muttering... industrial estate... Pilliga Crossing Industrial Estate – highlight & grab .....refers to headings of article...take some information about chemicals used in tanning....chemicals used in the manufacture of wood products and paper.....just looking at another file on disposal of farm chemical containers Disposal of Farm Chemical Containers - read
Problem Selection	Reread notes in PDA – looked at investigation/task – rechecked own notes in PDA several times ... I think I’ve got enough information to put it together now...

NOTE: primitive concept map used to put ideas together at end for development of report

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Action Plan CM 28 - Problem 1

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Peter – grab – read - goes to Zone 3
Locate Evidence	Tested water – selected all tools – wrote sampling points in PDA – explored - animals and plants – two articles ....I’m going to test the water to see how chemically polluted it is.....I’m trying to find an industry that would pollute the water ....nothing’s highlighting....
Locate Evidence	Newspaper – ‘Industry killed fish’, says worker – read
Locate Evidence	Newspaper – acid burns school boy at local tip – read – highlighted & grab Returns to WRC
Locate Evidence	Newspaper -- ‘Industry killed fish’, says worker –re read
Locate Evidence	TV – Chemical dumping witnessed – viewed/listened
Locate Evidence	TV – Resident’s call for tip closure – viewed/listened ... check out the radio reports
Locate Evidence	Radio – Chemical disposal Policy outlined – partially listened
Locate Evidence	Radio – Tip chemicals killed fish – partially listened
Hints	Peter - reflects on advice ...already done that...
Problem Selection	Read task again – gathered more information into PDA Went back to zone 3 ...where I tested it’s a lot more polluted down near the bottom of the tip...and from all the radio and TV reports I’m guessing that’s why all the fish have been killed and children have been burnt...
Locate Evidence	Newspaper – Keep out of river – read
Locate Evidence	Newspaper – Industry suspected of dumping acid – read - expresses confusion ...hmmm...I’ve got no idea of what I’m to look for...going back into the resource centre Returned to WRC – animal/plant book

NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	...looking at the fish...OK.. if we look at the fish a lot of siltation kills them... I thought that salinity and siltation are the same thing but obviously they're not....
Problem selection	refers back to task – reviews PDA content and own notes
Hints	Peter again – farming hint - acts on advice ... looking under farming... refers back to task... then measurements in PDA
Hints	Peter again – writing a report
Problem Solution	...I think that's about all I can do ...(thinking)....umm...from the information I've collected... its been basically about the tip disposing of chemicals incorrectly.... This would support the investigation....I don't know really....chemicals disposed of incorrectly... leads to killing of fish... burning of children.....(thinking – refers to notes)....that's about it, I can't think of anything else.....
NOTE:	primitive concept map used to put ideas together at end for development of report  critical thinking approach? - some highlighting - analysis of articles

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

# Participant Action Plans



## Problem 2

# Action Plan CM 21 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Tatiana – grab – reads - selects key points ... she wants to know why...and how to control....
Locate Evidence	Goes to Region – takes measurements – audio – takes several checks along river & records in PDA – random exploration of area ...just doing a comparison here....most weed is growing here (indicates creek) ....no change there at all ....more weed here ( indicates bend).....phosphorus levels are high at the bend....
Locate Evidence	Newspaper – Logging linked to weed growth – read – analyses article – note in workbook – h/g sections ...so he says it's the phosphorus and nitrogen levels, which I've already highlighted....but, where's it coming from?...
Locate Evidence	Radio – Logging linked to weed growth – listened – note in workbook - identifies possible causes OK, the cause could be sewage....or logging ...or both....
Locate Evidence	Newspaper – Weed Eradication program – reads Returns to WRC – further exploration of media elements
Locate Evidence	Newspaper – Logging linked to weed growth – rereads ....in this newspaper article ...logging linked to weed growth is what I'm interested in .....he still can't say...he doesn't know what part of the logging camp is responsible... he hasn't come to any conclusions ....I'll go to the filing cabinet
Locate Evidence	Filing Cabinet – waterplants/weeds folder – weed control – note in workbook – h/g sections .....how to control.....keep water clear.... this section is how to control it ...
Problem Selection	Refers to task – checks notes
Locate Evidence	Radio – Weeds cover river killing fish – listened
Locate Evidence	Radio – Logging linked to weed growth – listened (partially) then stopped ... I've heard that ...

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)



Locate Evidence	<p>Radio – Expert warns against weed invasion – listened – notes in workbook (alligator weed, water hyacinth, salvinia) – linked media – h/g sections - paraphrases report</p> <p>.....problem is someone has introduced the weed and the weed is growing faster because of what the logging company has put into the water as far as phosphorus and nitrogen is concerned....and the way to control it is in here (indicates filing cabinet)...</p>
Locate Evidence	<p>References other articles in filing cabinet – h/g sections</p> <p>...this would be why they want to control it ... I'll put this in ... why its happening ... why they want it to stop.....as far as I can see there are two problems why its there...this article here shows you what to do when you have found the problem...how to control it ... .biological control ... is what I'm after ...introduced plants...that's exactly what they have found there....how to control them ... I can't see any solution ...</p> <p>Returns to Region – random searching</p>
Locate Evidence	TV – River choked by Wild willows – viewed/listened
Locate Evidence	<p>Newspaper – Weed effort fails – reads</p> <p>Returns to WRC</p>
Hints	Tatiana (measurements/fisherman) - listens
Hints	Tatiana (journal/presentation) - listens
Problem Selection	Reads task and checks notes
Problem Solution	<p>Begins to outline solution</p> <p>....as far as I'm concerned I've got the jist of the problem.....don't know if I can do anymore...</p> <p>... main cause...the phosphorus and nitrogen in the river caused by emissions from the logging...and that's debatable really whether that's actual logging or sewage from the system....introduced weed.....as far as I'm concerned there are two major problems here ....introduced weed ....and emissions from the logging company ....and introduced weed in the river and willow trees as well.....so perhaps if native plants had been put down the banks you wouldn't have as much problem as well....</p> <p>Indicates completion of task</p>
Question	<p>Is this the normal way you would go about solving problems of this nature?</p> <p>.....probably do it the same way...I tend to waffle around looking for information and then try to make sense of it ...</p>
Question	<p>You put headings down to help guide your thought processes. You haven't strictly used a concept map structure. Is there any particular reason for that?</p>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

.....as far as I'm concerned there were only two questions....why and how to control it....

Question

Do you think the concept map structure could help you in clarifying the problem?

.... Yes, but I need to get used to using it....you need to remember its been a long time since I've been to school ... this is all new to me ...

Question

Does talking through the process help you or hinder you?

.....neither, really.....

#### **NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

# Action Plan CM 23 - Problem 2

<u>STEPS</u>	<u>REFINEMENT PROCESS</u>
Introduction	views/listens to guide – selects problem
Problem selection:	Tatiana – grab – read – note in workbook Goes to Region – general exploration
Locate Evidence	Newspaper – Weed effort fails – read
Locate Evidence	TV – Cause of algal growth found – viewed partially – stopped – linked media – read – h/g sections
Locate Evidence	Newspaper – Logging linked to weed growth – read – h/g sections
Locate Evidence	Radio – Logging linked to weed growth – linked – h/g/ sections
Locate Evidence	Newspaper – Farmer doubts beetle solution – read – h/g sections
Locate Evidence	Takes Measurements – selection of tools – P, N, coliform bacteria – tests above camp, level, below. – reselects tools and rechecks some measurements Indicates completion of task
Problem Solution	....when I’m finished what I’m planning to do...what I was planning to do was figure out if it was due to human habitation and the reasons for it which is the sewerage ...and the introduction of other weeds from different countries.....and then the efforts they use to get rid of it...
Question	Do you think there is a main cause? ...the main cause would be the logging camp....
Question	What are they doing to contribute to the problem? ...their sewage flows directly into the river, and they don’t plan on doing anything to fix it.....
Question	I notice you don’t specifically use a concept strategy. Any reason for that? ...this time I just used ...just looking at the picture and prior knowledge that that would be the reason for it...
Question	How do you normally go about solving this type of problem? .....I’d just read and waste time....

**NOTE**  
1. check each participant for reasoning skills and thinking strategies (define these)

Question

So you gather information?

...I gather information... and go through it to see if it is relevant to the actual problem...I tend to now go to the index and look ...that's generally how I do it....

Question

Does the ideas of concept mapping help you clarify the problem?

...it does help me if I sit down and think about it...but I'm set in my ways ...if I sat down and thought about this first (indicates the concept map strategy) I would probably look at more issues.

Question

You didn't talk about the process as you worked through it. Is there any reason for that?

.....I generally don't because my mind is going ahead ....and I'm thinking about what I'm doing...I suppose I've just got it set in my head what I'm going to do....

**NOTE**

1. check each participant for reasoning skills and thinking strategies (define these)

## Action Plan CM 24 - Problem 2

### STEPS

### REFINEMENT PROCESS

Introduction	views/listens to guide – selects problem
Problem selection:	<p>Tatiana – grab – headings in workbook - read – note in wkbk</p> <p><i>.... Were looking for the causes of the problem...and ways to fix it.....seems to be the weeds that are the problem ... or one of the main problems ...</i></p> <p>Goes to Region – random exploration</p>
Locate Evidence	<p>Newspaper – Logging linked to weed growth – reads - paraphrases - note in workbook</p> <p><i>....logging linked to weed growth.....read through that ... seems that logging has a bit to do with the weed growth in the area which is causing problems in the river...too many nutrients in the river now....obviously the weeds are feeding off that...bit strange how he can make these assumptions when he hasn't even inspected the site....Dr has made some assumptions that unless these chemicals can be cleared from the river the growth of weeds will continue.....try somewhere else..</i></p>
Locate Evidence	<p>Radio – Logging linked to weed growth – listened – note in wkbk</p> <p><i>...has a responsibility to contracts so he knows that he does contribute to the problem in the river but has obligations to fulfil....so he won't change and look at the environment instead ...</i></p>
Locate Evidence	<p>TV – Cause of algal growth found – viewed/listened– note in wkbk</p> <p><i>....weeds not only problem....its smells as well so the water is obviously becoming stagnant..... fishing not as good as it used to be ...</i></p>
Locate Evidence	<p>Newspaper – Weed effort fails – reads</p> <p><i>... good to see the residents are behind it..... that's one way to try to stop it...by using the resident's to clear out the weeds...efforts didn't help very much... they are growing back already ... when they did that it made things worse down the river....it was a temporary solution not a long term one....</i></p>
Locate Evidence	<p>TV – River choked by wild willows – viewed(x2) – note in wkbk</p> <p><i>.....I'll read through this once more.....willow trees are obviously used to help the area as well....it made it worse... they broke and fell in the water ...not very strong and didn't do the job they were supposed to do.....</i></p>
Locate Evidence	<p>Radio – Expert warns against weed invasion – listened – note in wkbk</p> <p><i>....he was also talking about human pollution and how we pollute our rivers as well....the activities we use....not just fix one problem, need to look at the whole problem, not just one thing....</i></p>

### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

Locate Evidence	Newspaper – Weed Eradication program – reads – note in wkbk ..... <i>irrigation farmers must report any weeds found in river.... Inform authorities</i>
Locate Evidence	Radio – Weeds cover river, killing fish – listened – note in wkbk ..... <i>obviously effecting the life in the water ... mustn't be enough oxygen.....will need to go and have a look at the oxygen in the area.....</i>
Locate Evidence	Measurements – selects tools, phosphorus, nitrogen, oxygen, algal count, coliform bacteria – takes readings at top, middle & bottom of screen (PDA records) - extensive comparisons ..... <i>click on P for phosphorus, ...nitrogen, ....oxygen....later on I can compare the top of the river, the middle....the bottom.....where the main lots of the weeds are compared to the logging...especially look at where the river's travelling .and where the weeds are in relation to the logging ...quick look while I'm here ...</i> (checks readings in PDA) ... <i>now I'll go onto the centre to check my reports ...</i> Returns to WRC
Locate Evidence	TV – Weed growth distresses residents – note in wkbk ... <i>O.K. they say what effects it but haven't said how to fix it....not very much help.....</i> Checks all media reports from clipboards & newspaper articles
Locate Evidence	Animal & Plant Book – seems unclear – random exploration ..... <i>checking the plants &amp; animals folder ....that's obviously a list ...quite a lot.....quite a listing of the trees and shrubs .....just having a look at one weed, pondweed.....reproduce by means of seeds .. have a look in the filing cabinet...</i>
Locate Evidence	Filing Cabinet – waterplants & weeds folder(weed control, waterplants, willows, alligator weed, salvinia) – outlines causes (logging, willows, foreign species) ... <i>O.K. water weed identification.....showing different types of weeds...floating weeds.....weed control options...this is quite good, because you have to find the extent of the problem which is what they are trying to find out...determine the causes....well, we've worked out that the causes so far are the logging....the willows that they tried to put in...the foreign species they have found ....its also effecting the water life there... problem requires intervention ...</i> ..... <i>control measures.... haven't really discussed how to fix it yet ...tried a few short terms methods like pulling out the weeds</i> ..... <i>consider the financial costs...I think that's the biggest problem at the moment , people are worried about the cost in fixing it, but we have to look at the long term effects...</i> ..... <i>suggestions for how the weeds can be controlled ... check the waterways ... take plants to authorities to identify ...</i> ..... <i>alligator weed and where it was found.....more about weeds ...a serious one is salvinia....</i>

#### NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Problem Solution

reviews notes from workbook & begins to structure a 'concept map' - talks through process

*...that's about it...I might reorganise this into some form that is readable...and...if I re-look at it...*

*main problem...water plants and weeds....problems we have are virtually...come down to a few areas...definitely got the logging....with....causes of that is their logging...the willow trees ....foreign species...other weeds....also have to look at how we are going to fix them...the people involved...the residents...the authorities...the logging company...seems as though everyone wants to fix this except the logging company at present...*

*... the ways to fix it...I don't think we have really got to this...we have the authorities trying to fix the problem...doing investigations ... looking for solutions and the residents are trying to help...haven't really found any ways to control it.....problem is virtually the weeds and the logging company ...methods to control it ... haven't really said ... obviously we have to do something with the weeds and the logging company but they haven't said how they might go about doing it, except they are doing investigations ... that's about it ...*

Indicates completion of task

## Question

Why is the logging company at fault?

*...good question....I've taken their word for it...I suppose it's the cut-offs from the bark , and everything.....maybe its what they are throwing into the river....*

## Question

I see you've used a strategy that resembles , to me a flow of ideas , like a flow chart. Do you think the concept mapping strategy does help you in clarifying your ideas or organise your own thoughts?

*.....definitely...I can't say I've really used it before I started at Uni, but I usually write whatever is in my head and it goes straight onto paper, like an essay type thing....what I've started doing is just pinpointing major issues...it has helped...try to pick the main ideas and decide which is the most important...*

## Question

How would you normally go about solving problems like this?

*...probably go through and read everything once ....and probably not write anything down ...or write down the main bits...then go through the second time and add a bit to that...you have a bit of a background knowledge then.....*

## Question

Did you normally go about writing down ideas on paper?

*....I have started...I never used to ....now that I've started my marks have improved.....actually gives you an avenue to look....*

## Question

How have you found the process with the tape-recorder on? Has it bothered you?

*...no, I thought it would but it hasn't really....sometimes you think its taking too long when you are reading and thinking about things ...*

## NOTE

1. check each participant for reasoning skills and thinking strategies (define these)

## Appendix 7

### *Publications from Study*

The following refereed articles and presentations have resulted from this research:

Brickell, G. J. (1998). Effective Interaction or a Maze of Confusion? Problem solving in a Multimedia Environment. *ASCILITE '98*, Vol. 15, pp. 97-106.

Brickell, G. J., Ferry, B., Harper, B. (2000). Investigating the Use of Alternative Thinking Strategies for Problem Solving in Technology-supported Learning Environments. *ASCILITE '00*, Vol. 17, pp. 15-18.

Brickell, G. J., Hedberg, J., Ferry, B., & Harper, B. (2001). Problem-solving Strategies – Is there a better way? In C. Montgomerie & J. Viteli (Eds). *Proceedings of ED-MEDIA/ED-TELECOM 01*. Tampere, Finland; June 25-30, 2001, pp. 197-198.