The development of a spatial technical writing technique: the application of concept mapping and sentence diagramming

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The Development of a Spatial Technical Writing technique: the application of Concept Mapping and Sentence Diagramming

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CERTIFICATION

I, Hung Manh Ha, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Information Systems by Research, in School of Economics & Information Systems, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Hung Manh Ha

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LIST OF ABBREVIATIONS

Abbreviation	Full Name
STW	Spatial technical writing
STD	Spatial technical document
IV	Independent variable
DV	Dependent variable
S	Subject
SD	Standard deviation
L	Frequency of the less frequent sign
T	Total frequency of both pluses and minuses
p	Probability of by chance obtaining L out of T

ABSTRACT

In today's era of dynamic information technology, technical documents are becoming bigger and are updated more frequently than ever before. As a result, people have to spend a huge amount of time and efforts to digest these technical documents. At present, traditional technical writing uses word-after-word narrative writing to produce technical documents. The resulting narrative document often has language ambiguity and an inefficient concept manipulation problem which can cause a lot of difficulty for readers. In this thesis, it is proposed that concept mapping and sentence diagramming are two techniques that have the potential to effectively solve the inefficient concept manipulation and the structural language ambiguity problems of natural language narrative.

The purpose of this research is therefore to offer a solution to the language ambiguity and inefficient concept manipulation problem existing in the traditional narrative technical documents. Specifically, it seeks to answer the question: is it possible to create a new technical writing technique that has its structure similar to the sentence diagramming technique, but is simpler for readers to understand, and can help readers to efficiently manipulate concepts in a text in a manner similar to that of a concept map?

A developmental research method approach was adopted. The research was conducted in two phrases. The first phrase was to develop a new and more effective technical writing technique called 'spatial technical writing' (STW) based on concept mapping and sentence diagramming techniques. The second phrase was to conduct a small exploratory study using students to compare the STW technique with traditional

narrative. The exploratory study used a small pilot experiment with basic quantitative and qualitative measurements.

The quantitative result showed that students achieved a slightly higher mark on comprehension of the narrative text test than the spatial text test. The probability analysis showed that the pilot experiment was not significant. The qualitative result revealed that the main reason that students did not do as well on the spatial text test was because they did not thoroughly understand the STW symbols used in the pilot experiment. Due to the lack of an experimental budget; the pilot experiment couldn't test all STW symbols, and the students didn't receive enough training to understand STW sufficiently. These two confounding variables distorted the pilot experiment and made the results of pilot experiment inconclusive. However there was enough encouragement to continue the research. The result of this pilot experiment will be used to refine the STW technique, and to plan a full-scale experiment in the future.

Finally, the implication of this research is that; if the Internet based STW software is developed, it can help people to digest technical knowledge in ashorter time and with less effort than traditional narrative.

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Chapter 1: Introduction

1.1 Research topic

Nowadays, technical documents are being developed quickly in vast quantities to keep up with the continual changes of the dynamic IT era. Technical documents are playing a vital role in all organizations (Albing, 1996). Moreover, technical knowledge, especially IT knowledge, requires frequent updates. For example, Microsoft Company launches its products at most every 1-2 years or even 6 months. These new products are imbedded with new concepts and new knowledge. To keep the knowledge updated, IT people have to spend a huge amount of time and efforts to learn this new knowledge through technical documentation.

The thesis is about how to rigorously represent the syntax of sentences in a technical document so that readers can more easily understand that technical document.

It is important to know that, although the thesis does not mention common Information System topics such as software development, database design, or IT management; this research addresses a significant issue in the field of Information Systems. Generally, an information system is a system that helps people to achieve information easily and effectively. This research proposes a new method to rigorously represent the sentence syntax in a technical document so that people can more easily understand that document. The new method proposed in this thesis can thus add knowledge to the information system area. Second, the method is only feasible if there is software that underlines this new method. Thus, although this thesis does not

directly relate to software development, it does suggest a foundation for making useful software in the future.

1.2 Research background

At the present, technical writers are advised not to use creative emotional writing (for example, essay writing) to write a technical document. Rather, they should use technical writing techniques to produce very rigorous, cohesive, structured documents.

"Technical writing is writing, apart from advertising and public affair writing, that effectively communicates all aspects of technological work in applied science, engineering, business, and industry" (Montgomery, 1988, p. 142).

Technical writing is thus quite a specialised activity which forces writers to limit unnecessary words and to use simple, easy sentences to produce good technical documents with high clarity and greater precision. While good documents save time and energy for readers, poor documents can cause confusion, give more information than readers need and impose irrelevant information (Lannon, 1997). The latter is often the case because of the rapid and dynamic state of IT, and the scarcity of good technical writers. Good writers prefer more creative activities and good technicians prefer dealing with technological issues.

Because this thesis proposes an alternative to the narrative technical writing technique, based on concept mapping and sentence diagramming, these two techniques will now be discussed briefly as following.

Chapter 1: Introduction

Concept Mapping was first developed by Joseph Novak and his research students in the 1970s at Cornell University (Soderston & et al, 1996). A concept map is a graphical representation of the relationships among concepts and ideas in a knowledge domain (Alpert & Grueneberg, 2000).

The concept mapping was derived from Ausubel's cognitive learning theory (Novak & Gowin, 1984). Ausubel's cognitive learning theory stated that the most important element of meaningful learning is the integration and clarification of the new concepts with the concepts that the learners already know (Ausubel, 1963 & 1968). In fact, concept mapping is an educational tool for applying Ausubel theory (Novak & Gowin, 1984).

Concept mapping is used very popularly in areas such as explaining ideas, planning a curriculum, effectively checking and evaluating the understanding of students, encouraging critical thinking and creative thinking.

Figure 1.1 is an example of a concept map:

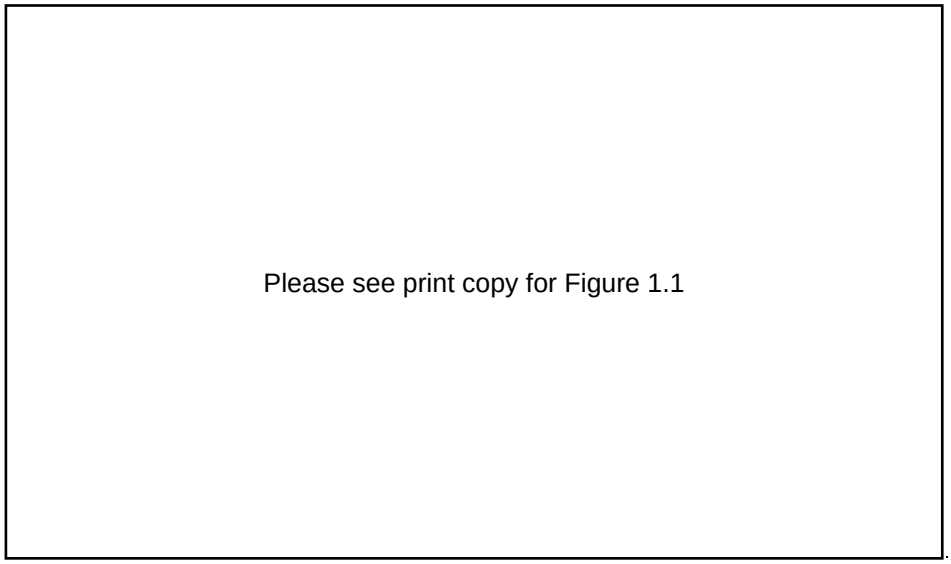


Figure 1.1: A concept map done by eighth-grade students (Dorough & Rye, 1997, p. 40).

Sentence Diagramming was developed and copyrighted by Reed and Kellogg in 1868. Sentence diagramming is a graphical representation of grammar relationships of every word in the English language and a tool for pupils to learn grammar easily and effectively (Reed & Kellogg, 1890). The most important character of sentence diagramming is that it can spatially represent all English sentences by adhering to the rigorous English grammar structure.

For example, the sentence '*Islands are the tops of mountains whose base is in the bed of the ocean*' is diagrammed in Figure 1.2:

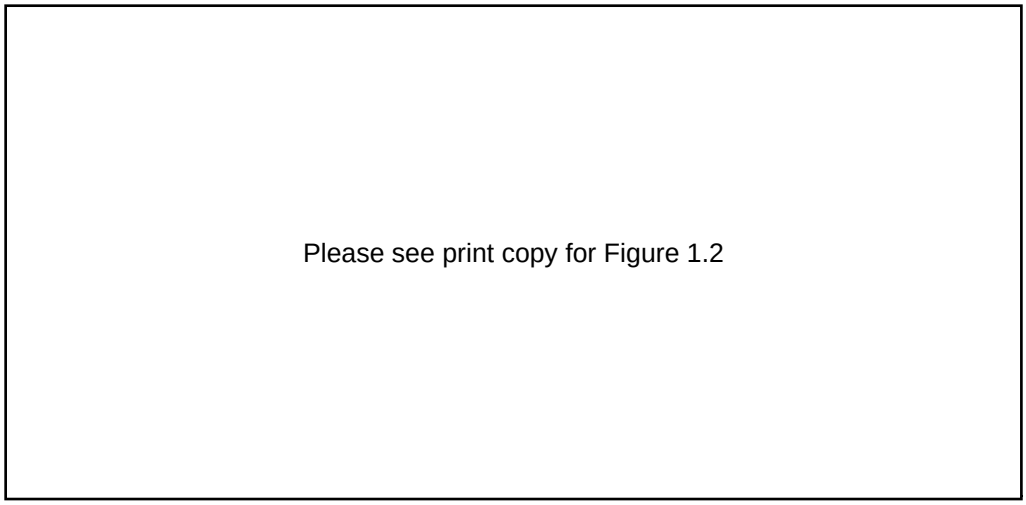


Figure 1.2: An example of a sentence diagram (Reed and Kellogg, 1907, p. 104).

1.3 Research problem

Narrative word-after-word documents written in the English language often have language ambiguity and inefficient concept manipulation problem. Language ambiguity includes lexical and structural ambiguity. Inefficient concept manipulation problem prevents a reader to clearly see the interrelationship among concepts, to efficiently manipulate, to rigorously control and quickly trace the concepts in a narrative document (Vaughan, 1984). These two problems present obstacles for readers who need to easily understand narrative documents.

Most current research relating to technical writing improvement only focuses on suggesting good writing guidelines for technical writers. Good writing guidelines such as never using a cliché, never using a very long word, never using an unusual word, never using the passive voice, etc. are very useful for technical writers, in order to produce good usable documents (Kennedy, 2004).

However, the current technical documents are still narrative word-after-word documents. Even though technical writers manage to use simple words and coherent structures in technical documents, narrative technical documents still suffer from language ambiguity and inefficient concept manipulation problem to a certain extent. These two problems are the inherent attributes in any narrative document no matter whether they are technical or non-technical documents.

For example, the following quote in Microsoft Word Help 2002 (Microsoft Word Help is the technical instructional document for using Microsoft word software) has structural ambiguity because of its narrative word-after-word text use.

> **About page margins**
>
> Page margins are the blank space around the edges of the page. In general, you insert text and graphics in the printable area inside the margins. However, you can position some items in the margins - for example, headers, footers, and page numbers ("Page Setup", 2002).

The sentence '*you insert text and graphics in the printable area inside the margins*' in the above paragraph can be understood as:

- 'text and graphics in the printable area *are inserted* inside the margins'.

- Or, 'text and graphics *are inserted* in the printable area which is inside the margins'.

Readers have to read it carefully and to rely on the context to be able to understand the sentence.

An example of inefficient concept manipulation is that readers often have to concentrate highly and turn back and forward through many pages of a narrative word-after-word document to check and see how the concepts mentioned in these pages are linked together. This concept manipulation work, which is very important in reading comprehension, is very laborious for readers. Unfortunately, the traditional narrative technical writing technique does not have any mechanism to facilitate readers to efficiently manipulate the concepts in a narrative document (Vaughan, 1984). As a result, reading performance is reduced significantly by this inefficient concept manipulation problem.

The language ambiguity and inefficient concept manipulation problem of the traditional technical documents later will be discussed in chapter two.

Currently, there are two techniques that can effectively solve the inefficient concept manipulation and the structural language ambiguity problem. These techniques are concept mapping and sentence diagramming.

First, by spatially representing the propositions and using arrows to link concepts, concept mapping can help readers to efficiently manipulate concepts because key concepts are connected together like a network. Readers can clearly see complex relationships between the previous and current concepts by looking at a concept map (Vaughan, 1984). The readers may not clearly see these relationships if they only read the word-after-word narrative text. As mentioned above in the “Research background” section, this most important characteristic of concept mapping relied on a robust theoretical foundation in Ausubel’s learning theory (Novak & Gowin, 1984).

For example, by looking at the Figure 1.1 concept map above, we can clearly see how concepts (‘*man*’, ‘*CFC*’, ‘*ozone*’, ‘*skin cancer*’, etc.) are interrelated with each other. The concept map diagram thus can help readers to manipulate concepts more efficiently than the narrative word-after-word text.

Second, although the main purpose of sentence diagramming is to analyse English grammar, sentence diagramming can be applied in the technical writing area to remove the structural language ambiguity (Ball & Heuser, 2005).

For example, the word-after-word sentence in Microsoft Word Help 2002, ‘*you insert text and graphics in the printable area inside the margins*’ (“Page Setup”, 2002) has a structural ambiguity because the ‘*in the printable area*’ phrase plays an adjectival role modifying ‘*text and graphics*’, or it plays an adverbial role modifying ‘*insert*’. Likewise, ‘*inside the margins*’ modifies ‘*the printable area*’ or ‘*insert*’. The sentence can be diagrammed as following:

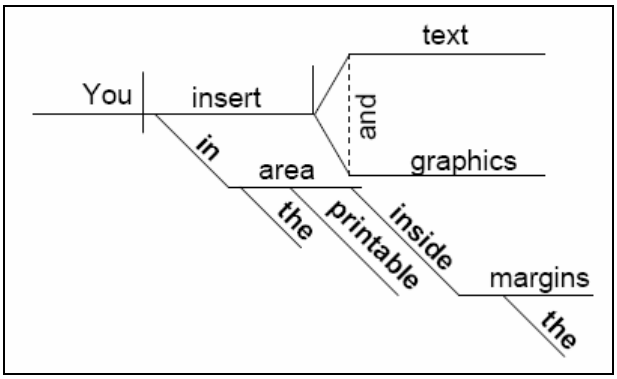


Figure 1.3: Another example of a sentence diagram.

By looking at this sentence diagram, we can clearly see that the phrase ‘*in the printable area*’ plays an adverbial role modifying the verb ‘*insert*’, and the phrase

‘*inside the margins*’ plays an adjectival role modifying ‘*the printable area*’. The sentence diagram thus can help to limit the structural ambiguity more efficiently than the narrative word-after-word text.

The candidate will discuss more carefully how concept mapping and sentence diagramming technique can be used to solve effectively the inefficient concept manipulation and structural language ambiguity problem in chapter two.

However, concept mapping and sentence diagramming are not used for writing technical documents. They only help readers to facilitate the efficient concept manipulation, and to see the clear grammar structure of a sentence. The candidate will discuss more clearly this issue in the section “Concept mapping and sentence diagramming as techniques for solving the word-after-word narrative technical document problems”. The following Table 1.1 shows the features of concept mapping and sentence diagramming:

Table 1.1: Features of concept mapping and sentence diagramming.

	Concept Mapping		**Sentence Diagramming**
Features	Concept mapping is used to spatially represent the relationships among key concepts of a text. A concept map helps readers to see a big picture of the text, to see how the new concepts and the previous concepts in the text relate to each other. However, people do not create a concept map that spatially represents every single word and sentence in a text, because the essence of concept mapping is to help readers to see the big picture of the text only.		Sentence Diagramming is used to analyse the grammar structure of an individual sentence. A sentence diagram helps readers to see clearly the grammar structure of a sentence, and to limit the structural language ambiguity. However, sentence diagram is not intuitive and too complicated for a typical reader to understand. Currently, sentence diagramming is not used as a technical writing method. People only diagram a sentence when they want to see the grammar structure of that sentence. This issue will be carefully discussed in the section "Disadvantages of sentence diagramming".

Note: the lexical language ambiguity problem of the traditional technical documents can be solved by applying dictionary utility software. This will be mentioned in the "Future Work" chapter. This thesis only focuses on solving the structural language ambiguity and inefficient concept manipulation.

1.4 Research question

As mentioned in the above "Research problem" section, traditional narrative technical writing often has language ambiguity and inefficient concept manipulation problem. Sentence diagramming and concept mapping are two techniques which can help to limit the structural language ambiguity and inefficient concept manipulation problem

of the traditional technical documents, respectively. However, concept mapping and sentence diagramming are not used for writing technical documents. Concept mapping only represents the relationship among *key* concepts of a text, but it does not represent all sentences in the text. On the other hand, sentence diagramming is too complicated and is not used as a technical writing method.

Hence, the questions of this thesis are as follows:

> *Is it possible to create a new technical writing technique that has its structure similar to the sentence diagramming technique, but is simpler for readers to understand, and can help readers to efficiently manipulate concepts in a text like a concept map?*

If a new technical writing technique, which has the both advantages of concept mapping and sentence diagramming, is developed; then people can have a good tool for solving the structural language ambiguity and inefficient concept manipulation problem that exist in a traditional narrative technical document.

1.5 Research method

To answer the above research questions, this research developed a new technical writing technique called ‘spatial technical writing’ (STW). STW has structures similar to the structures of sentence diagramming technique, but can help readers to manipulate efficiently the concepts in a text like a concept map.

The research takes a developmental approach where the STW is created and described and an experimental method used to evaluate it.

A small exploratory study was conducted at Wollongong University to test how a typical reader comments on the STW technique.

The candidate has accepted that it would be necessary to conduct a comprehensive full-scale experiment to demonstrate the usefulness of STW technique. However, that experiment will need a lot of time and budget, because the experiment would have to test if different types of readers can understand all STW sentence types and can see the relationships among concepts in a long STW document. Hence, due to the time and research fund limitation, the candidate has only conducted a small exploratory study to exam how some IT students (as typical readers of technical documents) comment on a short spatial technical document developed by applying some limited STW symbols. The exploratory study does not intent to demonstrate the whole STW method. Instead, the exploratory study will be used for redesigning and refining the STW technique, and for planning a full-scale experiment in the future.

Note: It is important to know that, because STW is a technical writing technique, STW has to be used by writers to write spatially all sentences in a technical document. Technical writer will apply STW to create a spatial technical document (STD) which is very different from the traditional word-after-word technical document. STD consists of spatial sentences created by using STW, while traditional narrative technical document consists of narrative sentences created by the traditional narrative

word-after-word writing. The candidate will discuss STW and STD in detail later in chapter three.

1.6 Research Limitation

One important point to be kept in mind, the proposed STW is not a full-fledged method because STW was created from an iterative, reflective process, i.e., the technique was refined through feedback opinions. Hence, some English structures have not been displayed in STW, and STW needs to be improved overtime to become fully developed in the future.

Second, the software must be developed to support STW in order to make the technique feasible and usable. This thesis only focuses on developing STW technique, but without supporting software. Different extensive research may discuss this problem further.

1. 7 Outline of this thesis

After this introduction chapter, this thesis will be organized into four main chapters: literature review; research method; result and discussion; and conclusion.

The “literature review” chapter will introduce technical writing techniques and some previous research in technical writing. It also discusses reading comprehension process and language ambiguity which obstructs the reading process. After that, the thesis will discuss concept mapping and sentence diagramming, which are two

techniques that can help to solve problems of traditional narrative technical writing. Finally, the literature review chapter will restate the research question.

The “research method” chapter represents the new novel proposal STW technique in great details and conducts an exploratory study. Most English language structures are represented in STW in this chapter. The exploratory study section discusses a pilot experiment which based on the basic quantitative and qualitative measure method.

The “result and discussion” chapter analyses the experiment results, and discusses the experiment shortcomings.

Next, the “future work” chapter discusses all jobs that need to be done in the future research in order to answer the research question.

Finally, the “conclusion” chapter closes the thesis by stating the contribution and implication of this thesis.

> **Note:** *from the chapter 2, a concept map can be created at the beginning of some sections to direct your mind before reading. The concept map represents only the key points. These concept maps are like a summary map where you can trace the meanings in the section at any time you want.*

Chapter 2: Literature Review

2.1 Introduction to this chapter

This chapter is the literature review of the research background. It first explains the needs of the technical writing technique and discusses some current research relating to the technical writing improvements. The chapter then explains the essence of the reading comprehension process, the information perception of humans, language ambiguity and the inefficient concept manipulation problem in narrative word-after-word documents. The chapter next discusses the definition, the advantages and disadvantages of the two important techniques - concept mapping and sentence diagramming. After discussing all the basic research background, the chapter addresses the research problem which stated that current word-after-word technical writing can not thoroughly solve language ambiguity and inefficient concept manipulation existing in the narrative technical documents. The chapter also comments on how the advantages of concept mapping and sentence diagramming techniques supplement each other in solving the research problem. Finally, the chapter is closed by a research question which states that, '*Is it possible to create a new technical writing technique that has its structure similar to the sentence diagramming technique, but is simpler for readers to understand, and can help readers to efficiently manipulate concepts in a text like a concept map?*'.

2.2 Technical writing technique

2.2.1 Requirement for technical documents

The concern of how to improve document quality exists not only in the present, but also in the past, dating back to the English Renaissance period (1475-1640). Technical writers at that time proposed a plain text writing style for instruction documents. Writing format, page design and adaptations of texts for each type of reader were also proposed at that time (Rutter, 1997).

In today dynamic IT era, technical documents are being developed at a dramatic speed. Technical knowledge, especially IT knowledge, in technical documents needs to be updated frequently. Hence, the concern of technical writing improvement is increasing more and more. Technical documents, which can be paper-based or electronic-based, are playing a vital role in all organizations (Albing, 1996).

To help people to understand quickly technical documents, a technical writer has to create technical documents that are unambiguous, simple, understandable, and facilitate the key-idea references. At present, technical writers do not use a creative emotional writing (for example, essay writing) to write a technical document; they use technical writing technique to produce very cohesive structured and rigorous documents. The candidate now will go into the details of the technical writing technique.

2.2.2 Technical writing

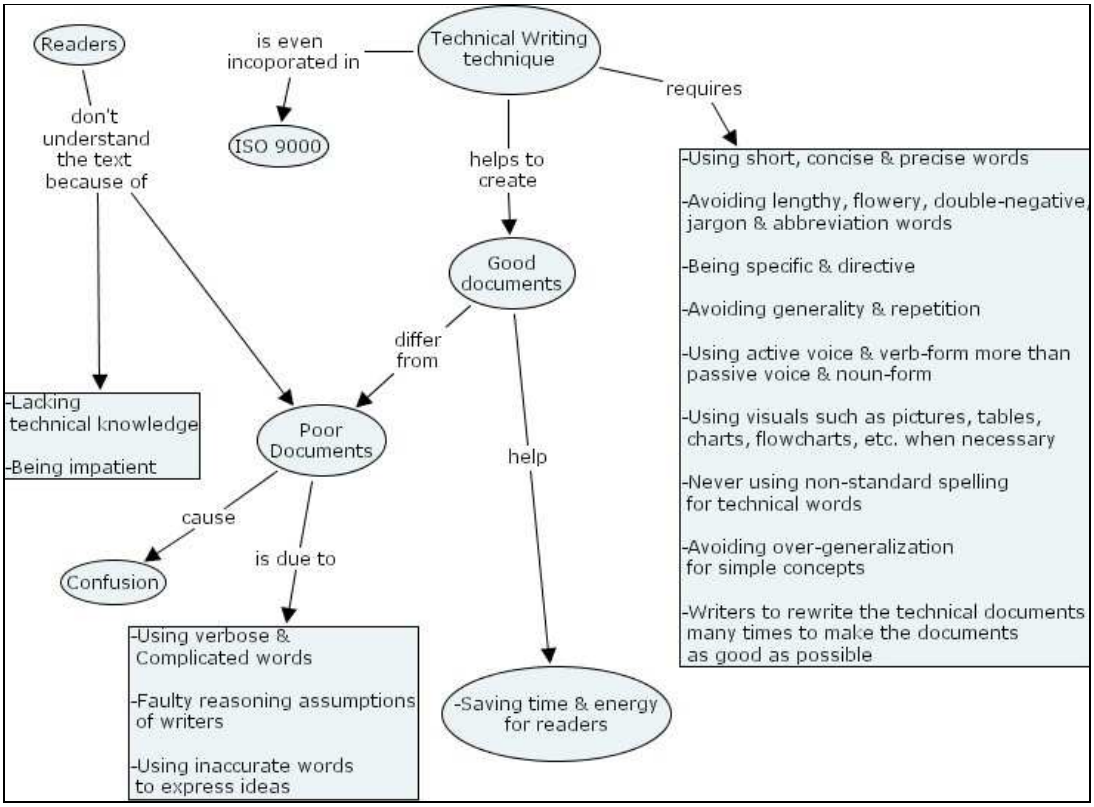


Figure 2.1: A concept map of 'Technical Writing'.

2.2.2.1 What is technical writing?

Following Montgomery (1988), there are many definitions of technical writing, but few of them gives a clear idea of what technical writing is. Montgomery suggested a workable and useful definition about technical writing. He defined:

> Technical writing is writing, apart from advertising and public affair writing, that effectively communicates all aspects of technological work in applied science, engineering, business, and industry (Montgomery, 1988, p. 142).

Technical writing, thus, is not for entertainment or imagination. It must facilitate readers to answer questions, to make decision, to solve a problem and to follow a

procedure in the technical documents. Moreover, rather than being read from the beginning to the end, technical documents should facilitate cross referencing. Readers have to pick up the information that they want as much as possible. Technical writing helps to create good documents. Good documents save time and energy for readers. Poor documents can cause confusion, give more information than readers need, impose irrelevant information, and create misunderstanding due to jargons (Lannon, 1997). Ryan (2003) stated that one of the most important aspects in business communication is technical writing. A business which does not have good technical writers can severely suffer from a poor document system. For example, suppose a business has to draft a contract worth millions of dollars; then, what if that business cannot clearly convey meanings in the contract?. The final result of this matter certainly adversely affects the business activities.

2.2.2.2 Poor documents

Lannon (1997) listed the characters of a poor document:

- Using the verboseness and complicated words which can reduce reading effectiveness. For example, read these two sentences:

> Complex sentence: ‘Avoid prolix nebulosity’.
>
> Revised sentence: ‘Don’t be wordy and vague’.

The second one is better for technical writing because it is more simple and easier to understand.

- One of the big problems that create confusions in the text is “the faulty reasoning assumptions of writers”. The faulty reasoning assumptions can be due to bias, impatience and discrimination. For example: ‘*The students can not pass the exam because the exams were unfair*’. The writer denies the real causes of his or her failures.

The faulty reasoning assumptions can also happen because document writers chose the wrong or overstated words to express ideas, and thus can cause huge confusion (Andrews & Blickle, 1978). For example: ‘Fortunately, each aspect of my topic has been *smothered* by recent technical journals’. The writers meant ‘*covered*’.

However, poor documents are not the only reason that negatively impacts reading performance. If a reader cannot understand the technical documents, it can be due to the proficiency of him or herself. It may be that the readers lack the technical knowledge expressed in the technical documents, or the readers do not make all their efforts to understand the documents (Pfeiffer, 1997).

Lannon (1997) gave a table showing the relationship among the proficiency of readers, technical level and the requirement of readers.

Table 2.1: The relationship among reader ability, technical level, and reader need

Please see print copy for Table 2.1

(Lannon, 1997, p. 30).

2.2.2.3 Some current research for improving the quality of technical documents

At the current time, most technical writing research mainly focuses on suggesting good technical writing guidelines and instructions to keep the documents readable and usable.

Weiss (2001) stated that good writing must clarify goals and explore the new concepts. The key point is to limit unnecessary words and make your documents clear, and precise. These are the lists that Weiss (2001) suggested to technical writers:

- Choosing short, concise and precise words. For example: using '*now'* in place of '*at the present time'*.

- Removing unnecessary words such as, '*It is obvious that'*, '*Needless to say'* and '*As you know*'.

- Removing flowery adjectives. For example: '*The beautiful, bounteous, breathtaking buffet'*.

- Being specific, avoiding generality. For example: don't say '*office equipment*' when you mean '*laser printer*'.

- Limiting the lengthy phrase to single-word verb. For example: using '*judge*' for '*pass judgment*'; using '*act*' for '*take action*'; using '*conclude*' for '*reach a conclusion*'.

- Avoiding double-negatives. For example: using '*possible*' instead of '*not impossible*', and '*aware*' instead of '*not unaware*'.

- Using the active instead of the passive voice. For example: '*The manager will interview the applicant*', instead of, '*The applicant will be interviewed by the manager'*.

- Be directive. For example: '*You can apply before the first of January*', rather than, '*The customer can do his application before the first of January*'.

- Be positive. For example: instead of, '*If you don't pass the exam, you will not qualify*', say, '*You'll qualify if you pass the exam*'.

- Using verb forms rather than noun forms. For example: '*The department requires that*', instead of, '*The requirement of the department is that*'.

- Avoiding jargon and abbreviation. For example: using '*Network*', rather than, '*LAN*', if listener is not a technical person.

- Avoiding inflated and ambiguous language. For example, 'each aspect of my topic has been *smothered* by recent technical journals'. The '*smothered*' should be changed to '*covered*'.

- Limiting your ego. For example: too many '*I'm*' and '*We're*' are not good. In fact, '*You're*' is more impressive.

Levin (1999) suggested another 6 easy rules for writing. They are:

- Never use a cliché.

- Never use a very long word.

- Never use an unusual word.

- Never use the passive voice.

- Cut unnecessary words whenever possible.

- Limit perfunctory sentences which have many dead words. For example, '*There are signs that bode well for the healing process between warring ethnic factions*'. Revised: '*Certain signs bode well for healing between warring ethnic people*'.

- Use '*first, second, third*', instead of, '*firstly, secondly or thirdly*' because it makes the paragraph friendlier to readers.

Kennedy (2004) added more guidelines for technical writers. Besides keeping the text simple, using jargon sparingly, writing in a clear style, and avoiding being redundant; technical writers must understand the knowledge areas of the readers in order to avoid "writing down" to a professional, or "over the head" to a novice. The functions of documents are also very important. If a document is intended for information only, then easy short concise words should be used. If a document is intended for building a product, detailed step-by-step guidelines must exist in the document. He also requires

writers to use visuals such as pictures, tables, charts, flowcharts, etc. to support and reinforce the text because that helps writers to organize and convey the ideas clearly.

Writers must keep in mind that they are writing for readers, not just for themselves. Nagle (1995) required that writers have to be very careful in using technical words. Writer should never use non-standard spelling. For example, 'benzine' is not just a non-standard spelling of 'benzen', but actually a different material. A professional writer should use a specialized technical dictionary software to check spelling for all words he wrote in technical documents.

However, writing is not an easy task. If you are too careful in writing, sometimes you can create verbosity in the text. Too much caution can lead to the over-generalization of simple concepts. If the writer does not limit the scope of a statement, he can make the statement so general that it's nearly impossible to recognize the specific meaning being described (Nadziejka, 1994). Some examples are:

> - Wildfires started by *inadvertent human-initiated ignitions* (inadvertent human-initiated ignitions = accidents).
>
> - Waste-fired *thermal combustion facilities* (thermal combustion facilities = boilers).
>
> - *Native aquatic animal organisms* (Native aquatic animal organisms = salmon).

In these examples, the authors complicated the simple words, which make readers unable to recognize the meaning.

Adhering to all these requirements is not enough. Ryan (2003) stated that the most important final requirement for all writers is '*rewrite*'. No one, even a professional

writer, can guarantee that they can produce good documents after a first draft. Sadly, after finishing their first draft, many writers think that they have produced a good, finished piece of writing.

Besides these writing guidelines, a mechanism for producing a quality technical document is even incorporated into ISO 9000. ISO 9000 is a tough international quality standard, not only for manufactured products, but also for technical documents. By adhering to the ISO 9000 for technical writing, an organization can limit the original document obstacles such as improperly organizing procedures on paper, making documentation unreadable, and disregarding standard rules of grammar and spelling (McKenna, 1993).

As stated above, a majority of technical writing research focuses on how to use correct simple sentences, punctuation, English grammar, document format/layout to produce good technical document. However, some technical documents are required to be more structured and precise than other types of technical documents, especially in areas such as programming specifications, and application user-guides (Kaczmarczyk, 2003).

Interestingly, many IT people saw the analogy between technical writing and computer programming a long time ago (Helm, 1988). Technical writing and computer programming both have a very similar principle, which requires organizing and communicating complex information effectively (Kaufman, 1988). For example, if programmers do not create a flowchart before programming, then their final program can have many errors. A flowchart is “a graphical representation of the steps

within a process" (Campbell, 2004, p. 50). Likewise, if technical writers don't make a plan before they write, then their final document can be hard for readers to understand. So, in order to produce a good technical document, writers may need to use some logical techniques of computer programming such as a flowchart (Helm, 1988). In addition, to avoid the redundancy of written sentences, technical writers should create blocks of sentence first and then try to organize these blocks in meaningful ways using a bottom-up approach rather than just jumping directly into writing a document without any planning (Kaufman, 1988).

One of the researchers who apply programming techniques to technical writing is Robert E. Horn. Horn (1974) developed a new method to organize the text called "Infomap". His method was affected by the modular approach in the computer programming realm (Horn, 1993). It is worth discussing Infomap because Infomap is a very rigorous, structured, valuable technical writing method. In addition, Horn (2001) claimed that Infomap was taught to at least 300,000 people in businesses and universities and plays an important role in the technical writing area nowadays. He also believed that his method will definitely have a future.

2.2.3 Information Mapping (Infomap)

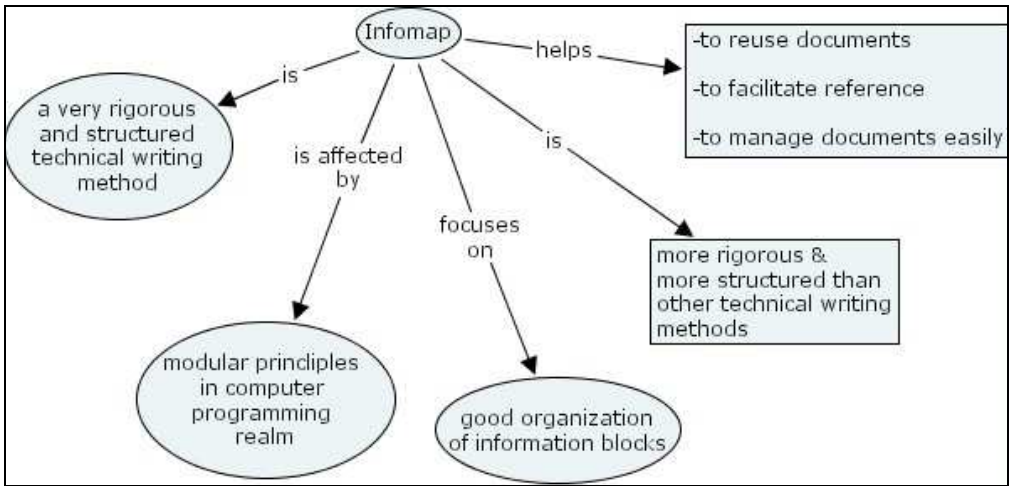


Figure 2.2: A concept map of 'Infomap'.

Horn's (1974, p. 27) definition: "Infomap is a method of bringing together current learning research and instructional technology into a comprehensive material development and presentation technology to improve technical communication. It is a system of principles and procedures for identifying, categorizing, interrelating and sequencing, and presenting graphically information required for learning and reference".

Or in other words, "Information mapping is a methodology specifically designed to make technical communication in business and industry easier and quicker" (Horn, 1974, p. 27).

Infomap research project was supported by the U.S. Air Force Systems Command. Infomap was represented in many workshops in universities and businesses and was approved of by many experts participating in these workshops (Horn, 1974, p. 27).

Horn (2001) shows how to convert a traditional narrative passage to an Infomap:

- First, the function of each sentence in the paragraph is identified. This is helped by asking the question, 'What function is this sentence performing?'.

- Second, those sentences that seem to go with each other are sorted into the same block. This is based on taxonomy. Horn (1974) developed around 40 information blocks representing the different subject matters; each block must be labelled explicitly.

- Third, a matrix was created to match a block with a suitable topic.

- Next, all blocks are added into some suitable information chunks, such as introduction, definition, example, etc.

- Finally, all blocks and chunks are skimmed and checked carefully to produce a meaningful Infomap.

The following is an Infomap example quoted from the Information Mapping website-*www.infomap.com*:

A conventional version of a memo:

TO: All Department Heads
FROM: Susan Thomson, IT Help Desk
DATE: October 2, 1997

Information on Software Virus

It has come to our attention that an active PC virus has been identified in certain departments located on various sites. An antidote for the virus has been obtained and it will be used to clean all infected servers.

Therefore, we need your help in checking all PCs and portables. Please confirm to the IT Help Desk, by Friday October 8, that all PCs will be available on Tuesday October 12 for checking and cleansing. You need to ensure that all field staff bring their portable PCs in on that day.

The virus is a new strain and was not detected by existing virus checking software. The nature of the virus is such that it can prevent sign on and produce unpredictable results causing damage to data.

Therefore, please warn all staff in your department of the presence of the virus.

("Infomap example", n.d.)

The Information Mapping version of the above memo:

TO: All Department Heads
FROM: Susan Thomson, IT Help Desk
DATE: October 2, 1997

Information on Software Virus

Problem	An active PC virus has been identified in certain departments located on various sites. The virus is a new strain and was not detected by existing virus checking software.
Effect	The nature of the virus is such that it can prevent sign on and produce unpredictable results causing damage to data.
Possible Solution	An "antidote" for the virus has been obtained. It will be used to clean all infected servers. We need your help in checking all PCs and portables.
Next Steps	Could you please complete the following:

Step	Action
1	Warn all staff in your department of the presence of the virus.
2	Confirm to the IT Help Desk that all PCs will be available on Tuesday October 12 for checking and cleansing.
3	Ensure that all field staff bring their portable PCs in on that day.

Deadline	Please respond to the Help Desk by Friday October 8.

("Infomap example", n.d.)

Form the above Infomap example; we can see that unlike traditional technical writing which the candidate mentioned above, Horn's Infomap approach is more structured and more understandable. Horn (2001) requires writers to create chunks of information or blocks and labels them 'definition', 'example', 'introduction', etc.

before they start to write a technical document. Then, writers assemble these blocks into meaningful and logical ways. This facilitates the readers to skim and scan the document more effectively than other types of documents (Horn, 1975).

By using the Infomap technique, readers can understand documents faster, documents are managed more easily because information blocks can be reused many times, document writing becomes simpler, and documents can be referenced quicker with minimum effort. All these benefits can help businesses to save on the costs of training and acquiring knowledge because the time to understand the documents is reduced vastly (Horn, 1974).

However, Infomap does not mention the writing guidelines in the documents like other technical writing methods. Infomap assumes that writers already use the simple language and correct grammar when they write technical documents.

Infomap was born in the 1960s and was implemented on paper-based applications without computer intervention. Nowadays, documents accumulate in vast quantities in organizations. To manage documents effectively, documents should be stored on CD-ROM or the internet. Although traditional narrative text documents can be stored digitally for convenient retrieval, they are less structured and difficult to use no matter where they are stored - ‘on paper’ or ‘on digital media’. To utilize the strength of digital documents, digital documents should be written using Infomap methods. At that point, information is both highly usable and conveniently retrieved (Boeri & Hensel, 1996).

However, the reasons preventing readers in comprehending a document are much more complicated. The candidate will discuss this issue more thoroughly in the next section.

2.3 Reading Comprehension

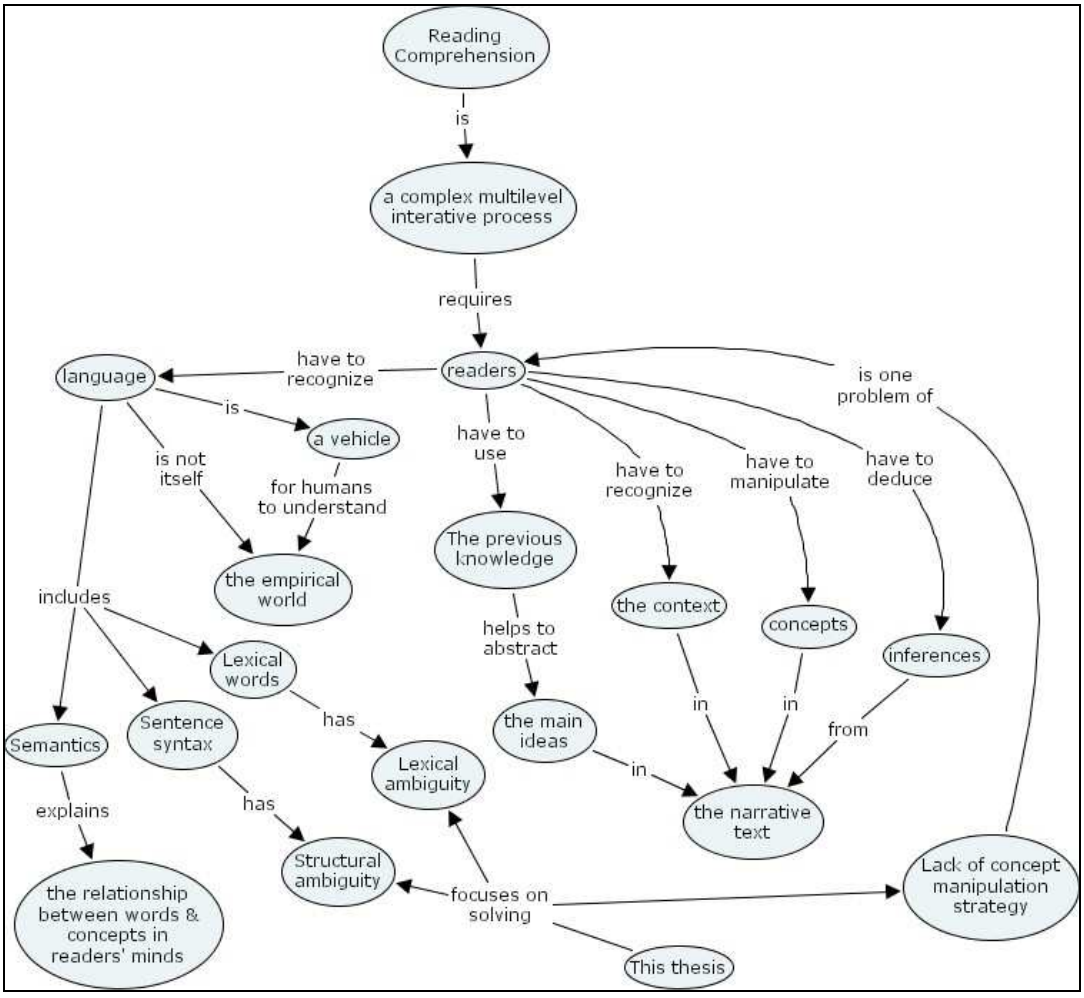


Figure 2.3: A concept map of 'Reading Comprehension'.

Spiro (1980), in the introduction of his book *Theoretical issues in reading comprehension*, said Reading Comprehension ability is vital in our society; people that lack this skill will confront many difficulties in their lives. Although many researchers mentioned this, they mainly focused on the educational area. However, Reading Comprehension is very complex and should be considered through inter-disciplinary or a number of fields such as cognitive psychology, linguistics, and reading education.

Adams (1980) emphasizes that reading is a complex multilevel interactive process between readers and the material.

First, to be able for a reader to understand a sentence, the reader has to understand the word, the syntax and the semantics of that sentence. Lexical words often have the lexical ambiguity which is a common feature of language. The unfamiliar words can be hard to be understood. However, it is not enough if researchers only study the words individually, because the meaning of individual words is ambiguous and diffuse. These words have to be analysed under syntax, which is a formula for helping to meaningfully organize the words in a sentence (Adams, 1980). For example, the sentence '*Crane flies like arrow*' is not clear if its syntax is not expressed explicitly. The sentence can mean that, '*Crane fly*' looks like an arrow. '*Crane fly*' means "a flying insect with a narrow body and very long legs" ("Definition of Crane fly", n.d). Or, the sentence can also mean that, '*Crane*' flies like an arrow. '*Crane*' means "a tall bird with long thin legs and a long neck" ("Definition of Crane", n.d).

"Syntax is the study of the principles and processes by which sentences are constructed in particular languages" and, thus, syntax is a device to produce sentences (Chomsky, 1965, p. 11). Syntax explicates the relationship among words in a sentence. Sentence syntax can have structural ambiguity. If a reader incorrectly analyses the sentence syntax, he or she may misinterpret the text and feel the sentence is even abnormal (Adams, 1980). For example: '*The carpenter fixed the picture with a hammer*' ('*picture of hammer'* or '*the carpenter used a hammer to fix the picture*'!).

So, if the sentence is obscured or distorted, readers are less able to understand it (Adams, 1980).

In addition to the words and syntax, the semantics of a sentence is also very important. Semantics is the relationship between the words in the text and the concepts in readers' minds. Recognizing the words and analysing the syntax are not enough; readers have to map the intended meaning of a word in a document to an equivalent concept in their minds and organize concepts in a coherent structure (Adams, 1980).

Second, readers have to bring their previous knowledge to comprehend the main ideas, and to understand the sequence of events in the text. What is unsaid in the narrative text is what readers can infer from their previous knowledge (Adams, 1980). Vaughan (1984) discussed why many students feel it difficult to digest new knowledge.

> The extent to which a reader is likely to comprehend concepts expressed in a textbook is largely determined by his or her familiarity with those concepts. Because the function of most reading assignments is to expose students to new learning, readers of academic textbooks typically encounter concepts with

> which they have only a cursory familiarity. The difficulty caused by lack of prior knowledge is predictably high for reading of expository material, and it can become much higher when authors use unfamiliar, precise, technical vocabulary to present and discuss unfamiliar, complex concepts. Many students are thereby left to struggle with new ideas as best they can, at least until some post-reading discussion (Vaughan, 1984, p.129).

Third, context is very important in reading comprehension. Spiro (1980, p. 245) emphasized that "meaning does not reside in words, sentences, paragraphs, or even entire passages considered in isolation". He implied that if each of these levels is taken out of context, incomplete understanding will occur. The meaning of language is insufficient to convey the experience of the world. Language, thus, is only a vehicle to let people to understand the empirical world. Language is not the empirical world itself. Sometimes, prior knowledge is the context for comprehension. Langer (1951) stated that words are only the 'symbols' or 'labels' of the conceptions that we have in minds. The conceptions in our minds are not the tangible things. For example, if I say '*Napoleon*', you will not see the real conqueror of Europe standing in front of you, but you merely think of him. These symbols (words) are only a vehicle for the conceptions. To sum up, the word is just a printed writing symbol on a paper and nothing else. Hence, to be able to understand a word, we can not just rely on that particular word itself, but we have to link that word to the context in our world.

The importance of context is also mentioned by Norman & Rumelhart (1975, p. 5) who asserted that "we have to combine the knowledge of the world with the knowledge of the structure language and the meaning of the parts of the sentence to understand a sentence".

Following Anderson & Shifrin (1980), if we look at words in a sentence carefully, we can see that most words' meaning will shift from context to context. The words in a sentence should not have a fixed meaning, but are considered to have a 'family' of potential meanings. For Example: '*The baby kicked the ball*'.

The word '*ball*' can be explained differently in different contexts. The ball could be big if the baby was playing with his father in a yard. Or the ball could be made of light plastic if the baby was playing with his father in the bed. Or the ball could be a small balloon that his father just bought for him.

The word '*kick*' can be due to his anger, his happiness, or it is just an accidental kick, etc.

Next, another important aspect of reading comprehension is concept manipulation. A good skilled reader has to effectively manipulate the key concepts or ideas in the text. In other words, a reader has to know how to efficiently control and clearly see the relationships of concepts in the text. So, reading is the process of clarifying the relationships among concepts. Reading is dominated by a cognitive manipulation of the concepts. For example, when you read a book, you often turn the pages back and forward many times to see how the concepts or ideas in the book interrelate to each other. However, many students are not supported by a good strategy for manipulating the concepts in the text that they are reading (Vaughan, 1984). Concept mapping techniques, which will be discussed later, can help readers to manipulate the concepts effectively.

Finally, if the text has an implication, readers have to deduce or draw inferences and form a question to understand what the text is going to talk about in the bigger context (Adams, 1980). To be able for a reader to understand a passage or a whole text, the reader not only sequentially connects the events in the text, but also infers the implication of the text. Good skilled readers have to think beyond the obvious or literal meaning of the text. So, the reading activity is nearly a problem-solving process (Collins & et al., 1980).

To sum up, if the readers want to understand the text thoroughly, they have to go through a very complicated reading comprehension process. This process requires them to recognize the language, to use the previous knowledge, to recognize the context, to manipulate the concepts, and to deduce the inferences in the text. If the readers fail one of these elements, they can not understand the text thoroughly (Adams, 1980).

Out of these elements, the difficulty level of language recognition and concept manipulation can be created by the document writers. This means that, if the writer uses simple words and sentences in technical documents, then it will be easy for readers to understand the documents. On the contrary, if the writer uses complex words and sentences, then the readers have to struggle hard to perceive the document. Thus, language ambiguity and a lack of concept manipulation strategy are the two problems mainly caused by writers. This research will focus on suggesting a new technical writing technique for writers so that they can produce better technical documents that can help readers to easily recognize language and effectively

manipulate the concepts in the technical documents. These two problems will be discussed in more details in the section 2.5 and 2.6.

Other elements such as previous knowledge, the inference ability, and the context recognition ability mainly depend on the proficiency of readers. It means that readers can do something to improve them. These elements should be studied in other research. For example, '*using video to facilitate the readers to see the context of the text*' can be a good thesis to solve the context recognition problem.

However, the elements such as the language ambiguity, the lack of concept manipulation strategy, the previous knowledge, the inference ability, and the context recognition ability that the candidate mentioned above are not only the main reasons that prevent readers to understand the text. The way that information is organized is also a main reason that can slow down the perception process of readers. The next section will explain how humans process the information and why the information organization is very important for enhancing the reading performance.

2.4 The information perception of humans

To be able to understand how the human brain perceives information, we must first understand the organization of human memory.

2.4.1 Human's memory organization

Following Lindsay and Norman (1972), human memory has three aspects including sensory information storage, short-term memory and long-term memory.

- Sensory information storage is the place where the sensory information arrives at the sense organ.

- Short-term memory is the place where information is maintained and contained in the memory for only a few seconds.

- Long-term memory is the place where information is recorded permanently.

They confirmed that the way information is organized impacts long-term memory. Repeated rehearsal does not facilitate long-term memory; students still may fail to retrieve the information later.

For example, you are given 30 words randomly organized and are required to memorize them. If you just say the sound of the words over and over again, you still may not memorize them effectively. But, if you organize them in a meaningful way, you can memorize them better. For example, you can classify those words into '*vehicle*', '*food*' or '*concept*' word groups to help you to remember them better. This is called the "forming a mental image" process, or an attempt to divide big text into small parts then trying to make sense of the relationship among them (Lindsay & Norman, 1972).

Holley & Dansereau (1984b) also supported a judgment by Lindsay & Norman (1972), which said that organizing information in a good way helps to create more depth memory.

A concept map, which focuses on the good spatial organization of information, can facilitate readers to perceive the information quickly. Although it is easy to see this, the candidate still needs to demonstrate this ability of a concept map by using some very basic and simple experiments in psychology.

2.4.2 Experiments on the memorization of humans

Bartlett (1995) did some very simple basic experiments on the memorization of humans. He asserted that the condensation level and the symmetry level of the symbol can affect the speed of the readers' memorization. The following is an illustration of his experiment, the symbols used in the experiment were revised:

First experiment

Look at the first symbol in one second, and then tell me if you can draw it from memory (without looking at it) or not.

First symbol

Now, look at the second symbol in one second, and then tell me whether or not you can draw it from memory (without looking at it):

Second symbol

In the first experiment, you will find that the second one is harder to memorise, because the second symbol has details which are more "condensed" than the first one. The condensation level of a symbol is measured on the space in between the details of that symbol. For example, there is little space in between the details of the second symbol; on the contrary, there is more space in between the details of the first symbol. Hence, the condensation level of the first symbol is higher than the second symbol's. In other words, the more detailed the symbol is, the harder it is to remember it (Bartlett, 1995).

Second experiment

Look at the first symbol in one second, and then tell me whether or not you can draw it from memory (without looking at it).

First symbol

Now, look at the second symbol in one second, and try to draw it without looking at it:

Second symbol

In the second experiment, although the detail level of the first and the second symbol are the same, it is harder to memorize the second one than the first one. This is because the second one does not have the symmetrical shape while the first's shape is very symmetrical.

Bartlett (1995) concluded that the symmetry level of the symbol affects the memorization speed of that particular symbol. The more symmetric the symbol is, the easier it is to remember that symbol.

Although these experiments by Bartlett (1995) were done on the single symbol, it can also be true in narrative text.

For example, let read this narrative paragraph:

'*Plants produce sugar which is food. They have stems, roots and leaves. Some plants have flowers. Stems maybe brown, roots absorb water. Leaves are green and also require water. Flowers are visited by bees*'.

Then read the following concept map (concept map will be discussed later in the section 2.7) which has the same meaning as the above narrative paragraph:

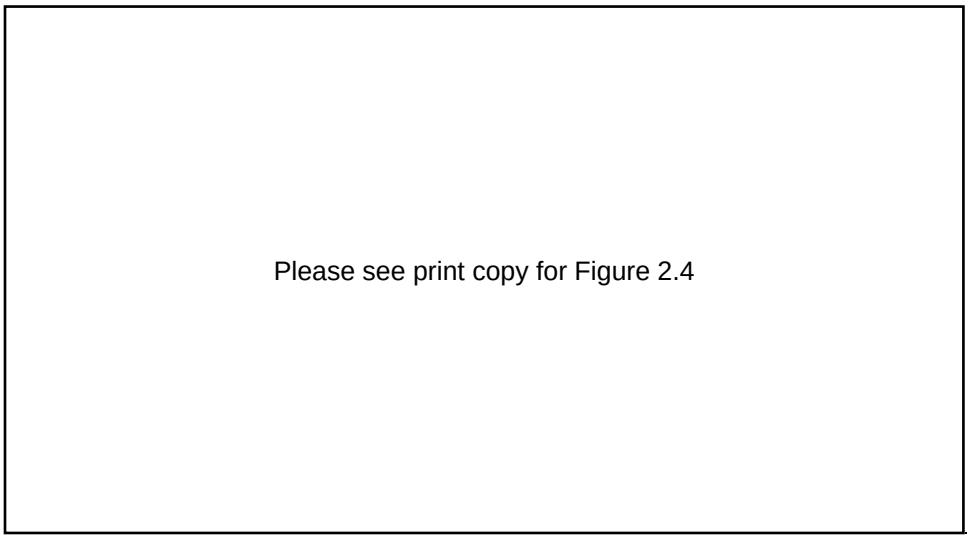
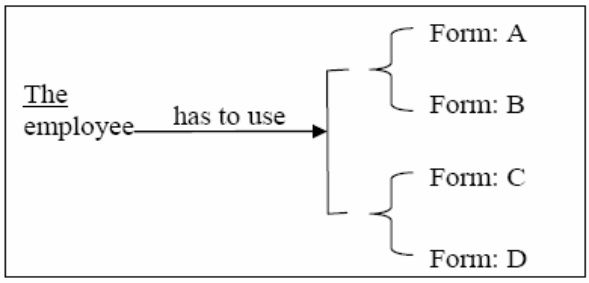


Figure 2.4: A concept map of 'Plants' (Canas & et al, 2001).

We can see that it is easier to remember the concept map in the figure 2.4 than the above narrative paragraph. People feel more relaxed when looking at the concept map because it has more space among words, is very symmetrical and is not a condensed text block. On the contrary, the above narrative paragraph is a condensed text block, has very little space among words, and does not have symmetry.

Likewise, spatial technical writing (STW) (STW will be mentioned in chapter three) also has the characteristics of good symmetry and low condensation among words. For example, the narrative sentence '*The employee has to use form A and form B or they can use form C and form D*' is represented spatially as the following:



First, it can be seen that the above narrative sentence is more condensed than the spatial sentence using spatial technical writing, and thus the narrative sentence is harder to understand. Second, the narrative sentence is a liner line, not symmetrical. The spatial sentence is more symmetrical, and thus it is easier to perceive the meaning.

One good point to remember: the simplicity or complexity level of the symbols is not the same for each person. Some might see it as complex, but others see it as simple (Neumaier, 2003). However, a majority of people do like the visual text graphical representations, such as a diagram and a table (Richard, 1986).

From the experiments of Bartlett (1995), it can be concluded that the good organization of the information is measured through the condensation level and the symmetry level of the text. The more condensed and the less symmetrical the text is, the harder it is for readers to perceive the information.

2.5 Language Ambiguity

As mentioned in the section "Reading Comprehension" above, language ambiguity negatively affects the reading comprehension process. This problem will be discussed later in more detail.

Ambiguity is a common feature of linguistic expressions. Something is ambiguous when it has more than one meaning. If the ambiguity is in a single word, it is called *lexical ambiguity*. If the ambiguity is in a sentence or clause, it is called *structural ambiguity* (Quiroga-Clare, 2003).

Examples of lexical ambiguity are everywhere. In fact, almost any word has more than one meaning. For example:

> '*Note*' = '*A musical tone*', or '*A short written record*'.
>
> '*Lie*' = '*Statement that you know is not true*', or '*present tense of lay: to be or put yourself in a flat position*'.

The word '*ambiguity*' itself is also ambiguous. '*Ambiguity*' can mean an indecision; or an intention to mean several things; or unclear because of having several meanings (Quiroga-Clare, 2003).

Another example of lexical ambiguity where the contrast meanings exist in one word is '*overlook*'. Following Merriam-Webster Online Dictionary, '*Overlook*' can be '*inspect*' (look carefully), or '*ignore*' (look carelessly) ("Definition of Overlook", n.d.).

The followings are examples of structural ambiguity:

- John told the man not to use his car. He went out with his wife. (Who is he?).

- The carpenter fixed the picture with a hammer. (A picture of a hammer, or the carpenter used a hammer to fix the picture!).

- Liz attacked the man with a knife. ('Liz attacked the man who had a knife', or 'Liz used a knife in her attack on the man'). The sentence '*Liz attacked the man with a knife*' is ambiguous because readers don't know whether 'w*ith a knife'* has a direct structural relationship with '*attacked*', or with '*the man*'. In other words, '*with a knife*' modifies '*attacked*', or modifies '*the man*' (Huddleston, 1988, p. 10).

- Harry knew Fred, Bob and Tom knew Liz. (Harry knew both Fred and Bob; or Harry knew Fred only).

- They talked about the disaster on the train. ('O*n the train*' modifies '*the disaster*', or modifies '*talked*').

Language ambiguity can also be categorized as 'part of speech ambiguity' and 'word-sense ambiguity' (Schutze, 1997):

- Part of speech ambiguity:

Example: '*Crane flies like arrow*'; '*flies*' can be a verb or a noun.

- Word-sense ambiguity:

Example: '*The suit is in Los Angeles*'; 's*uit*' can mean '*legal*' or '*sartorial*'.

The sense of a word can be expanded; this change in meanings is called "generalization" because the meanings become wider in their range of applications. For example, 'Lady' can be a large number of women. Or the range of meanings can be narrower; this is called "specification". For example, 'Lady' can be specified, a particular lady named Mary or someone else (Pyles & Algeo, 1970).

One of the characteristics of language is arbitrariness. That is, language has the ability to paraphrase the same information in different ways. This is one of the most important attributes of language (Norman & Rumelhart, 1975). For example, the following two scenarios convey the same meaning:

- Scenario 1 (Norman & Rumelhart, 1975, p. 4):

-Peter put the package on top of the table. -That package is on the table, how did it get there? -It was Peter who did it.

- Scenario 2 (Norman & Rumelhart, 1975, p. 4):

-Peter has performed some operation (as yet unspecified) that has caused the package to change its location from its previous location (as yet unspecified) to its present location, on top of the table.

Another important characteristic of language is redundancy. The writer may use more words than is really needed to explain the meaning. A redundancy of language can allow readers to perceive the text even though readers may miss some details in the text. However, this is not always true. Sometimes, one word is missed and the whole meaning of a sentence might be lost or misperceived (Lindsay & Norman, 1972). Some people judged negatively the language redundancy. Breuker (1984) stated that word redundancy makes the use of language relatively cumbersome.

Segerdahl (1996), a linguist, emphasized that meaning in natural language rarely corresponds exactly to their literal meanings; meaning must be based on the context of utterance. If the information is taken out of context, communication will be a painful and hazardous process. Meanings do not express true or false propositions of the world, but express the human acts such as promising, requesting and warning. A figurative meaning is often added for many other additional meanings.

Sentence diagramming (will be discussed in section 2.8); which is a technique for diagramming the parts of speech such as adjectives, adverbs, nouns, verbs, etc. in a sentence; can help to effectively solve the structural ambiguity problem in language.

2.6 Lack of concept manipulation strategy for readers

As mentioned in the section “Reading Comprehension” above, the ability to manipulate concepts significantly affects the reading process. Reading is very difficult even for a good reader if the reader doesn’t have a good strategy to control the

cognitive manipulation of concepts encountered while reading. Reading will be easy if readers know how to efficiently manipulate the concepts (Vaughan, 1984).

Unfortunately, many students do not even realize the importance of concept manipulation in the text. They also do not see the importance of the links between new and previous knowledge. In addition, students often have teacher-driven, or passive study, and do not have a pioneer or active learning attitude (Vaughan, 1984).

The main reason for a student's passive learning attitude is that the traditional textbook, which uses narrative text as a major knowledge representation method, can contain many "linguistics flaws such as the lack of unity, lack of cohesion, and semantic elaboration" (Vaughan, 1984). There was little cohesion to tie the details and the main points declared in the narrative text. These traditional textual textbooks even tend to distract the search by readers for understanding. On the contrary, a concept map (will be discussed in the next section) effectively facilitates the manipulation of the concepts and key ideas, because readers can quickly trace the meaning of concepts or key ideas in that particular concept map (Carriço & Guimarães, 1998). This creates a strong cohesion between the details and the whole in a concept map. It is very difficult to trace and control the concepts in narrative word-after-word text, especially the complex one.

2.7 Concept Mapping

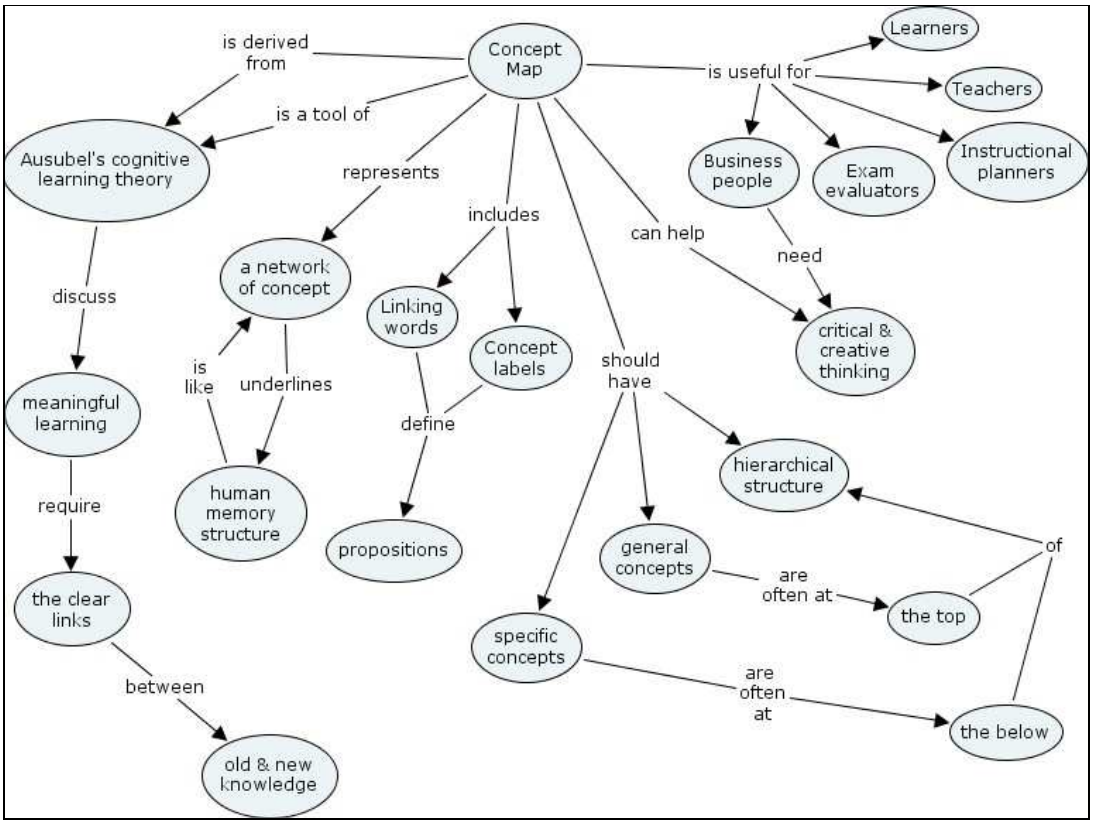


Figure 2.5: A concept map of 'Concept Map'.

Concept mapping was first developed by Joseph Novak and his research students in the 1970s at Cornell University (Soderston & et al, 1996). In 1984, Novak & Gowin (1984) published a book, '*Learning how to learn*', in which they presented a full discussion of this technique.

Originally, the concept mapping was derived from Ausubel's cognitive learning theory. The theory discusses meaningful learning as opposed to rote learning. Meaningful learning requires learners to firmly link their new knowledge to their previous knowledge that they already know. On the contrary, rote leaning is just a

verbatim physical memorization; the new knowledge of the learners is not connected and incorporated with the knowledge that learners acquired before (Novak & Gowin, 1984). Ausubel's cognitive learning theory stated that the most important element of meaningful learning is the integration and clarification of the new concepts with the concepts that the learners know; "ascertaining what learners know and teaching them accordingly" (Ausubel, 1963 & 1968).

The second reason for developing concept mapping technique is based on human memory research (Soderston & et al., 1996). Quillian (1968) found that human-beings stored semantic information and knowledge in their brain like a network of concepts or nodes that are interconnected through their relationships or associative links.

Novak (1991, p. 48) claimed that "knowledge is made of concepts and concept relationships, much like words are made of letters, and matter is made of atoms". This network of concepts is first constructed inside the brain of a new born person. When that person is grown up, his brain's concept network become bigger and bigger, according to his life experience. The process of developing and elaborating this concept network in the human brain will continue until death.

Lindsay & Norman (1972) argued that if text is constructed like the network of knowledge that underlines the human memory structure, then readers can understand that text better. For example, we often feel there is an intangible mental picture in our mind after we finish reading a paragraph in a book. In fact, a concept map itself is this intangible mental picture. Concept mapping, in other words, is a tool for externalizing formally and explicitly human knowledge (Dorough & Rye, 1997).

Another reason for developing concept mapping technique is because Ausubel has not suggested a teaching tool for applying his theory. Concept mapping was developed as an educational tool for externalizing and ascertaining what the learners already know (Novak & Gowin, 1984).

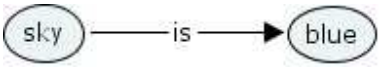
2.7.1 What is a concept map and concept mapping?

"A concept map is a visual representation of knowledge of a domain. A concept map consists of nodes representing concepts, objects, or actions, connected by directional links that define the relationships between and among nodes. Graphically, a node is represented by a rectangle or oval (for example) containing a textual name, and relationship links appear as textually labelled lines with an arrowhead at one or both ends. Together, nodes and links define propositions, assertions that can be about a topic, domain, or thing" (Alpert & Grueneberg, 2000, p. 313).

"Concept mapping is a graphical technique that identifies concepts, ideas, facts, and examples, and shows the interrelationships among them. The two-dimensional maps show the interrelationships among a group or set of related concepts" (Soderston & et al, 1996, p. 179).

Novak defined "concept as a perceived regularity in events or objects, or records of events or objects, designated by some labels" (Novak, 1991, p. 45). For example, 'Chair' is the label identifying the object for sitting on, which has legs, a seat, and a back. 'Wind' is the label of event of air motion. A linking word is used to link two concepts together to form a meaningful proposition. A concept map is a network of

many cooperating propositions (Novak & Gowin, 1984). For example, 'sky is blue' represented in a concept map form a proposition of the concepts 'sky' and 'blue':



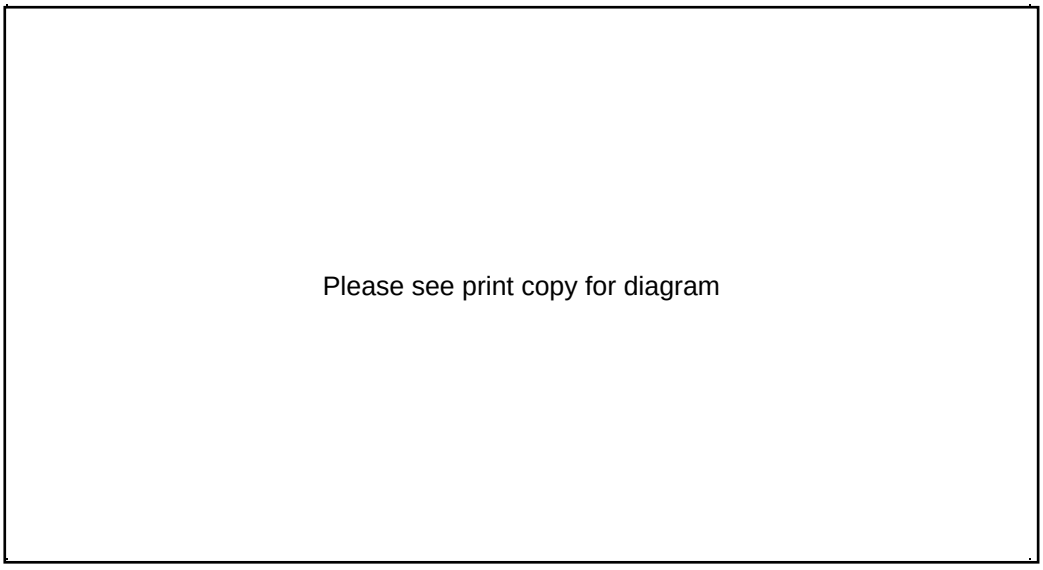
Please see print copy for Figure 2.6

Figure 2.6: A concept map representing 'the idea of concept mapping' (Novak, 1991, p. 46).

2.7.2 Application of Concept Mapping

Concept mapping can be useful for many types of people such as learners, teachers, instructional planners, and exam evaluators. The followings are summarized from research by Novak (Novak & Gowin, 1984):

For the learners, by developing a concept map, they can check their understanding after acquiring new knowledge. For example, students are required to convert a paragraph into a concept map for checking whether or not they understand that paragraph. Besides, by looking at a concept map, the learners can see how the new knowledge to be learned and the knowledge they already know are linked to each other. The learners can efficiently manipulate concepts in a concept map in order to see how these concepts are interrelated each other. This concept manipulation process is very useful for learners to direct their thinking (Novak & Gowin, 1984). The concept mapping technique thus can help readers to manipulate concepts more efficiently than the narrative word-after-word text. For example, by looking at the following concept map (copied from Figure 1.1), we can clearly see how concepts (‘*man*’, ‘*CFC*’, ‘*ozone*’, ‘*skin cancer*’, etc.) are interrelated with each other:



A concept map is done by eighth-grade students (Dorough & Rye, 1997, p. 40).

By showing the concept map to students, teachers can check the flaws and gaps in students' knowledge. A concept map also saves time for teachers in explaining the new concepts and ideas to students, because a concept map helps to create a mental picture which is very hard to be explained verbally, sentence-by-sentence (Novak & Gowin, 1984).

For instructional planners, concept mapping can be a tool for planning a curriculum in an educational environment. A concept map can outline which concepts or knowledge is central to the course, and the relationships between general and specific knowledge. This is very useful in strategic learning planning because a concept map can be a road map that helps students to choose correctly which courses and subjects are to be learned first, in order to utilize their abilities (Novak & Gowin, 1984).

For an exam evaluator, concept mapping can be an effective tool for evaluating the understanding of learners. As mentioned above, rote memorization is destroying the constitution and mentality of learners, especially school children. However, the traditional evaluation tools, such as essay questions and multiple choice questions, did not help the evaluators see if a learner actually understood the requiring knowledge or he/she just rote-memorises superficially that knowledge. Concept mapping can be an evaluation tool for identifying the misconceptions of learners. This ability of concept mapping is the most important contribution in the educational area (Novak & Gowin, 1984).

Concept mapping is used most in the education or training disciplines such as science, chemistry, nursing, medicine, business, engineering, etc. For example, concept mapping are used:

- to test if engineering students understand the technical materials, and if there are any weaknesses in the knowledge blocks that students acquired (Besterfield-Sacre & et al, 2004).

- to facilitate school students in linking complex mathematical ideas to achieve meaningful learning (Baroody & Bartels, 2000).

- to help teachers to know whether students understand mathematical knowledge; and from there, teachers can make instructive directions for the future (Wilcox, 1998).

- to assist nursing students in wading through and critically analysing the vast amount of complex nursing information (All & et al, 2003).

- to help students and business people to organize ideas, share understanding, eradicate misconceptions, solve problem in teams, take initiatives and increase skills (Preece, 1999).

- to help students to present changes in their knowledge structures in the chemistry subject, which is often "conceptually opaque" (Pendley & et al, 1994, p. 9). Let see this useful concept map in chemistry:

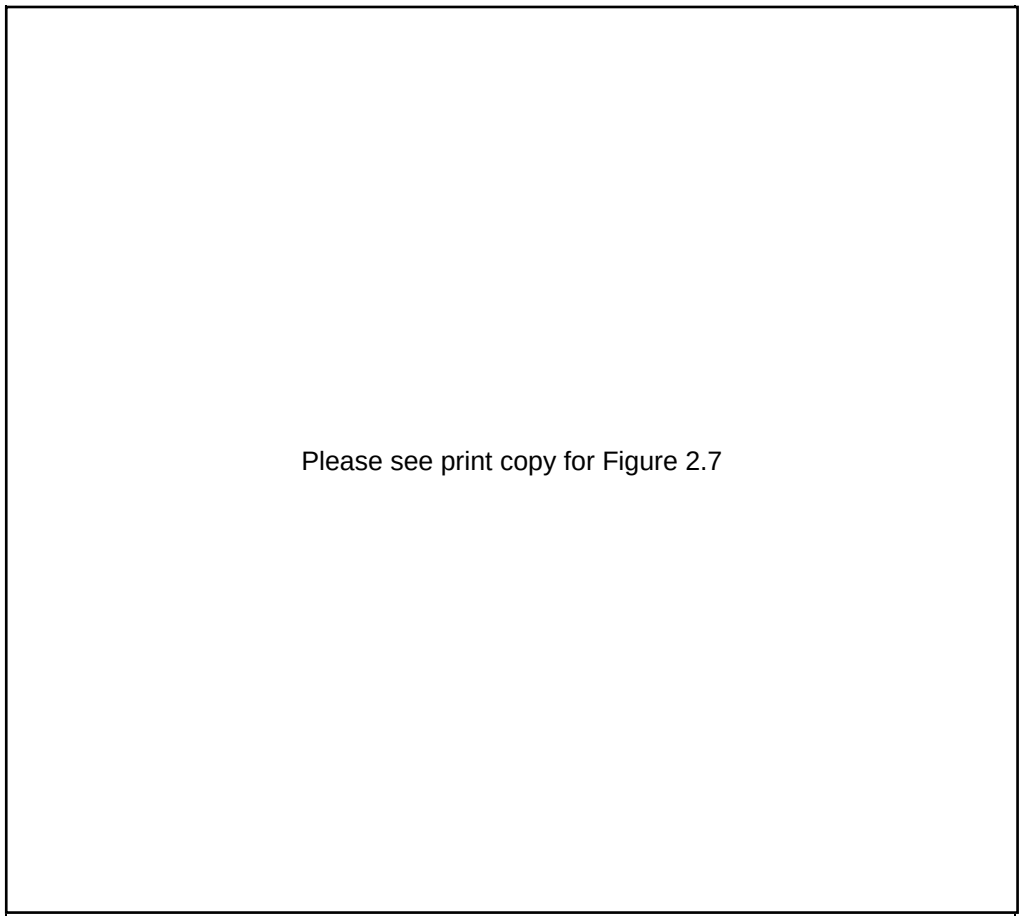


Figure 2.7: A concept map in chemistry subject (Regis & at el, 1996, p. 1085).

- to facilitate inter employee cooperation and communication in an organization. By using concept mapping, an employee can understand what other employees and managers are thinking about, which is becoming very important today (Fraser & Novak, 1998).

Concept mapping can also be used to encourage critical thinking (Daley & et al, 1999), and creative thinking (Dorough & Rye, 1997). Critical and creative thinking are the two biggest concerns of businesses in the IT era today because technology and creativeness always contribute considerably to business competitive advantages.

2.7.3 Paper-based and computer-based concept map

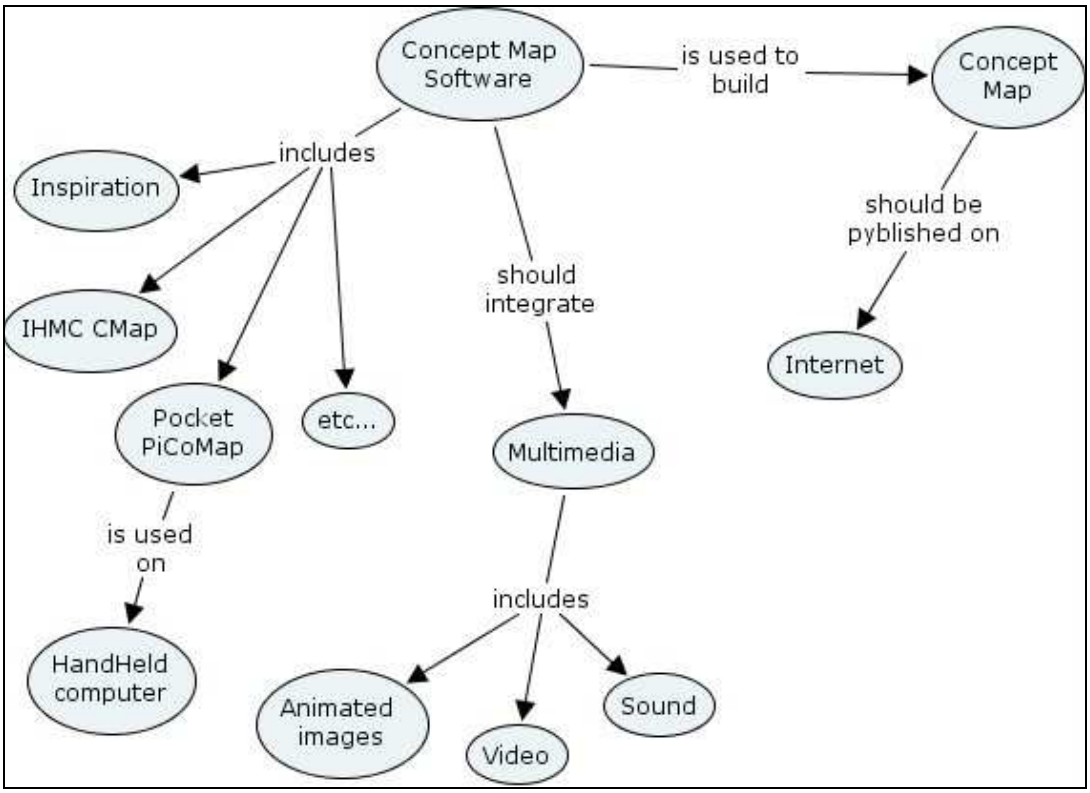


Figure 2.8: A concept map of 'Paper-based and computer-based concept map'.

In the past, people had to use their hands to build a concept map, which is difficult and error-prone. A concept map, which is implemented on paper in the past, has not had much success, partly because paper is too limited to represent a complex detailed concept map. As computer-based applications develop dramatically nowadays, people can take advantage of a computer's ability to build Concept Map Tools, which are applications that help to design the concept map. People can use software such as Inspiration or CMap to design a complex concept map easily and effectively (Scappaticci, 2000).

Because concept mapping is becoming popular at the present, at the moment most visual drawing softwares support a concept map design. The reason for using Concept Map softwares is that "the electronic version of a concept map allows teachers and students the freedom of creating and editing a web/concept map on a computer, without the restrictions of paper, pencils and erasers" (Marchinko, 2004, p. 6).

Moreover, in recent years, the world-wide-web and the internet became popular. A concept map became more useful when it was published on the internet. Another good reason to use an electronic concept visual software is that, the software can be shared online, and thus facilitates time and distance independent learning. This facilitates learners to access the concept map online, available 24/7 (McLoughlin & et al, 2000). Students will not need to come to class to get a face-to-face lesson like traditional white board, pen and paper study (Rapanotti & et al, 2002).

For example, in the 1990s, IBM Latin America initiated a project called "Project Quorum" whose purpose is to support collaborative learning using concept mapping technique across classrooms and countries in Latin America from Chile to Mexico. A software called "Knowledge Soup" was developed to allow elementary and secondary school students to create and share concept maps on the computer. These concept maps represented the ideas of children on some topics and issues. Then, the maps are shared over the computer network by accessing the closet IBM server via a local phone system. When the students access the Knowledge Soup, they will see some existing concept maps which were done by students in other countries. The students can then add or draw the links to the current concept maps to express their ideas. They

also can question and criticise the concept maps and the propositions of other students. This greatly facilitates the innovation and analysis of students (Canas & et al, 2001).

Moreover, traditional computer-based concept mapping tools are often used with the plain text. To utilize the power of computer and concept-map tools, the concept mapping tools should cooperate with dynamic multimedia such as sound, video, and animated images. This makes concept maps more pedagogically effective for students using them to learn new concepts, and capitalise more fully on the capabilities of the computational medium (Alpert & Grueneberg, 2000).

The candidate has just discussed the concept mapping technique and its advantages. However, concept mapping also suffers many disadvantages that the traditional narrative text does not have. The following section discusses the disadvantages of concept mapping.

2.7.4 Disadvantages of concept mapping

First, one of the most obvious disadvantages of concept mapping is the messiness. A huge messy concept map is not usable in practice (Holley & Dansereau (1984a). It is very hard to see a concept map or diagram when it became too ‘crowded’. People can only understand easily a diagram that has less than nine blocks of information (Satzinger, Jackson & Burd, 2000). For example, it is very hard for you to find out the proposition ‘*VS are Q4*’ out of 121 propositions in this concept map:

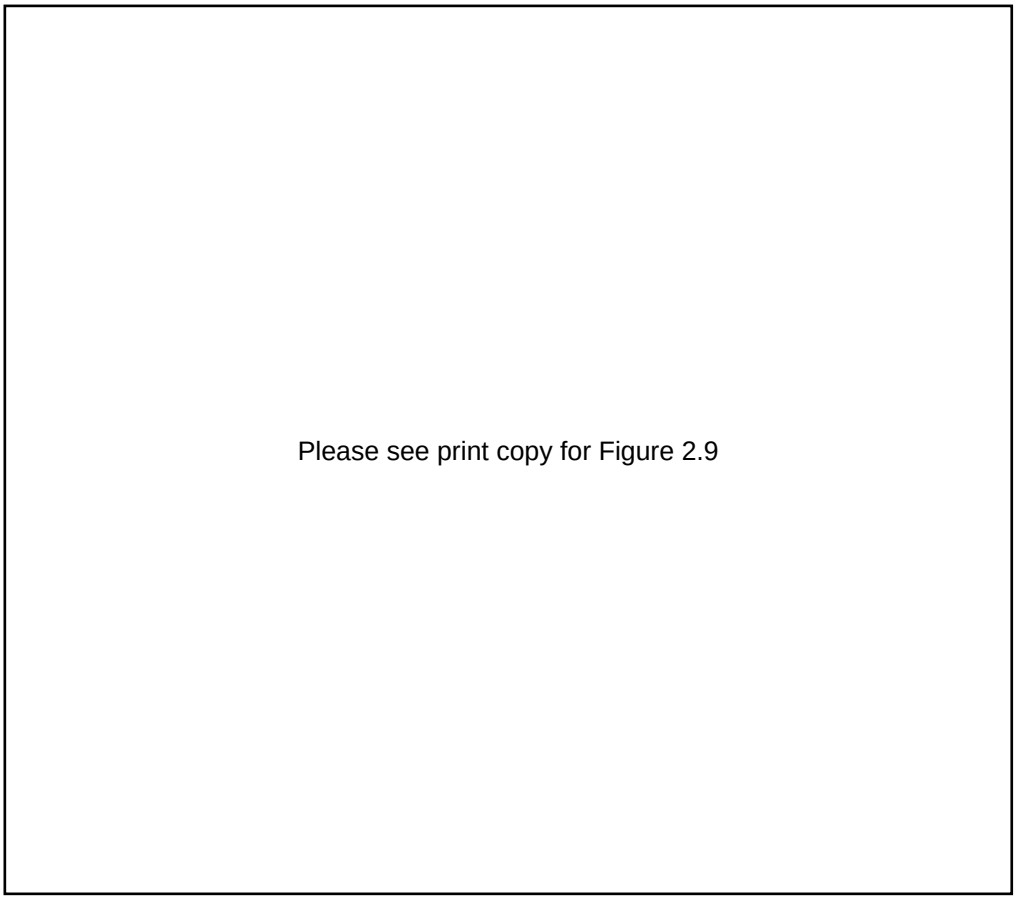


Figure 2.9: A concept map of 'Demographic History' (Daley & et al, 1999, p. 46).

Moreover, a messy concept map can be a danger for readers because readers can forget reading some important propositions that are not seen easily. On the contrary, if you have already read all the sentences in a narrative document, you will at least know that you have already read all of them, whether or not you understood them.

Second, creating a concept map (even with the support of concept map software) can consume a lot of time and effort because the concept mappers have to create a lot of links to logically connect all concepts together (McKeachie, 1984).

Third, because the current concept mapping softwares use the drag-and-drop graphical components, a very big concept map can make the concept mapping software run very slowly and heavily.

Next, there is no standard for drawing a concept map at this moment. The formula for drawing a concept map is rather arbitrary and relies on the creativities of the concept mappers. For example, the linking word sometimes is a noun, sometimes is a verb, sometimes is a whole sentence, etc. Because of its arbitrariness, it can be difficult for some readers to understand a concept map (Novak & Gowin, 1984).

Beside, the linear sentence-after-sentence narrative documents have a strength that a concept map does not have. The strength of a narrative document is that the sentences in the narrative document can be organized in *a logical sequential order* (Goetz & Armbruster, 1980). For example, in an instructional document, the sentences that represent the most basic and easiest knowledge are often written first before the difficult ones.

However, concept map does not have that strength of narrative text. When we read a concept map, we can not see clearly a logical sequential order of propositions; a proposition in a concept map is equivalent to a sentence in a narrative text. This is because the spatial text representation of a concept map makes readers capture the meaning as a whole rather than as a logical sequence order. Concept mapping is often used to spatially represent the propositions which are highly independent. For example, look at this following concept map:

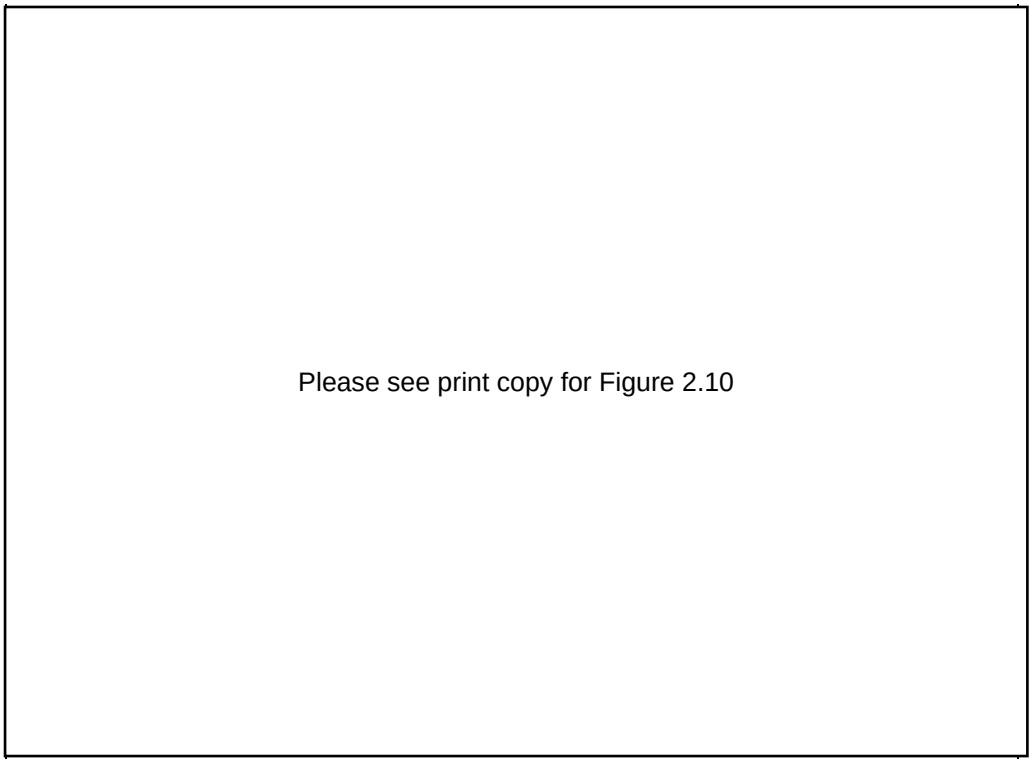


Figure 2.10: A concept map of 'ecosystem' (Steve, 2001, p.34).

These are propositions of the concept map in Figure 2.10:

- Clouds reflect sun's light and heat.
- Sun's light and heat warms air.
- Clouds produce rain.
- Rain adds humidity to air.
- Rain taken up by plants.
- Plants add oxygen to air.
- Nutrients in soil taken up by plants.
- Carnivores eat herbivores.
- Herbivores breathe air.

- Herbivores eat plants.
- Carnivores breathe air.
- Herbivores die & become nutrients in soil.
- Carnivores die & become nutrients in soil.

We can rearrange these propositions in any order without losing the meaning of the text. However, if you are required to convert a paragraph that forces you to read in a sequential sentence-after-sentence way to a concept map, you will feel it is hard to do it. For example, this paragraph is extracted from '*Egg Rolls*' recipe in *www.richsand.com* website:

> Mix pork and vegetables. Cover egg roll skins with damp towel to prevent drying. Place 1/4 c. pork mixture in centre of each egg roll skin. Fold one corn of egg roll skin over filling, overlapping the two opposite corners. Moisten fourth corner with water. Fold over to make into a roll. Heat oil to 360ø. Fry egg rolls until golden brown. Drain. ("Egg Rolls Cooking Instructions", n.d.).

It will be very difficult to convert the above paragraph into a concept map due to the requirement of reading the sentences in a logical sequence order.

Finally, concept mapping only represents spatially the propositions of the regularity of the facts, events and objects (Novak, 1991). However, concept mapping is seldom used to represent the conditional sentences (IF), comparison, relative clause sentences, and other English grammar structures. This is the main reason why concept mapping is unable to map all types of sentences in narrative documents.

2.8 Sentence Diagramming

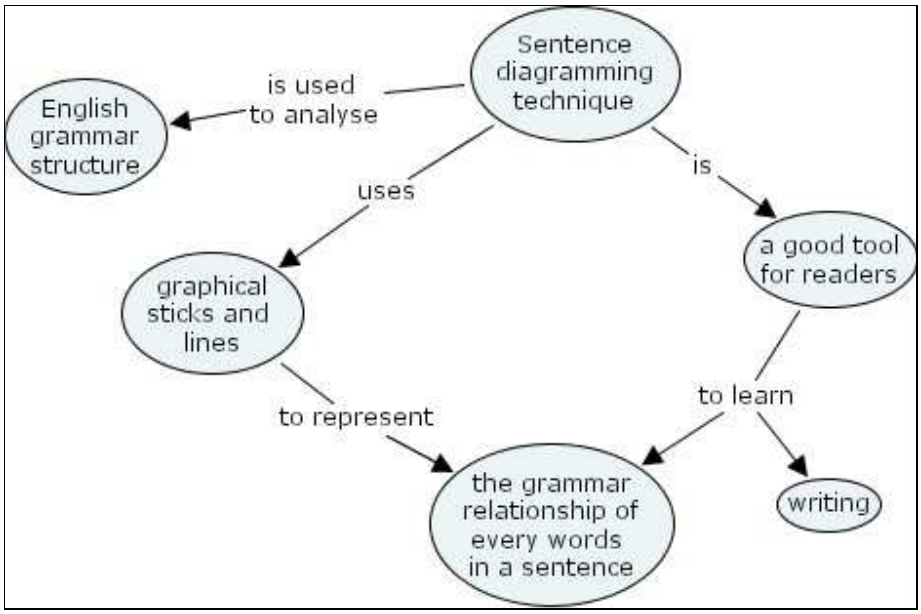


Figure 2.11: A concept map of 'Sentence Diagramming'.

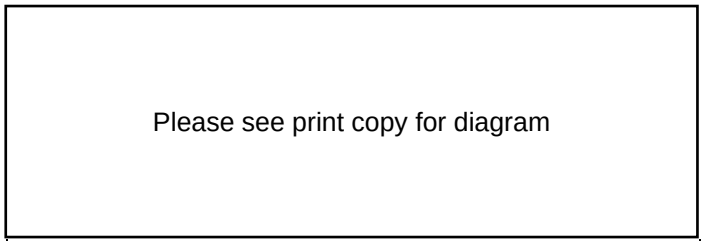
2.8.1 What is sentence diagramming?

Sentence diagramming, which is an English grammar teaching tool, was developed and copyrighted by Reed and Kellogg in 1868. Basically, it is a graphical representation of grammar relationships of every word in an English sentence to help pupils to learn grammar easily and effectively (Reed and Kellogg, 1890).

Sentence diagram (also called Reed-Kellogg diagram) indicates a certain aspect of English syntax structure in a sentence. Reed-Kellogg diagram incorporates "a mixture of information about constituent structure, dependency relations, and grammatical relations" (Trask, 1993, p. 232).

The Reed-Kellogg diagram uses a graphical stick or line to represent grammar structure in a sentence. The base horizontal line shows the structure of the sentence while the lines branching from base line show the modifiers (Brinton, 2000, p. 314).

For example, '*the crafty cat has caught three large rats*' is diagrammed as following:

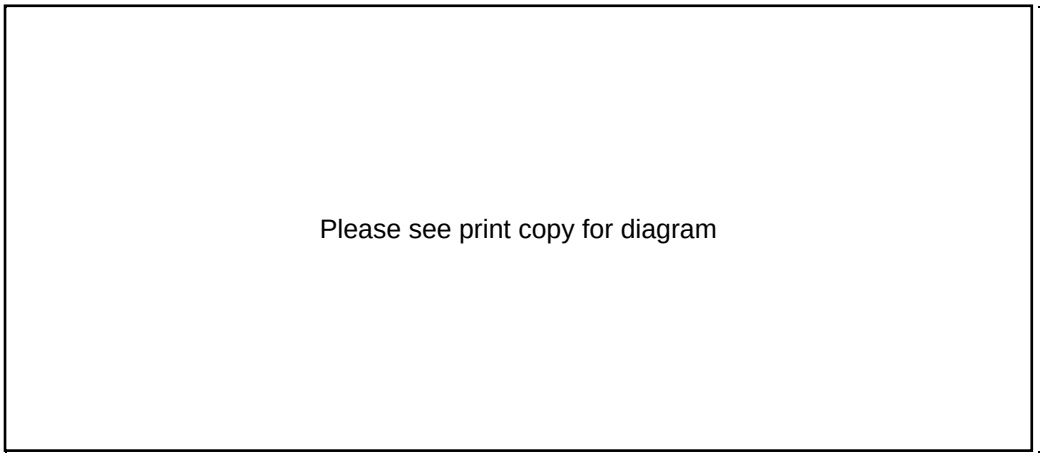


(Brinton, 2000, p. 314).

The subject of a sentence always occurs on the leftmost of the base line. A vertical line going across the base line divides the subject and the predicate. Next, the verb and the direct object are divided by a vertical line perpendicular to the main line, but not passing through the base line. Modifiers such as *the, crafty, three, large* are put on slant lines downward from the noun or pronoun it modifies (Brinton, 2000).

Because of its graphical representation, sentence diagramming can attract pupils to study English grammar. Without the support of this tool, it is hard for pupils to understand the grammar structure of complicated sentences, and pupil must labour hard to see clearly the functions of all parts of speech in a word-after-word sentence by piecemeal, or in succession (Reed and Kellogg, 1907).

This is one example of a complex sentence diagram: '*Islands are the tops of mountains whose base is in the bed of the ocean*'.



(Reed and Kellogg, 1907, p. 104).

2.8.2 The application of sentence diagramming

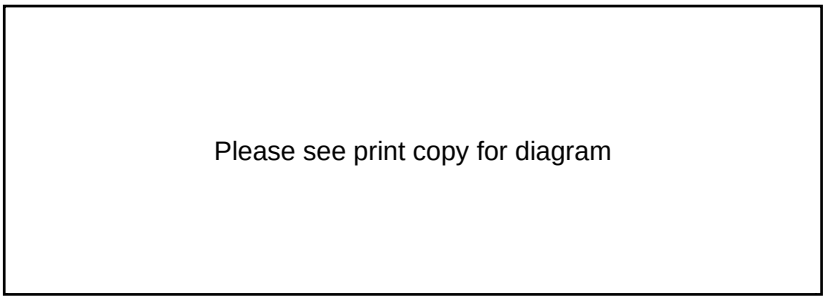
The popular application of sentence diagramming is to analyse the grammar structure; however, it also can be applied in other areas. For example, sentence diagramming can be applied in technical communication. Ryan (2003), a well-known professional writer, declared that sentence diagramming is a very useful tool that helped him to become a good writer from when he was in secondary school until now.

If you are a novice technical writer and if you want to become a good writer in the shortest time, then sentence diagramming is a good start for you. Sentence diagramming can be used as a good tool to train your mind to distinguish the proper order of the different parts of speech in a sentence. This simple but very powerful technique will help you to see a visual picture of how words fit together in a sentence. After understanding all the basic grammar structures, you will feel very confident in writing narrative sentences no matter how complicated the sentences are (Lamerson, 2004). Lindemann (2001) implied that sentence diagramming is even more useful than

most writing exercises taught in schools such as underlining, circling and filling words in blanks. These exercises don't encourage writing, but just make students bored.

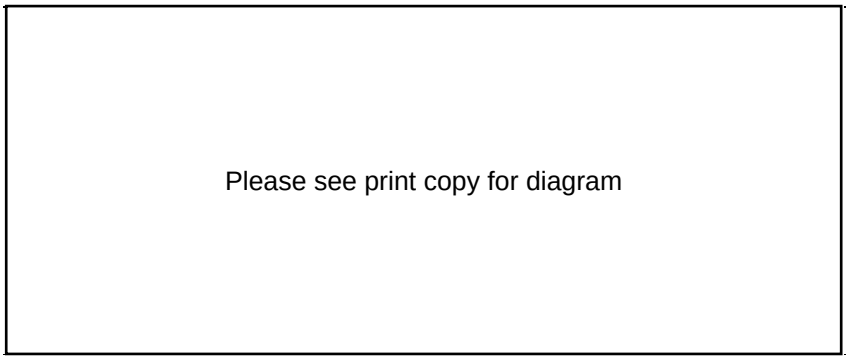
Sentence diagramming is an important tool for technical writers to analyse their writings because other people, especially non technical people, may not understand what the writers actually want to express in the text. By applying sentence diagramming to communication processes among team members who may come from many different backgrounds, they can somehow improve the communication among themself. Technical sentences are often short and straightforward and thus can be diagrammed quickly. In fact, writing errors often happen in technical documents. It does not guarantee that all writers will express their ideas through words exactly as they were actually thinking in their minds. Writing errors do happen to everyone, even to a professional technical writer (Ball & Heuser, 2005).

For example, the sentence '*The modification only should be made to the retrofit*' has an error. The adverb '*only*', in this case, modifies the verb phrase '*should be made*'.



(Ball & Heuser, 2005, p. 3).

This error sentence should be rewritten as, '*The modification should be made only to the retrofit*'. The word '*only*', in this case, is an adjective that modifies the prepositional phrase '*to the retrofit*'.



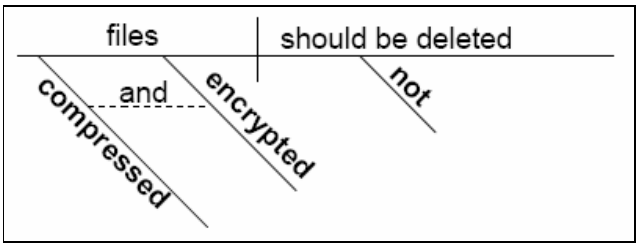
(Ball & Heuser, 2005, p. 3).

By drawing the sentence diagram, the writers can help the readers to figure out which words modify which words, and can help to thoroughly remove the misunderstanding and ambiguity.

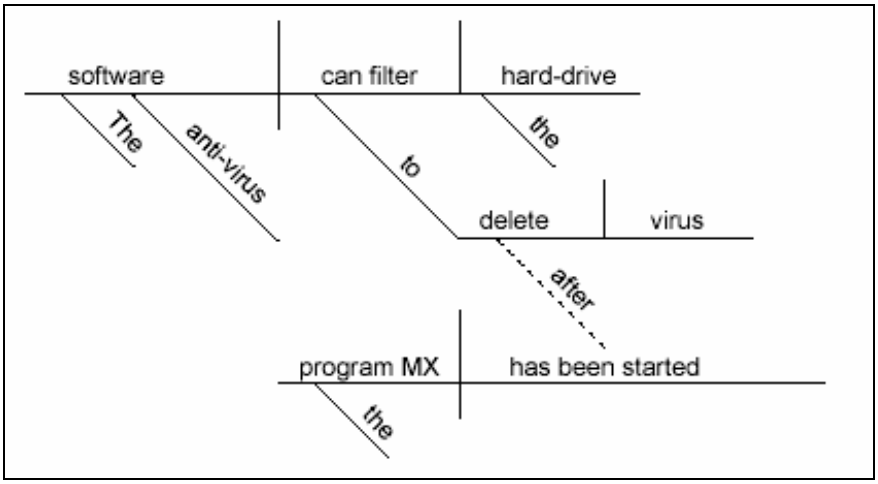
Nagle (1995) stated that sentence diagramming is particularly good for writers to understand English grammar. The visual structure of a sentence diagram can help writers to see clearly what words are related to what words in a sentence. Sentence diagramming is particular useful for writers to analyse compound and complex sentences. It is very easy to inaccurately write the compound and complex sentences if the writer does not accurately analyse these sentences. By diagramming these sentences, writers can minimize the wrong expression.

For example, the sentence '*compressed and encrypted files should not be deleted*' is ambiguous because the phrase '*compressed and encrypted files*' is a compound

subject (i.e., '*compressed file and encrypted file*'), or it is a subject with a compound adjective (i.e., '*compressed encrypted file*'). If the sentence is represented as following, then the readers will know that the writer wants to mean '*compressed encrypted file should not be deleted*':



Another example, this complex sentence '*The anti-virus software can filter the hard-drive to delete virus after the program MX has been started*' (*note*: '*filter*' means searching all files in the hard-drive in order to find out computer virus) is ambiguous because the readers don't know whether the adverb phrase '*after the program MX has been started*' modifies the verb '*filter*' or '*delete*'. That is, the sentence means '*the software **filters** the hard-drive after the program MX has been started, in order to delete virus*', or '*the software filters the hard-drive, and then **deletes** the virus after the program MX has been started*'. The sentence '*The anti-virus software can filter the hard-drive to delete virus after the program MX has been started*' can be represented as following:

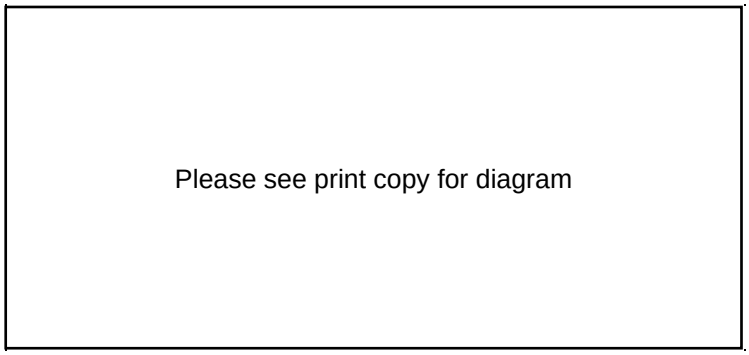


By looking at this sentence diagram, the readers know that the adverb phrase '*after the program MX has been started*' modifies the verb '*delete*', but not '*filter*'.

2.8.3 Disadvantages of sentence diagramming

Reed-Kellogg diagram technique was very effective in that it lasted for several decades in secondary schools in America as a principal English grammar teaching tool before falling into disfavour and being replaced by other grammar diagram techniques in about the 1960s (Jeske, 2004). At the present, grammar tree diagram is used much more and is more popular than Reed-Kellogg diagram because of the following disadvantages of sentence diagramming:

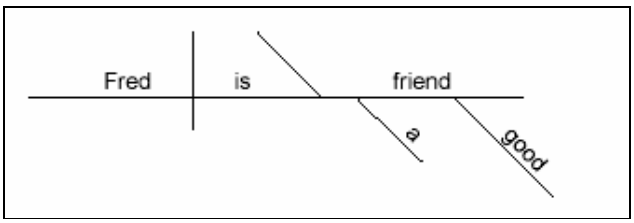
There are no grammar "part of speech" labels for words making up a sentence in a sentence diagram (unlike the tree diagram). So, it is not easy to see what part of speech the words are at first glance. On the contrary, everyone can see the part of speech labels for words making up a sentence in a tree diagram at first glance (Jeske, 2004). For example, the following is a tree diagram of the sentence '*They must have been eating popcorn*':



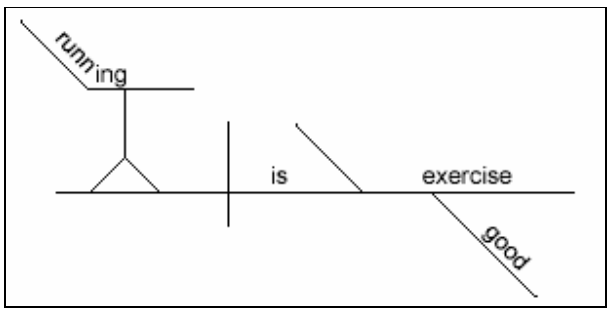
(Leech, 2004, p. 137).

Second, a sentence diagram is sometimes arbitrary, counterintuitive and too complicated (Williams, 1999). For example, the diagram of the sentence '*Fred is a good friend*' and '*Running is good exercise*' are examples of a counterintuitive nature; whereas the diagram of '*Buggsy believed that he was a handsome dog of a man*' is too complicated (Williams, 1999). The followings are the sentence diagrams of '*Fred is a good friend*' and '*Running is good exercise*':

'*Fred is a good friend*'.

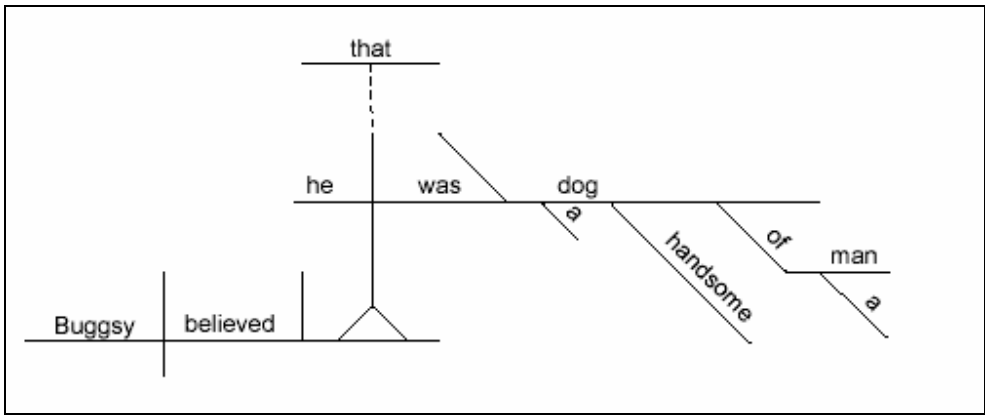


'*Running is good exercise*'.



The two sentence diagrams above show that '*Fred*' is a noun and functions as subject in the first diagram, while '*Running*' is also a noun (a verb functioning as a noun) and also functions as a subject. A majority of students could not distinguish these two noun forms when they look at these sentence diagrams (Williams, 1999).

The followings are the sentence diagram of '*Buggsy believed that he was a handsome dog of a man*':



The above sentence diagram is too complicated. Students have to work hard to understand this sentence diagram (Williams, 1999).

However, the sentence diagram structures represent many things that a tree diagram could not show and vice versa. That is, sentence diagram emphasises the rigorous word relationships in a sentence, while a tree diagram emphasises the logical order of words in a sentence (Matthews, 1993).

Note: because this research focuses on how to spatially represent and effectively control the rigorous word relationships in a sentence so that the language ambiguity

can be removed, the candidate will use sentence diagramming in this research rather than use a tree diagram which specialises more in grammar analysis.

2.9 Research problem

2.9.1 Limitations of narrative word-after-word technical writing

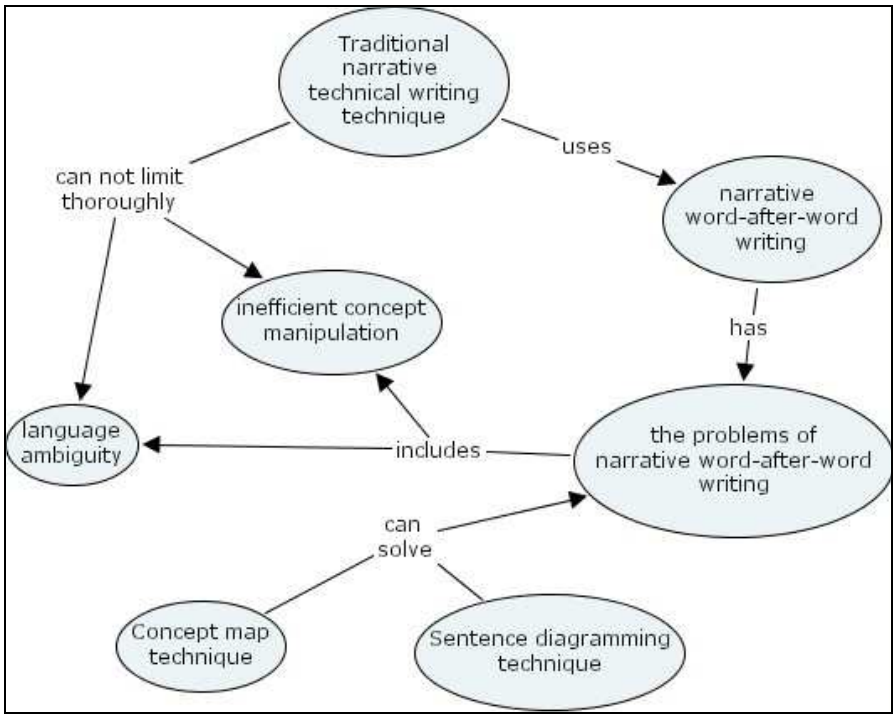


Figure 2.12: A concept map of 'Limitations of narrative technical writing'.

The word-after-word narrative documents written in English language often have the language ambiguity and inefficient concept manipulation problem as mentioned in section 2.5 and 2.6. These two problems present obstacles for readers who need to easily understand the technical documents.

Although technical writing attempts to create good narrative technical documents with good syntax and simple vocabulary, the narrative technical documents *still* suffer from the limitations of the word-after-word narrative documents. Narrative technical writing technique forces writers to produce good narrative technical documents which have a rigorous word control mechanism. Good technical documents are less ambiguous than narrative documents which do not use technical writing methods at all. Good narrative technical documents can also somehow help readers to manipulate the key concepts, because they have simple rigorous sentence structure.

However, it does not mean that word-after-word narrative technical writing can *thoroughly* solve the language ambiguity and inefficient concept manipulation problem in technical documents. Language ambiguity and inefficient concept manipulation *still* do exist in the good technical documents. Technical writing, including Infomap, can only *partially* limit the language ambiguity and inefficient concept manipulation problem in the technical documents.

For example, read the quote in Microsoft Word Help 2002; Microsoft Word Help is the technical instructional document for using Microsoft word software. Because of its narrative word-by-word text use, the paragraph has structural ambiguity.

> **About page margins**
>
> Page margins are the blank space around the edges of the page. In general, you insert text and graphics in the printable area inside the margins. However, you can position some items in the margins - for example, headers, footers, and page numbers (“Page Setup”, 2002).

The sentence, '*you insert text and graphics in the printable area inside the margins*' in the above paragraph can be understood as:

- 'text and graphics in the printable area *are inserted* inside the margins'.

- Or, 'text and graphics *are inserted* in the printable area which is inside the margins'.

To be able to understand the sentence, people have to read it carefully and rely on the context.

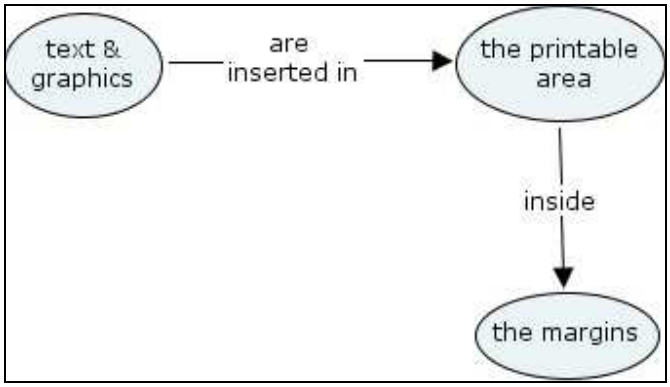
In addition, in a long narrative technical document, there is no mechanism for readers to clearly see how concepts in the technical document interrelate to each other. That is an example of the inefficient concept manipulation problem in narrative technical documents. *Note*: concepts are often nouns playing subjects or objects in a sentence.

Currently, concept mapping and sentence diagramming are the two techniques that can effectively solve the inefficient concept manipulation and language ambiguity problems of current technical writing technique.

2.9.2 Concept mapping and sentence diagramming as techniques for solving the word-after-word narrative technical document problems

As mentioned above, unlike traditional technical writing which uses the structured narrative word-after-word text, concept mapping facilitates readers to see the relationship among concepts in a text. Concept mapping, thus, can solve the inefficient concept manipulation problem more thoroughly than the traditional narrative technical writing technique.

For example, the sentence '*you insert text and graphics in the printable area inside the margins*' can be displayed in the concept map as following:

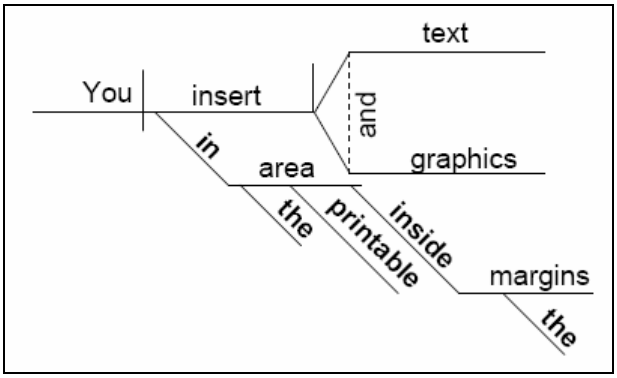


By looking at the above concept map diagram, readers can know how concepts are interrelated with each other. This can help readers to manipulate concepts effectively.

The second technique which is very useful in removing the structural ambiguity is sentence diagramming. As mentioned above, sentence diagramming is a graphical representation of English grammar relationships of every word in a sentence, and a tool for a pupil to learn grammar easily and effectively (Reed and Kellogg, 1890).

Although the main purpose of this technique is to analyse English grammar, it can be applied in the technical writing area to remove language ambiguity (Ball & Heuser, 2005).

For example, the narrative sentence in Microsoft Word Help 2002 '*you insert text and graphics in the printable area inside the margins*' ("Page Setup", 2002) is quite ambiguous because '*in the printable area*' phrase plays an adjective role modifying '*text and graphics*', or it plays an adverb role modifying '*insert*'. Then, '*inside the margins*' modifies '*the printable area*' or '*insert*'. The above sentence can be diagrammed as following:



By looking at this sentence diagram, we can clearly see that the phrase '*in the printable area*' plays an adverbial role modifying the verb '*insert*', and the phrase '*inside the margins*' plays an adjectival role modifying '*the printable area*'.

Sentence diagramming technique, thus, can help to efficiently solve the structural language ambiguity problem existing in the traditional word-after-word technical writing technique.

However, concept mapping and sentence diagramming were not used for writing technical documents. Generally, they only help to facilitate the efficient concept manipulation and to limit the language ambiguity problem.

Concept mapping is often applied to map the structured documents in science, chemistry, nursing, technical document, etc. areas, which require representing the relationships among key concepts consistently, logically and firmly (Baroody & Bartels, 2000).

Up to now, concept mapping is only used to map the most important concepts and is not used to map every word in a document. This is because the essence of concept maps is to hep readers to see the big picture of the text only (Croasdell & & et al, 2003).

Sentence diagramming is used to analyse the grammar structure of an individual sentence, but it is not used to diagram all sentences in a text. People only diagram a sentence when they want to see the grammar structure of that sentence. It is too laborious and too difficult for writers to create a sentence diagram even though they are supported by software. Second, a sentence diagram is too complex and counter-intuitive for a typical reader to understand (Williams, 1999).

The following table (copied from Table 1.1) lists the features of concept mapping and sentence diagramming:

	Concept Mapping		**Sentence Diagramming**
Features	Concept mapping is used to spatially represent the relationships among key concepts of a text. A concept map helps readers to see a big picture of the text, to see how the new concepts and the previous concepts in the text relate to each other. However, people do not create a concept map that spatially represents every single word and sentence in a text, because the essence of concept mapping is to help readers to see the big picture of the text only.		Sentence diagramming is used to analyse the grammar structure of an individual sentence. A sentence diagram helps readers to see clearly the grammar structure of a sentence, and to limit the structural language ambiguity. However, sentence diagram is not intuitive and too complicated for a typical reader to understand. Currently, sentence diagramming is not used as a technical writing method. People only diagram a sentence when they want to see the grammar structure of that sentence.

Note: the lexical language ambiguity problem of the traditional technical documents can be solved by applying the dictionary utility software. This will be mentioned in the "Future Work" chapter. This thesis only focuses on solving the structural language ambiguity and inefficient concept manipulation.

2.10 Research question

As mentioned in the "Research Problem" section above, because narrative word-after-word technical writing can not effectively solve the language ambiguity and inefficient concept manipulation problem, a new way of writing which is better than

the traditional technical writing should be developed so that the writer can apply that new writing method to create easy-to-understand technical documents for readers. Moreover, as mentioned above, sentence diagramming and concept mapping are two techniques which can help to limit the structural language ambiguity and inefficient concept manipulation problem of the traditional technical documents, respectively. However, concept mapping and sentence diagramming are not used for writing technical documents. Concept mapping is only used to represent the relationship among *key* concepts of a text, but it is not used to represent all sentences in a text. Sentence diagramming is too complicated and is not used as a technical writing method.

Hence, the questions of this thesis are as follows:

> *Is it possible to create a new technical writing technique that has its structure similar to the sentence diagramming technique, but is simpler for readers to understand, and can help readers to efficiently manipulate concepts in a text like a concept map?*

If a new technical writing technique, which has the both advantages of concept mapping and sentence diagramming, is developed; then people can have a good tool for solving the structural language ambiguity and inefficient concept manipulation problem that exist in the traditional narrative technical document.

2.11 Summary of this chapter

This chapter provided a critical review and analysis of the knowledge areas relating to technical writing. The chapter first summarised the traditional narrative technical writing technique and some current research about it. The chapter then explained a variety of elements that can affect the reading performance. The chapter showed that the language ambiguity and inefficient concept manipulation existing in narrative word-after-word documents are the main problems that can create a lot of difficulty for readers. The chapter next addressed the research problem which stated that the current technical writing can not thoroughly solve language ambiguity and inefficient concept manipulation problem existing in the narrative technical documents. The chapter then commented on how the advantages of concept mapping and sentence diagramming technique supplement each other in solving the research problem. That is, concept mapping can help readers to manipulate efficiently the concepts in a text, while sentence diagramming can be applied in removing the structural language ambiguity of narrative text. Finally, the chapter raised a research question that; if the candidate can somehow create a new technical writing method which has the advantages of both concept mapping and sentence diagramming, then the candidate can solve the language ambiguity and inefficient concept manipulation existing in the narrative technical documents.

Chapter 3: Research Method

3.1 Introduction to this chapter

This chapter discusses the research method used in this thesis in order to answer the above research question. The research method involves two phrases.

The first phrase will be to develop a new technical writing technique called ‘spatial technical writing’ (STW) which has its syntax structure similar to but simpler than the sentence diagramming technique. Unlike traditional narrative word-after-word writing, STW represents spatially the English sentences and forces writers to consistently show the clear relationships among concepts in a spatial text created by applying STW. A spatial text, thus, can have characters like a concept map. The section “Development of STW technique” in this chapter first discusses the basic knowledge of English grammar before representing a variety of STW grammar structures such as basic English sentences, comparison and condition sentences, and references.

The second phrase will be to implement a small exploratory study for testing how students reflect to STW technique. The exploratory study uses a small pilot experiment based on some basic quantitative and qualitative measurements. The result of this exploratory study will be used for identifying key issues of the proposed STW technique that need to be further investigated in the future. The section “Exploratory study” in this chapter discusses the basic knowledge of quantitative and qualitative research, the experiment design, the experiment instrument and the experiment

planning. Finally, the details of what actually happened in the real experiment will be discussed.

3.2 Development of Spatial Technical Writing (STW) technique

3.2.1 English grammar

The candidate first discusses the English parts of speech to briefly understand English grammar, and then later discuss all different types of English grammar syntax.

3.2.1.1 Parts of speech in English

A part of speech is "a collection of words that all behave in a similar way", and perform the same function in a sentence (Hurford, 1994, p. 148). Following Huddleston (1988), in English, there are eight parts of speech which are illustrated as following (*Note*: the underscored words are the examples of the part of speech):

1-She <u>will</u> perhaps <u>say</u> it <u>is</u> hers	(*Verb*)
2-<u>Tom</u> bought a <u>bottle</u> of <u>sherry</u>	(*Noun*)
3-The <u>new</u> captain was very <u>good</u>	(*Adjective*)
4-She <u>usually</u> says they are <u>very</u> useful	(*Adverb*)
5-A thick carpet <u>of</u> snow lay <u>on</u> the ground	(*Preposition*)
6-<u>The</u> boss had <u>a</u> chance to get <u>his</u> revenge	(*Determinative*)
7-You can have fish <u>and</u> chips <u>or</u> stew	(*Coordinator*)
8-He says <u>that</u> he asked <u>whether</u> it was free	(*Subordinator*)

This is a brief explanation of each part of speech from Huddleston (1988):

- Verbs such as '*go*', '*stop*' and '*eat*' are words denoting actions or processes that often stand before the objects.

- Nouns such as '*Tom*', '*cat*' and '*imagination*' are words denoting persons, concrete objects or concepts. A noun often functions as a subject or object.

- Adjectives such as '*careful*', '*beautiful*' and '*good*' are words denoting properties or states. An adjective modifies nouns.

- Adverbs such as '*carefully*', '*beautifully*' and '*well*' are words that can be derived from adjectives. An adverb modifies a verb, adjective and other adverbs.

- Prepositions such as '*at*', '*in*', '*on*', '*under*', '*over*', '*to*' and '*from*' are words that express spatial relations. Prepositions often stand before nouns and after verbs.

- Determiners such as '*a*', '*the*', '*this*', '*that*', '*some*', '*my*' and '*every*' are words that stand before nouns to determine whether these nouns are specifically or generally referred to. For example, '*this hat*' is referred to a specific hat.

- Coordinators include '*And*' and '*Or*' are words that represent the conjunction or disjunction between words or between sentences in English. Huddleston (1988, p. 195) stated that "the most basic semantic role of coordinators is to

express the logical relations of conjunction and disjunction, corresponding approximately to English '*and*' and '*or*' respectively".

- Subordinators such as '*that*', '*whether*' and '*if*' are words whose primary role is to make a clause become a subordinate. A complex sentence often has a subordinate clause that depends on the main clause.

To be able to understand STW technique, we first have to understand the basic English grammar structures. The following section defines common English grammar structures.

3.2.1.2 Common English grammar structure definition

English grammar is "the science which teaches the forms, uses, and relations of the words of the English Language" (Reed & Kellogg, 1890, p. 12).

A word is "the sign of an idea". For example, when we see the word '*bud*', we immediately think about a mental picture of '*a sprout is blossoming*' in our mind (Reed & Kellogg, 1890, p. 10).

A sentence is a series of words beginning with a capital letter and ending with a period (.), a question mark (?) or an exclamation mark (!) (Hurford, 1994, p. 220). Reed and Kellogg (1890, p. 13) stated that "a sentence expressed a thought in words". For example, when we heard someone say '*Leaves falling*', we only see the two associated ideas. However, when we heard '*Leaves fall*', a thought has been formed in

our mind. Thus, '*Leaves fall*' is a sentence because it expressed a thought, but '*Leaves falling*' is not a sentence because it only expresses two associated ideas.

A phrase is "a part of a sentence or clause which holds together as a meaningful unit on its own" (Hurford, 1994, p. 171). A phrase may contain several words. For example, these are phrases: '*extremely tall*', '*under the kitchen table*', '*not very convincingly*'. In other words, "a phrase is a group of words denoting related ideas but not expressing a thought" (Reed & Kellogg, 1890, p. 42).

A clause is "a part of a sentence, which itself has all or many of the basic ingredients of a whole sentence"; that is, it can include a verb, a subject and perhaps direct or indirect objects. The difference between clause and phrase is that clause has its own verb, while a phrase may or may not have verb (Hurford, 1994, p. 28). For example: '*It is a pity <u>that you arrived so late</u>*'; the underscore is a clause in the sentence.

Note: a sentence contains at least one clause, a clause contains at least one phrase and a phrase contains at least one word (Hurford, 1994, p. 221).

A modifier is "a word or group of words joined to some part of the sentence to qualify or limit the meaning" (Reed & Kellogg, 1890, p. 27).

Simple subject and predicate:

In English, a clause is divided into two fundamental parts: subject and predicate. There are two different types of predicates in English:

A predicate of a clause is every thing in clause excluding its subject and any adverb phrases modifying that clause (Hurford, 1994, p. 185). For example: '*the hyperlink is blinking*'; '*is blinking'* is the predicate and '*the hyperlink'* is subject.

A noun (or noun phase), adjective (or adjective phase), prepositional (or prepositional phrase) after the verb '*be*' (or equivalent) is called the predicate noun (or predicate noun phrase), predicate adjective (or predicate adjective phrase), or predicate prepositional (or predicate prepositional phrase), respectively. The predicate noun/adjective/prepositional (phrase) can also be called complement (Hurford, 1994, p. 186).

Complement:

Everything following the verb '*be***'** (or any other copular verbs) is not an object, but a complement of a copular verb. For example, '*Bill is an Associate Professor of Wollongong University* '; '*an Associate Professor of Wollongong University*' is a complement but not an object because it complements or supplements more meanings to the subject '*Bill*' (Hurford, 1994, p. 38).

Following Downing & Locke (2002), there are two types of complement: subject complement and object complement. **Subject complement** is any word following a copular verb like the candidate has just mentioned above. For example, '*They are very friendly*', and '*Data Link Control (DLC) is a non-routable protocol*'. The underscores are the subject complements. **Object complement** is words that complete the meaning

of a direct object. For example, '*People vote Bill President*', '*Sport exercise keeps us strong*'. The underscores are the object complements.

A copular verb is any form of the verb '*be*' used as a "linking" or "coupling" between its subject and a following phrase. The link either expresses identity or describes some property or attribute of the subject. Copular verbs are *be, seem, appear, remain, become, look, sound, state, feel, smell,* etc. For example: '*The file becomes corrupted if it is attacked by viruses*'. Moreover, copular verbs are not transitive verbs because there no kind of "carrying over" of an action or effective relationship from the subject to the phrase standing after the copular verb (Hurford, 1994, p. 51).

The following example expresses the differences between complement and direct object:

- '*The event made Bob a martyr*'; (*a martyr* is the object complement).

- '*The event gave the movement a martyr*'; (*a martyr* is direct object). The event gave a martyr to the movement.

A transitive verb is "a verb that has a direct object". For example, '*Additional protocols adversely affect network performance*'. In this example, '*affect*' is a transitive verb because it needs the direct object '*network performance*' to complete its meaning (Kirszner & Mandell, 2004, p. 973).

An intransitive verb is "a verb that does not take an object". For example, '*the hyperlink is blinking*'. In this example, '*blinking*' is an intransitive verb because "it does not need an object to complete its meaning" (Kirszner & Mandell, 2004, p. 973).

A conjunction such as '*and*', '*or*', '*but*' is "word used to connect words, phrases, or clauses" (Reed & Kellogg, 1890, p. 48).

The direct object is typically the noun phrase expressing the recipient of an action (verb) created by the subject in a clause, the person or thing most clearly affected by this action (Hurford, 1994, p. 66). For example, '*Foreign students can bring English dictionary into the exam*'. '*English dictionary*' receives the '*bring*' action from the subject '*foreign students*'.

The indirect object is "typically the noun phrase referring to the person or thing for whose benefit the action concerned was carried out" (Hurford, 1994, p. 103). For example, '*the administrator should give printing permission to all suitable users*'. '*All suitable users*' is indirect object.

An adjective such as '*careful*', '*quick*', or '*good*' is "a word typically used to modify a noun, and describes some property of the thing referred to by the noun, such as its shape, colour, age, value, size, origin or the impression it gives" (Hurford, 1994, p. 8).

An adverb such as '*carefully*', '*quickly*', or '*well*' modifies verbs, adjectives and other adverbs. Adverbs often express time, manner or place. Thus, there are adverbs of time, adverbs of manner and adverbs of place. In English, adverbs can often be placed at the beginning, middle or end of a clause. "Adverbs are always optional

elements of clauses; if you omit an adverb, you just get less information, but the clause still makes sense without it" (Hurford, 1994, p. 11).

A preposition such as '*at*', '*in*', '*on*', '*under*', '*over*', '*to*', '*from*', etc. is a (typically small) word that occurs before a noun phrase to make up a prepositional phrase. Prepositions mean "position before" noun phrases. Prepositions typically express relationships in time or place between things and events. A prepositional phrase can modify both nouns and verbs, or whole clauses. Prepositional phrase can be imbedded inside, or can modify another prepositional phrase (Hurford, 1994, p. 190). For example: '*you can click the **Clear List** button under the **Advanced** tab of the **Customize Start Menu** dialog box to empty the My Recent Documents folder*'. The underscored words are prepositions.

A particle is a term used of small words (and occasionally affixes), which do not easily fit into any clear word class, such as common noun, auxiliary, modal, article or preposition (Hurford, 1994, p. 153). For example: '*The VPN server may be unreachable if you see the error 800*'. '*May*' is a particle.

A phrasal verb is a verb that goes with prepositions such as '*up*', '*over*', '*to*', '*of*', etc. These prepositions of a phrasal verb cannot be separated from its verb. For example: *take out, give up, get rid of, push over*, etc. (Hurford, 1994, p. 154).

A gerund is "a form of a verb used as a noun". A gerund plays roles as a subject or object of a clause, and acts as the head of a noun phrase (Hurford, 1994, p. 84). For

example: '*Recovering encrypted data requires a private key*'. '*Recovering*' in this sentence is a gerund.

A present participle (PP) also has the same form as gerund, but present participle is "the form of a verb that accompanies the auxiliary *be* in the progressive", as in, '*recording the errors into the log book* w*hen you suspect that one or more specific programs are causing the problem*'. English present participles are all formed by adding the suffix-'*ing*' to the base form of the verb (Hurford, 1994, p. 84).

A present participle, especially of intransitive verbs, can often be used as adjectives, modifying a noun as in '*You can find more troubleshooting information on the Internet*'. A present participle of transitive verbs can be used in adjective phrases following a noun as in '*Some programs only supports applications working on Windows*' (Hurford, 1994, p. 196).

Again, in English, the present participles and gerunds are identical in shape, both ending in '*–ing*'. But they contrast: PP is a verb form behaving like an adjective, whereas a gerund is a verb form behaving like a noun (Hurford, 1994, p. 195). For example, '*shooting*' in '*shooting game*' is a verbal noun gerund. But, '*fading*' in '*fading game*' is a present participle functioning as an adjective.

An infinitive is "a form of a verb with no marking for tense, and usually (but not always) with no agreement with any subject". In English, the word '*to*' before the bare form of the verb marks it as infinitive. The infinitive clause acts as the subject or object of the main clause (Hurford, 1994, p. 108). For example: '*To err is human*',

'*To err*' is an infinitive playing a subject role in the sentence. Infinitive also acts like an adverb or object of preposition.

Note: gerund is a verb functioning as a noun. Infinitive is also a verb, but can function as noun, adjective and adverb.

Passive voice is a form of an English sentence where the receiver of the action is expressed as the subject of the clause. The doer of the action may or may not be mentioned in the clause. Passive voice is made of the verb '*be*' and a past participle. However, since past participles can often play a role as adjectives, or adjectives can look like past participles; there can be clauses which seem very much like passives, but in fact are not. For example, '*If you are interested in this product, please contact the nearest Microsoft office for more information*' does not mean '*someone interests you in this product*' because the word '*interested*' is an adjective not a passive verb (Hurford, 1994, p. 154).

Note: some transitive verbs such as '*cost*' and '*weigh*' does not have passive form.

Apposition: "when 2 noun phrases occur immediately next to each other, both referring to the same thing, but giving different information about it, the second one is said to be in apposition to the first. In writing, there is often a comma between these two phrases". For example: '*Open Office, a word-processor, run reliably*'. "Personal pronouns can never be in apposition, though other phrase can be in apposition to them" (Hurford, 1994, p. 17). Thus, '*We, the people, demand a voice*', is fine, but '*The people, we, demand a voice*' is not.

Determiners are words including articles, demonstratives and possessives (but not numerals). So, all of the following are determiners: *a, the, this, those, my, your*. Determiners modify nouns, and stand before adjectives which also may modify that noun (Hurford, 1994, p. 60).

An article is one of the traditional parts of speech. It is a very small part of speech, just only two words - '*the*' and '*a*'. '*The*' is the definite article, while '*a*' is called the infinite article. There are no more articles in English (Hurford, 1994, p. 18).

'*The*' behaves very much like demonstratives such as '*this*', '*that*', '*these*', '*those*' and the possessives such as '*my*', '*your*', '*his*' and '*our*'. '*A*' behaves like number one (Hurford, 1994, p. 19).

The definite article, '*the*', expresses something which is already known to the hearer. For example: '*put it on the table*', by using '*the*', we presuppose that the hearer will be able to identify the particular table I am talking about. However, sometimes, '*the*' is used for generic expression as in '*the blue whale migrates to its breeding grounds every spring*'. '*The blue whale*' in this sentence refers to any general blue whale (Hurford, 1994, p. 58).

'*A*', '*an*', or '*some*' or no article at all are indefinite articles. Indefinite noun phrases may refer to specific things (in the widest sense of things), but there is no assumption that the hearer already knows about these things, as in, '*there is a file in that folder*'. Indefinite noun phrases may not refer to any particular thing(s) at all, but just indicate what type of thing is being talked about, as in, '*please contact the IT Helpdesk office,*

if you wish to have a new computer mouse '. There is no particular '*new computer mouse*' that I am talking about or refer to; any '*new computer mouse*' will do (Hurford, 1994, p. 99).

The difference between indefinite noun phrases and definite noun phrases is subtle. "The latter mentions particular thing(s) referred to and the hearer know of its existence while the former used when particular thing is referred to for the first time but the hearer do not know about that thing" (Hurford, 1994, p. 100).

Interestingly, indefinite noun phrases are the "only kind used after a so-called existential expression", as in, '*There is a file in that folder*'. '*There*' is used to state the existence of something. If you are telling someone the existence of something, you obviously don't assume that they know about it already. For example, '*If we have a car, we will lend it to you*'. The speaker does not have one (Hurford, 1994, p. 101).

A demonstrative is "a word that typically modifies a noun, and is used to indicate the position of something in relation to the speaker. In speech, demonstratives are often accompanied by a pointing gesture". There are just four demonstratives in English: *this, that, these, those* (Hurford, 1994, p. 59).

A subordinate clause is a clause inside another clause playing a role such as subject, object, or modifier in the containing clause. Complement clause, relative clause and adverbial clause are subordinate clauses (Hurford, 1994, p. 232).

A complement clause plays a role as the subject, or direct object of the verb of the main clause. A complement clause is introduced by a subordinating conjunction such

as '*that*', as in, '*some people claim that Ancient Egyptians visited America*'. The underscores are complement clauses (Hurford, 1994, p. 35).

A relative clause plays a role as an adjective modifying a noun existing in the main clause. A relative clause is introduced by a relative pronoun such as *who, which, or that*, as in, '*Microsoft Word comes with sample document templates which you can customize to your own needs*'. The underscores is a relative clause (Hurford, 1994, p. 213).

An adverbial clause plays a role as an adverb modifying the verb, the adjective or the other adverbs in the main clause. An adverbial clause can modify the whole containing clause. An adverbial clause is introduced by another subordinating conjunction such as '*when*', '*after*', '*if*', '*since*', '*because*', or etc., as in, '*There is a civil war where I was stationed when I was in the army*'. The one line underscore is an adverbial clause; the double line underscore is also an adverbial clause staying inside another adverbial clause (Hurford, 1994, p. 233).

The adverb clause may express a real cause (Reed & Kellogg, 1907). For example, '*Access was denied because the user name or password was invalid on the domain*'.

After discussing all the basic ideas of English grammar structure, the candidate now goes into the details of STW grammar. You will see how STW technique is used to represent spatially all the English grammar structures.

3.2.2 STW as a new technical writing type

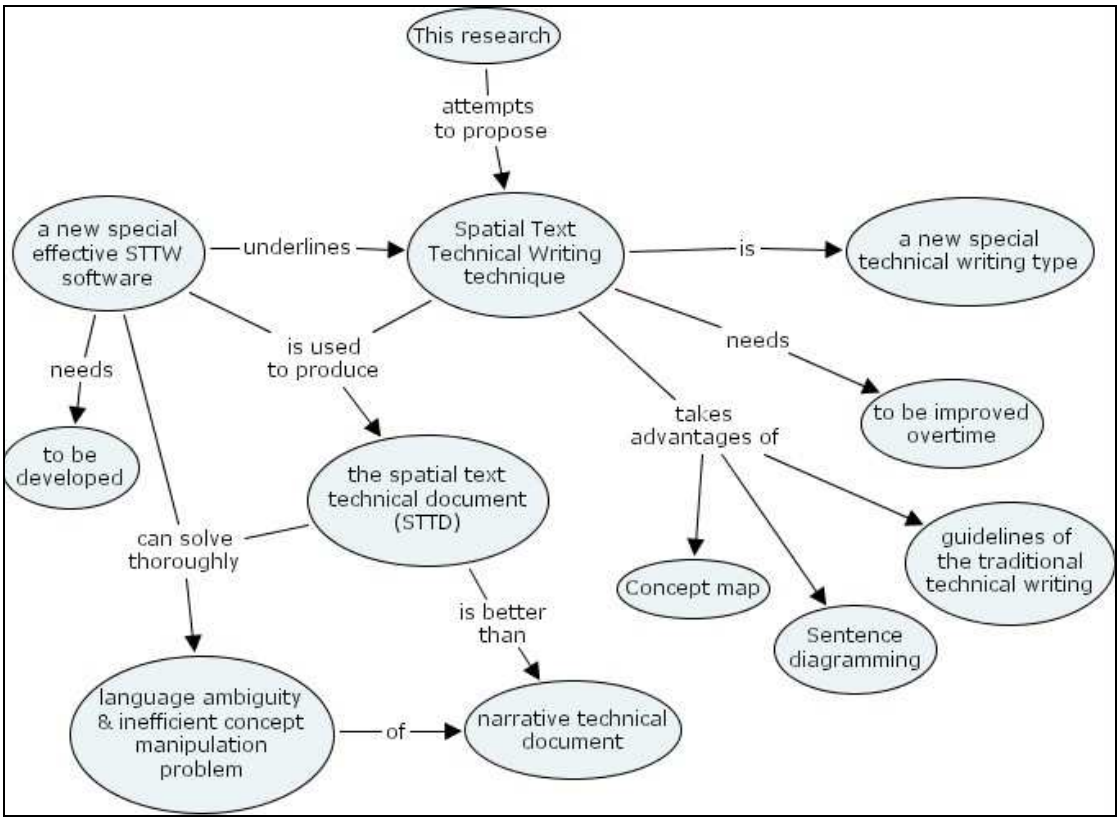


Figure 3.1: A concept map of 'STW as a new technical writing type'.

To respond to the research question mentioned above, the candidate attempted to propose a new technical writing type which is called 'spatial technical writing'.

Spatial technical writing (STW) takes advantages of sentence diagramming, concept map and guidelines of the traditional technical writing technique. STW has three requirements:

First, STW should inherit all good guidelines of traditional technical writing such as using clear words and short sentences, etc. as mentioned in section 2.2.2 “Technical writing”.

Second, STW grammar structures should be based on sentence diagramming technique, so that it can have the ability to limit the structural ambiguity as in sentence diagramming. However, the rigorous degree of controlling words in STW is less than in sentence diagramming in order to make STW more simple and friendlier to readers.

Third, the writers should represent clearly and specifically the relationships among concepts in the spatial document developed by STW, so that readers can manipulate easily the concepts in the spatial document like a concept map.

To create a technical document using STW, a technician first has to know thoroughly the knowledge underlining that technical document. Then, the technician will start to write spatially the sentences one by one until forming a fully completed technical document which should be called a ‘spatial technical document’ (STD). In STW, technical writers have to create STD for learners. Learners only need to learn directly from STD. On the contrary, concept mapping technique requires learners to convert the narrative text to concept map for checking their understanding.

Note: a new special effective software that underlines the STW technique needs to be developed. The main reason is that, using STW technique only by hand without supporting software to produce STD is very laborious. STW software can help technical writers to quickly produce STD with the lowest effort and in the shortest

time. Beside, as mentioned later in the "Future Work" chapter, STW software can help readers to effectively manipulate the concepts in STD.

One important point to be kept in mind, this STW is not a fully-developed method because STW was created from an iterative, reflective process, i.e. a technique that is refined through feedback opinions. Because some English structures have not been displayed in STW, STW needs to be improved overtime to become fully-developed in the future.

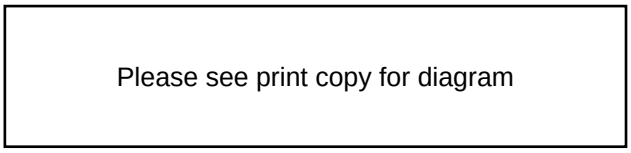
3.2.3 STW grammar

The grammar of a language is "a conventional system of rules for making and putting together the expressions, e.g. sentences and phrases, which belong to the language" (Hurford, 1994, p. 87).

Likewise, the grammar of STW is a conventional system of symbols and rules for representing spatially English sentences in coordinating with English grammar syntax.

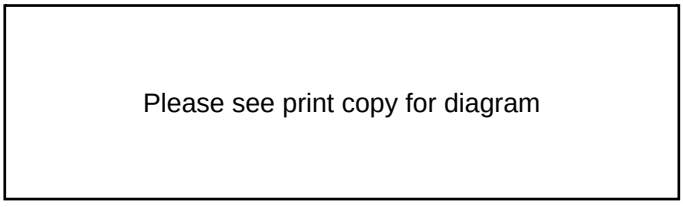
The STW mentioned here was based on sentence diagramming. All words in a spatial sentence developed by STW are divided, grouped and controlled rigorously as in the sentence diagramming technique. Basically, STW syntax is based on sentence diagramming syntax; however, the rigorous degree of controlling words in STW is less than in sentence diagramming to make STW simpler and friendlier to readers. Beside, STW forces writers to rigorously control the relationships among concepts (nouns) in a STD like a concept map, which can help readers to manipulate efficiently concepts in a STD.

In the following section, for each spatial sentence represented by STW, there will be a sentence diagram represented accordingly. The first picture represents the sentence diagram; the second picture represents the spatial sentence created by using STW. The grammatical explanation of the sentence diagramming technique here was based on Reed and Kellogg (1890 & 1907), but the sentence diagram symbols were based on Brinton (2000). The sentence diagram symbols of Brinton (2000) and Reed and Kellogg (1890 & 1907) are generally the same, except that some symbols of Brinton (2000) are simpler. For example, the horizontal line of Reed and Kellogg (1890 & 1907) used to contain subject and predicate is a heavy line. The narrative sentence '*Love conquers*' is diagrammed in Reed and Kellogg as following:



Reed and Kellogg (1907, p.8)

On the contrary, for the sake of ease, Brinton (2000) used a normal (not heavy) horizontal line to contain subject and predicate. For example, '*the crafty cat has caught three large rats*' is diagrammed as following:



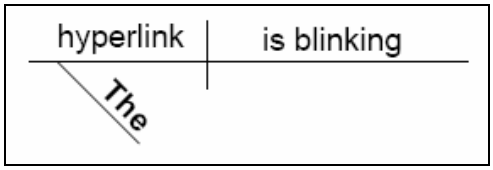
(Brinton, 2000, p. 314).

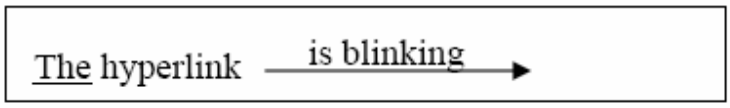
3.2.3.1 Basic STW syntax based on sentence diagramming syntax

1 Simple subject and predicate

Note: for the sake of ease, the candidate means the word "writer" and "reader" as "the person who writes sentences" and "the person who reads sentences" respectively in this thesis.

The followings are the sentence diagram and the spatial sentence of '*The hyperlink is blinking*':





In the above sentence diagram, the subject '*hyperlink*' is separated from the predicate '*is blinking*' by a vertical line passing across the horizontal base line. The vertical line divides the sentence into two parts. The first part represents the subject of the sentence, while the second part represents the predicate (Reed and Kellogg, 1907). By looking at the above sentence diagram, readers can see that '*The hyperlink is blinking*' is a sentence, '*The hyperlink*' is the subject, and '*is blinking*' is the predicate.

The slant line, which is placed under and joined to the subject, stands for the modifier of that subject (Reed and Kellogg, 1907). In the above sentence diagram, the article

'*the*', which plays an adjective role modifying the subject '*hyperlink*', is sat on a slant line.

In STW, a verb, which is a part of a predicate, is represented by sitting on a single arrow. The arrow direction goes from the subject to the object in a spatial sentence.

The reason why the arrow was adopted to represent the verb in a spatial sentence is that the arrow is a very popular and effective symbol for helping to direct ideas for the readers (Richard, 1986). Moreover, the first sentence that occurred in human history can be explained by Noble & Davidson as following:

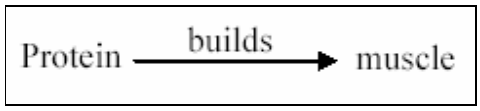
Before humans had script language, humans had used their gestures as a main communication media (Place, 2000).

It could be possible that the first sentence was born when a group of hunters *aimed their weapons (often arrows) at the target* that they wanted to attack. "Given the ability to use pointing to distinguish (a) who is to perform the action, (b) the object to be manipulated and (c) the individual to whom the object is to be transferred, it becomes possible for the first time in the history of communication between living organisms to construct novel sentences" (Noble & Davidson, as cited in Place, 2000).

Hence, a sentence, which often has three components: Subject-Verb-Object, may have originated from an intentional activity by humans. It is important to understand that every sentence does not stand in a vacuum, but has its intent (Place, 2000).

However, the traditional narrative text does not help the readers to see graphically and explicitly the intent of a sentence. On the contrary, the arrow used in the spatial sentence can graphically and explicitly facilitate the readers to realize clearly the Subject-Verb-Object structure, rather than implicitly having the readers realize the S-V-O structure by themselves. The readers don't need to force their brains to work hard to figure out the Subject-Verb-Object structure. The readers can see more easily which one is subject, which one is object and which one is action in a spatial sentence. The arrow, thus, can facilitate readers to see more clearly the intent of a sentence.

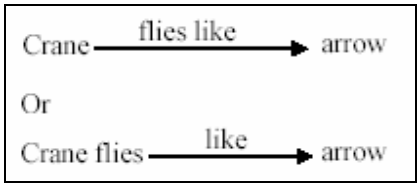
For example, this narrative sentence '*Protein builds muscle*' requires the readers to implicitly figure out which word is subject, which is object and which is verb by themselves. If writers display that sentence as following, readers can see explicitly and clearly the intent of the sentence:



In the above spatial sentence, the arrow, which contains the verb '*build*' and goes from the subject '*Protein*' to the object '*muscle*', helps readers to clearly see that the action '*build*' is transferred from '*Protein*' to '*muscle*'. The direction of arrow in the spatial sentence helps to direct the thinking and reading.

Moreover, using arrow to represent verb can also help to remove the structural language ambiguity problem. For example, as mentioned in section 2.3, the sentence '*Crane flies like arrow*' has a structural ambiguity because readers don't know whether the word '*flies*' is a verb or noun. If the writer expresses the sentence as

following, then the writer can limit the structural language ambiguity because the readers can quickly figure out which word is subject and which is verb:

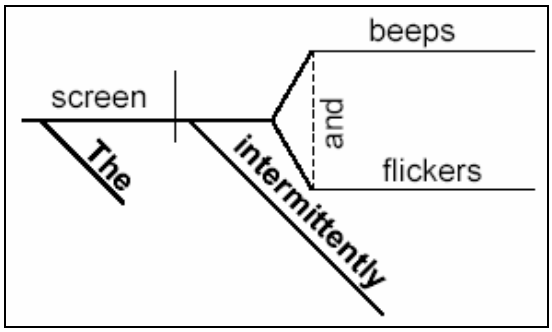


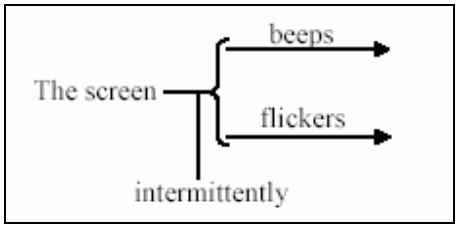
Second, unlike sentence diagramming, all the determiners such as '*the, a, this, that*' will be underlined in STW. The candidate will explain this later when the candidate explains the adjectives in STW.

Note: in narrative text, a sentence is delimited by a period. In STW, a spatial sentence is delimited by an encompassing rectangle. This makes the spatial sentence clearer and limits the messiness created by representing many sentences spatially.

2 Adverb-Compound predicate

'*The screen beeps and flickers intermittently*'.





The compound subject, compound verb, compound object, etc. in sentence diagram are represented by branches connecting through a dot conjunction line such as '*and*', '*or*', '*but*', etc (Reed and Kellogg, 1890). The adverb '*intermittently*' is put on a slant line connecting to the predicate part to modify both '*beeps*' and '*flickers*'.

In STW, the symbol ❴ is used to represent '*And*' or '*But*'. The symbol ❘ is used to represent '*Or*'. The reason of adopting the brace symbol { for '*And*' or '*But*' is very simple. Because the brace has the curl sides that are like holding the words, the brace make people feel that all words inside the brace must be selected. On the contrary, the | (vertical bar) is adopted for '*Or*' because the vertical bar does not have the two curl sides. So, people will think any word hold by the vertical bar can be selected.

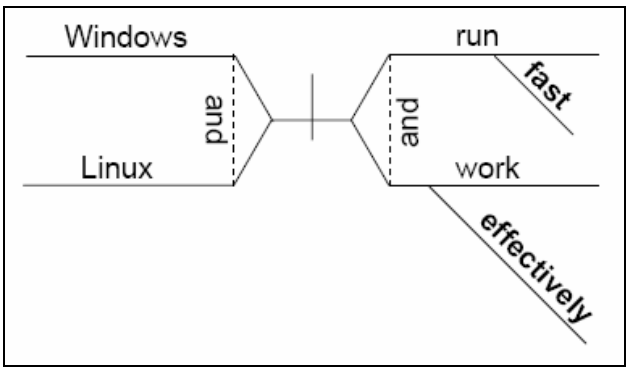
Second, the adverb in the above STW spatial sentence is linked to the verb that it modifies through a straight non-arrow line. The reason the candidate adopted the straight line to represent adverb or adjective is that, that way of representation has some benefits over the way the modifiers in sentence diagram represented. In sentence diagram, the modifier is laid slantingly on a slanted line, which can make it hard for a reader to read. On the contrary, a reader does not have that problem in STW because the adverb stays horizontally and is connected through a straight non-arrow line. In

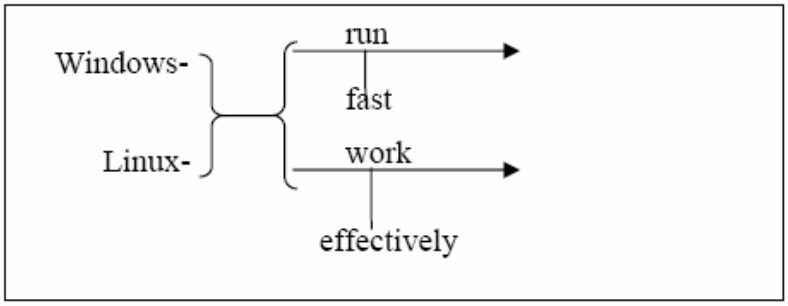
addition, the candidate uses non-arrow line for adverb and adjective because the arrow line was adopted to represent verb and preposition.

Note: the above narrative word-after-word sentence is ambiguous because readers don't know whether the adverb '*intermittently*' modifies the verb '*beeps*', or '*flickers*', or both. If the writer represents spatially this sentence, then the ambiguity will be removed. By looking at the spatial sentence, readers can know that '*intermittently*' modifies both '*beeps*' and '*flickers*'.

3 Compound subject and predicate

'*Windows and Linux run fast and work effectively*'.

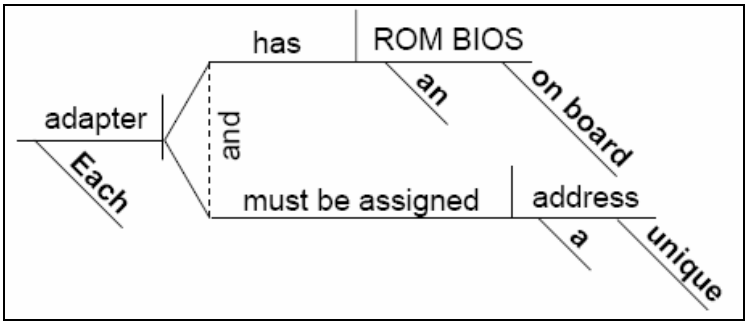


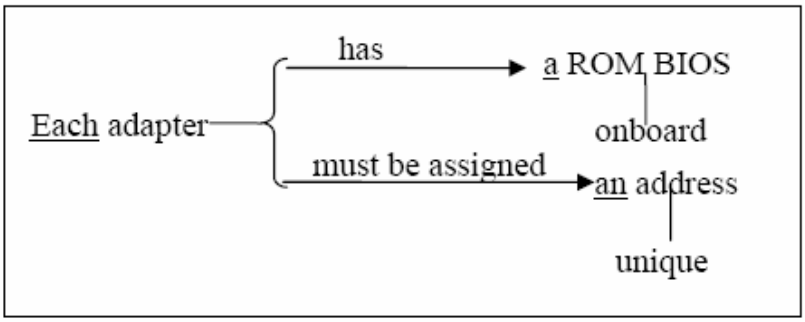


Note: in STW or sentence diagramming, the adverb must be connected to the word that it modifies through a non-arrow or slant line, respectively. This can help to limit the ambiguity and facilitate the reading process.

4 Compound predicate with direct objects

'*Each adapter has an onboard ROM BIOS and must be assigned a unique address*'.



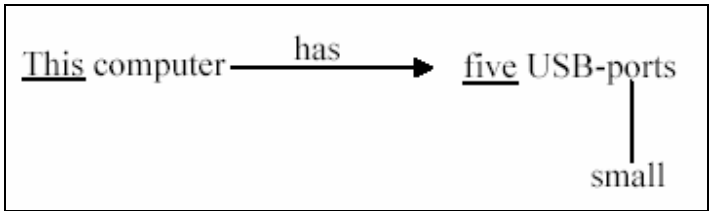


In sentence diagramming, the direct object is separated from the verb by a vertical line without cutting the horizontal base line of the sentence diagram (Reed and Kellogg, 1890).

While sentence diagramming uses slant lines to represent an adjective, STW uses a non-arrow line to connect the adjective with the noun that the adjective modifies.

Note: in sentence diagramming, the adjective '*each*' is put on a slant line connected to the noun that it modifies. On the contrary, in STW, '*each*' is underscored like determiners (a kind of adjectives) such as '*a*', '*the*', etc. In STW, only the adjectives that describe the attributes of the noun will be connected through a straight non-arrow line. All other types of adjectives (such as *a, the, all, each, every, some, none, one,* etc.) will be underscored. The reason why the writers have to underscore the determiners and adjectives such as *all, each, every, some, none, one,* etc. rather than connecting them to the noun through a straight non-arrow line is that, they are very important words for identifying or quantifying the noun. If the writers connect *a, the, each, every,* etc. to the noun they modify through a straight non-arrow line, readers can feel the spatial sentence too counterintuitive. This is unlike sentence diagramming. In sentence diagramming, *a, the, each, every,* etc. are put on a slant line like all other adjectives. This can make sentence diagram counterintuitive to readers (Williams, 1999). That is the main reason why the candidate developed the STW technique, because STW can be more intuitive than sentence diagramming.

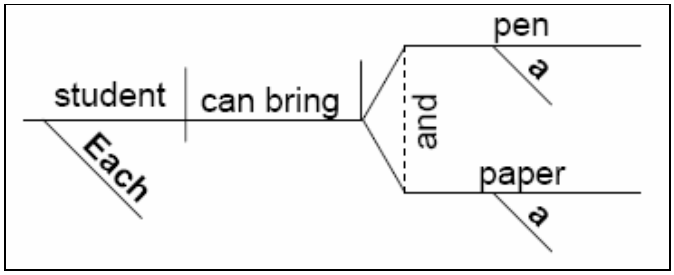
For example, in the sentence, '*This computer has five small USB-ports*'; the adjective '*small*' is connected to the noun '*USB-port*' though a non-arrow line because '*small*' describes the attribute of '*USB-port*'. However, the word '*five*' is also an adjective, but does not describe the attribute of '*USB-port*', so it is underscored.

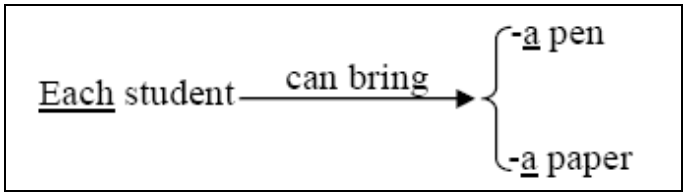


Finally, in STW, unlike sentence diagramming, because ‘a’ or ‘an’ stands next to the noun, so writers have to adhere the grammar rule for the article. For example, ‘a unique address’ is in narrative English, but it will be “an address---unique” in STW because ‘an’ stands right next to the ‘address’. Writers can not just write “a address---unique” because readers may think that the sentence is grammatically wrong.

5 Compound direct objects

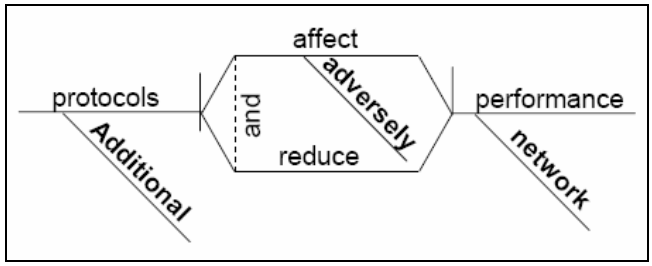
‘*Each student can bring a pen and a paper*’.

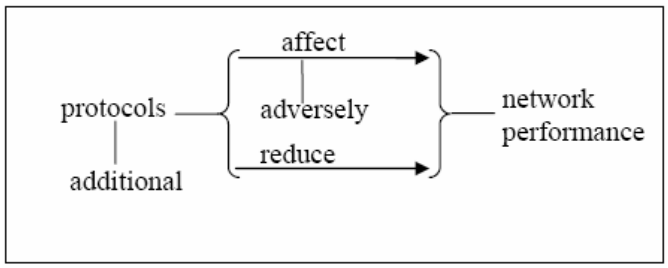




6 Compound predicate with one direct object

‘*Additional protocols affect adversely and reduce network performance*’.



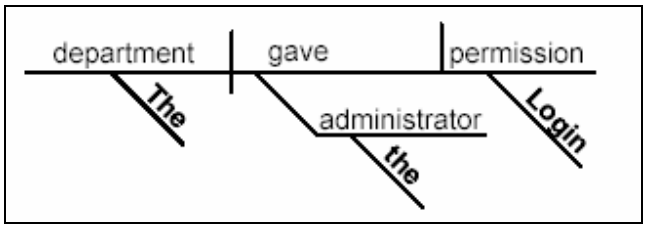


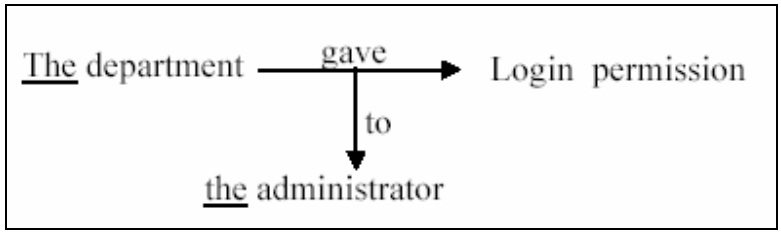
The '*network*' in this sentence is a noun playing a role as an adjective of the noun '*performance*' in the compound noun '*network performance*'.

Note: in sentence diagramming, writers have to represent '*network*' like an adjective. However, in STW, unlike sentence diagramming, the compound noun is considered as one unified word. This helps the readers to think of the compound noun as a whole. This also makes the spatial sentence familiar to readers. The main function of STW technique is to help readers to clearly see the English structure; but STW is not used as a rigorous tool for analysing the grammar, though it can be applied in grammar analysis at a certain level.

7 Indirect object

'*The department gave the administrator Login permission*'.



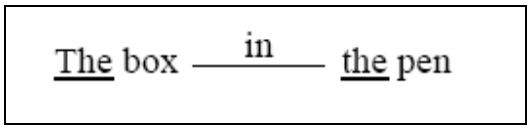


This narrative sentence '*The department gave the administrator Login permission*' is not very clear because '*the administrator Login permission*' is a compound noun, or two separate words. That is, the sentence means '*The department gave the Login permission of administrator*', or it means '*The department gave Login permission to the administrator*'. By looking at the sentence diagram or the spatial sentence, readers will see that '*the administrator*' is an indirect object and '*Login permission*' is a direct object.

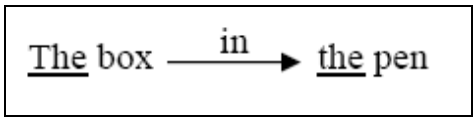
Note: in STW when writers want to represent the structure:
Subject + verb + indirect object + direct object, the writers have to convert that structure to this structure: **Subject + verb + direct object + preposition + indirect object**.

This will make the sentence become clearer in STW. For example, the above sentence has to be changed to '*The department gave Login permission to the administrator*' before it is represented in STW. The preposition '*to*' stands next to the arrow connecting '*gave*' and '*the administrator*'. The simple reason writers have to use arrow to contain the preposition '*to*' with the arrow-head point to the object '*the administrator*' of the preposition '*to*' is that, the arrow can help to direct reading for readers. A second reason is that, a spatial sentence in STW can be read from left to

right, or vice versa from right to left. The readers can misread if writer uses a straight line rather than an arrow. For example, readers can misunderstand if writer spatially writes the phrase '*The box in the pen*' as following:

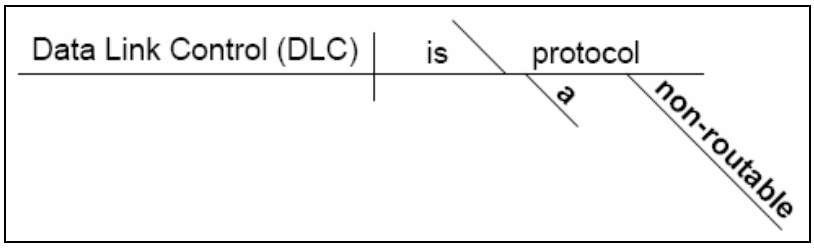


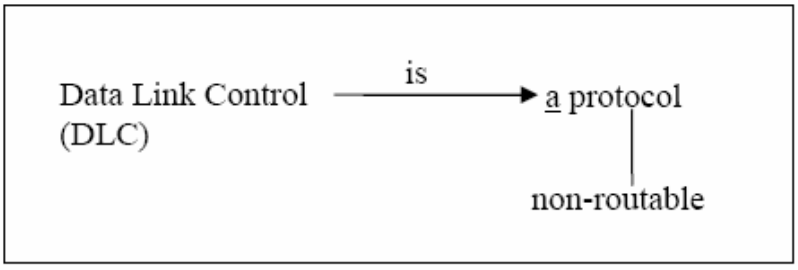
The above spatial sentence is very ambiguous because readers may interpret the spatial sentence as '*The box in the pen*' or '*the pen in the box*'. The ambiguity will be removed if this spatial sentence is represented as following:



8 Predicate noun

'*Data Link Control (DLC) is a non-routable protocol*'.



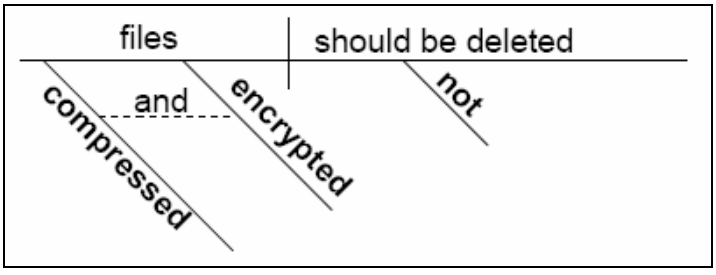


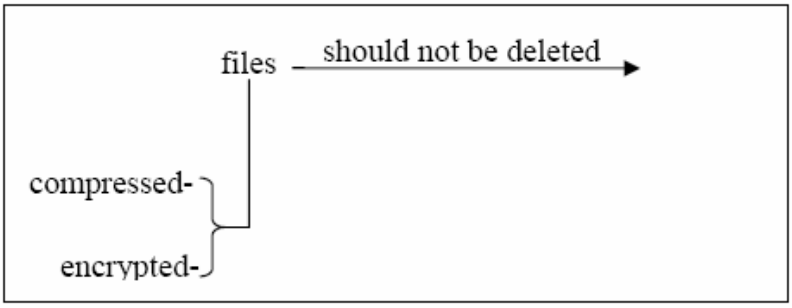
In sentence diagramming, the predicate noun/adjective/prepositional phrase is separated from the copular verb by a line running diagonally, pointing upwards toward the subject as represented in the above first diagram (Reed and Kellogg, 1907).

In STW, the copular verb is treated like other kinds of verbs. That is, the copular verb will be sat on an arrow. The simple reason why the candidate uses arrow to express the copular verb is that, the arrow can help readers to clearly distinguish the S-V-O structure as mentioned early in this current section 3.2.3.1.

9 Compound adjectives

The narrative sentence, '*compressed and encrypted files should not be deleted*' is not very clear because the writer wants to say '*compressed file and encrypted file*', or he just mentions one file '*compressed encrypted file*'. This ambiguity will be removed in spatial sentence, or in sentence diagram.



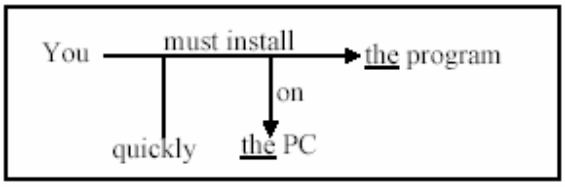


By looking at the above spatial sentence, readers can figure out that the writer is referring to the file with two attributes, compressed and encrypted.

In STW, writers have to use symbol { (brace) or | (vertical line) to contain the compound adjectives or compound adverbs. In the above spatial sentence, a straight line with a perpendicular portion links the noun '*files*' to the brace holding the compound adjectives '*compressed and encrypted*'.

Besides, in the above sentence diagram, the adverb '*not*' will be put on a slant line connecting to the verb '*should be deleted*'. However, in STW, '*should not be deleted*' is treated like a unified verb group.

Note: in STW, all the important adverbs of a verb should **not** be used with a non-arrow line. The important adverbs are the adverbs that if you omit them, then the whole **core** meaning of the sentence will be changed. For example, if the adverb '*not*' above is omitted, then the sentence will have a contrary meaning. All other adverbs which only add more meanings to a verb will be connected to that verb though non-arrow lines. For example, '*quickly*' in '*You must install quickly the program on the PC*' will be represented in STW as the following:

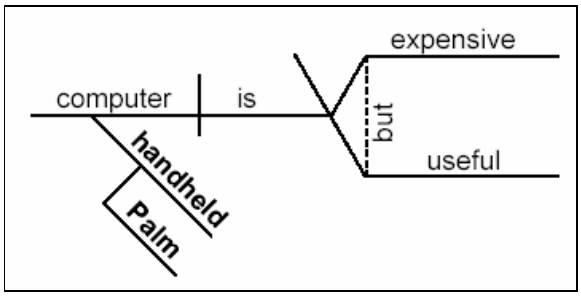


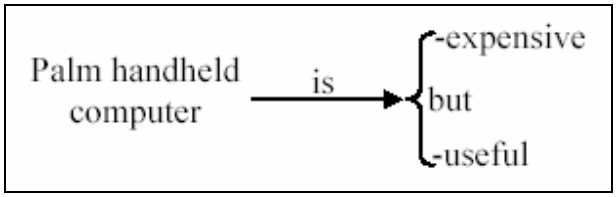
The sentence will not change its ***core*** meaning if you omit the adverb '*quickly*'.

The simple reason that the candidate does not diagram the important adverbs as other adverbs in STW is that, it can make the spatial sentence more intuitive and familiar to the readers. Readers can forget reading some important adverbs if writers diagram these important adverbs by connecting them to the verb they modify through a straight non-arrow line. This is very different from sentence diagramming. For example, readers feel it hard to read the above sentence diagram because the phrase '*should not be deleted*' is separated into '*should be deleted*' and '*not*'; with the word '*not*' linked to '*should be deleted*' through a slant line.

10 Predicate adjective and compound predicate adjectives

'*Palm handheld computer is expensive but useful*'.



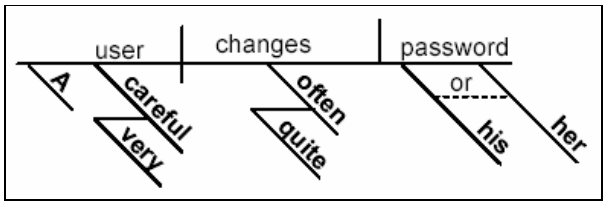


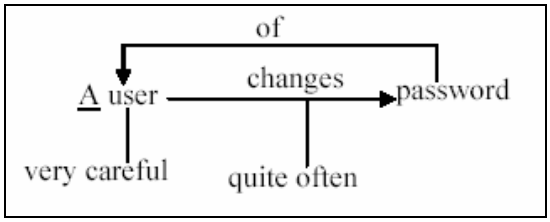
In the above sentence diagram, '*Palm handheld computer*' will be separated into three words in which '*Palm*' modifies '*handheld*' and '*handheld*' modifies '*computer*'. On

the contrary, as mentioned above, the compound noun '*Palm handheld computer*' is treated as a unified noun group in the spatial sentence.

11 Adverbs modifying adjectives, verbs and other adverbs

'*A very careful user changes his or her password quite often*'.





In this sentence, the adverb '*very*' modifies the adjective '*careful*'; the adverb '*quite*' modifies the adverb '*often*'; and the adverb '*often*' modifies the verb '*changes*'.

In the above sentence diagram, '*very*' and '*quite*' are put on a slant line connected and parallel to '*careful*' and '*often*', respectively.

In STW technique, if an adverb modifies an adjective or another adverb such as '*very careful*', '*quite often*', '*rather good*', etc.; then writers will not separate them like in the sentence diagram above; they are seen as a unified word unit. This can make spatial sentence simple and friendly to readers.

Second, in STW, writers don't use personal pronouns (such as *her, his, its,* etc.) or reflexive pronouns (such as *himself, herself, themselves,* etc.) or demonstratives (such as *this, that, these, those*) because STW requires explicit reference. Good spatial technical documents should limit the implications as much as possible. The spatial text technical writers must keep in mind that "*never assume that readers can figure out the writers' implications, the writers must explicit all their thinking as much as possible*".

12 Prepositional phrase with transitive verb

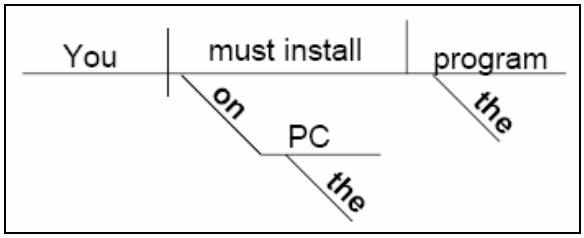
In sentence diagramming, all the modifiers are connected to the words that they modify through a slant line (Reed & Kellogg, 1890). Hence, if the prepositional phrase modifies a verb or noun, the preposition of that phrase will stand on a slant line, connecting it to that verb or noun.

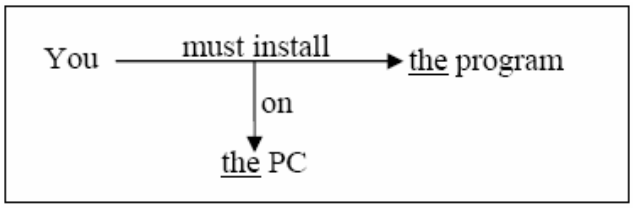
The sentence, '*You must install the program on the PC*' is ambiguous because the prepositional phrase '*on the PC*' modifies the noun '*the program*', or the verb '*install*'. If '*on the PC*' modifies '*the program*', then the writer may imply '*The program was already on the PC and you have to install that program*'. On the contrary, if '*on the PC*' modifies '*install*', then the sentence can mean:

- '*The program is on the CD-ROM outside the PC, and you need to put the CD-ROM into the computer to install*'.

- Or, '*The program was already on the PC and you have to install that program*' like in the case '*on the PC*' modifies '*the program*'.

By spatially writing the sentence, the writer can help readers to figure out what he or she actually means.

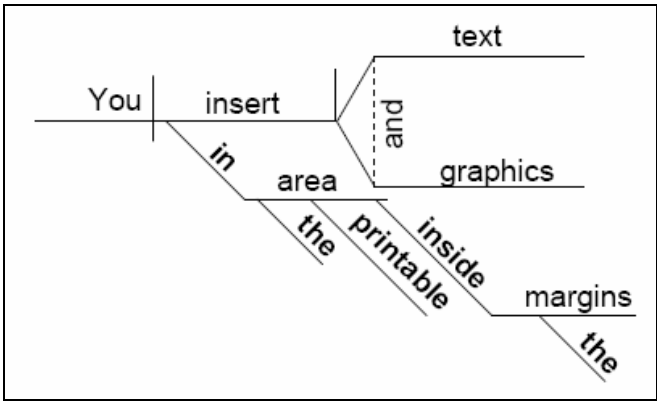


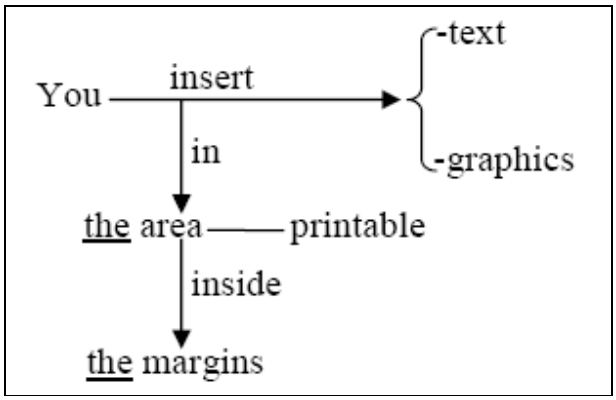


By looking at the above spatial sentence, readers can know that '*on the PC*' modifies '*install*'.

13 Prepositional phrase modifying another prepositional phrase

The narrative sentence '*You insert text and graphics in the printable area inside the margins*' ("Page Setup", 2002) is very ambiguous because '*in the printable area*' plays a role as an adjective phrase that modifies '*text and graphics*', or it plays a role as an adverbial phrase modifying '*insert*'. Likewise, '*inside the margins*' modifies '*the printable area*' or '*insert*'.

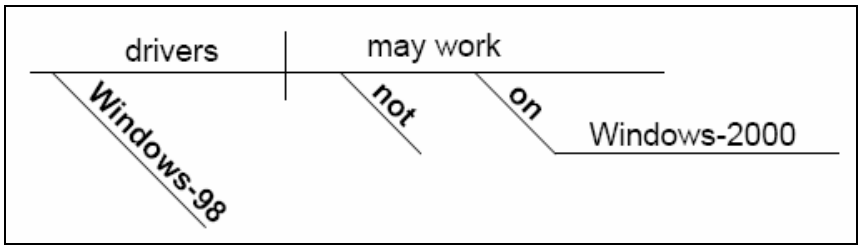


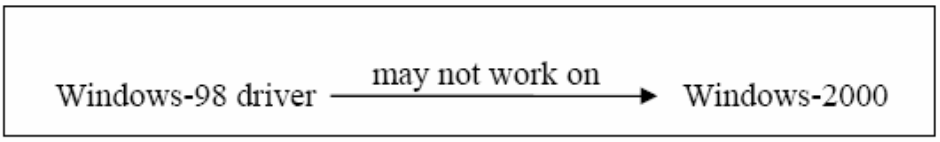


If the writer expresses his or her idea as the above spatial sentence, then readers will know that '*in the area*' modifies '*insert*' and '*inside the margins*' modifies '*the area*'.

14 Prepositional phrase with intransitive verb

'*Windows-98 drivers may not work on Windows-2000*'.



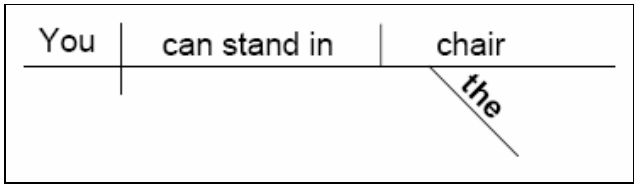


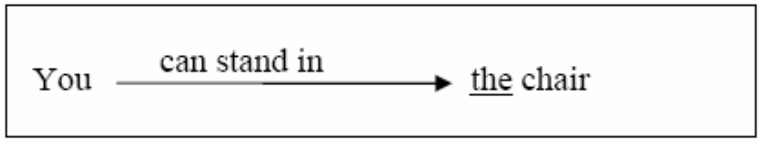
Note: in the above spatial sentence, although the adverb phrase '*on Windows-2000*' modifies the verb '*work*', writers can put the preposition '*on*' to be on the same arrow containing the verb '*work*'. This can make the spatial sentence friendlier to the readers, though that way of representation is not correct in grammar analysis.

15 Phrasal verb

A phrasal verb can have lexical ambiguity. For example, looking at the sentence '*You can stand in the chair*'. Readers can not actually understand what the writer means in this sentence; the writer may intend '*stand in*' to mean '*depute*' and '*chair*' as '*mayor*'.

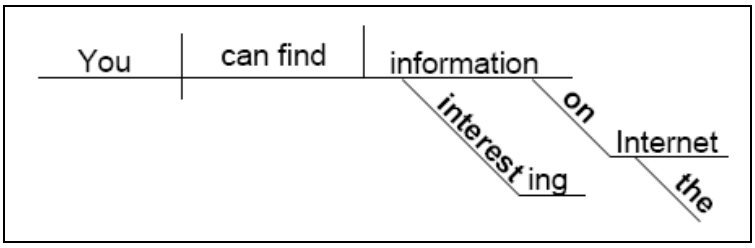
Because technical writing guidelines require using simple and easy words to express ideas, so a phrasal verb should not be used in technical writing. If the writer wants to use a phrasal verb or any word that can cause ambiguity, then he or she should use the dictionary function in STW software to limit the lexical ambiguity. The candidate will discuss later in the "Future Work" chapter how to use the dictionary utility on the STW software to limit lexical ambiguity.

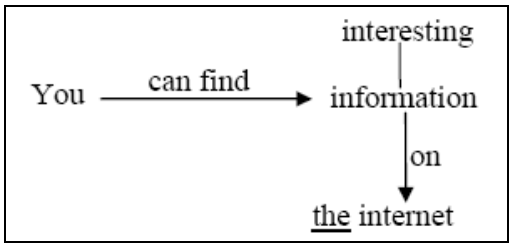




16 Present Participle (PP)

'*You can find interesting information on the Internet*'.

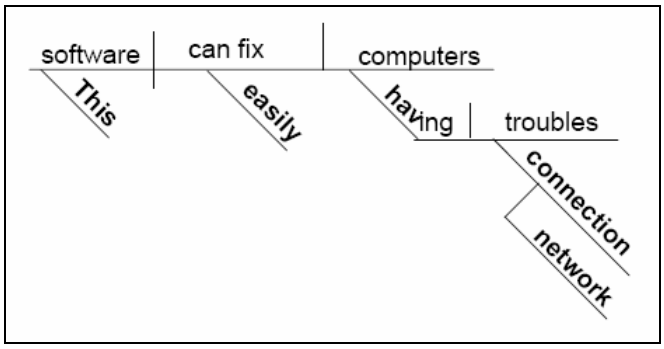


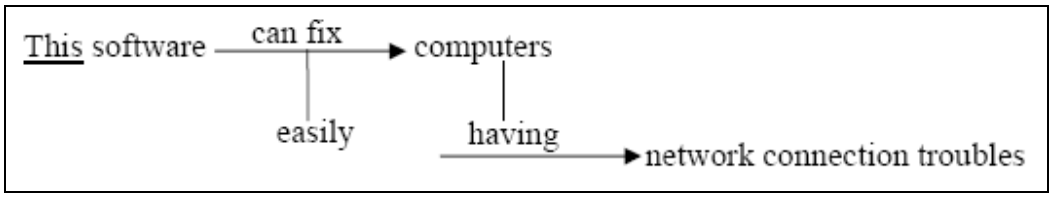


The present participle '*interesting*' plays a role as an adjective modifying the noun '*information*'. *Note*: because the PP '*interesting*' is used as mere adjective, '*interesting*' is diagrammed like a normal adjective in sentence diagramming, except that the part '*ing*' of '*interesting*' is stayed on a horizontal line to show the verbal character of '*interesting*' (Reed & Kellog, 1907). In STW, the PP '*interesting*' is diagrammed like a normal adjective.

17 Present Participle Phrase

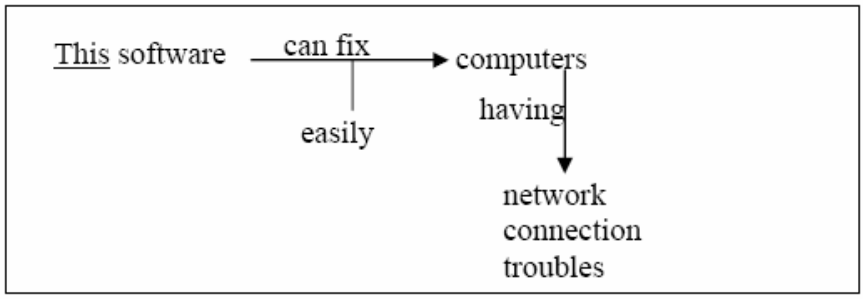
'*This software can fix easily computers having network connection troubles*'.





The present participle phrase '*having network connection troubles*' plays a role as an adjective modifying the noun '*computer*'. The compound noun '*network connection troubles*' is the direct object of the verb '*have*'.

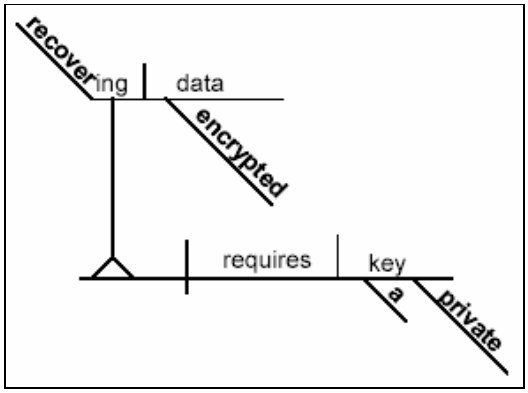
Note: the PP '*having*' is used as both an adjective (because it modifies '*computers*') and a verb (because it has a direct object '*network connection troubles*'). Thus, in sentence diagramming, the first slant part of '*having*' represents the adjective nature of the participle, and the other horizontal part of '*having*' represents the verbal nature of the participle (Reed & Kellog, 1907). Likewise, in STW, '*having*' represents its adjective nature through a straight non-arrow line connecting '*computers*' with itself; and '*having*' is also sat on an arrow to represent its verbal nature. However, to keep the STW sentence simple and friendly to reader, writers can use the shorthand way as following:

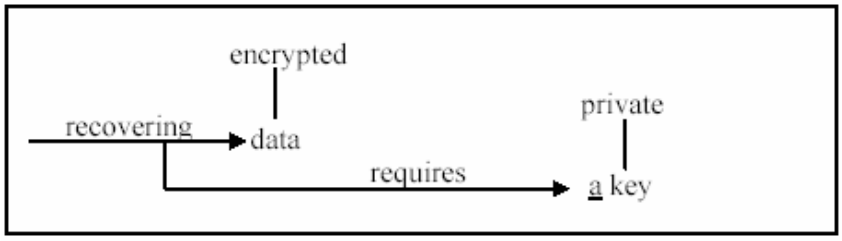


In the above shorthand spatial sentence, '*having*' is sat on an arrow pointing from '*computers*' to '*network connection troubles*'. Thus, instead of drawing an extra straight non-arrow line connecting '*computers*' to '*having*', writers just need to link directly the tail of the arrow to '*computers*'.

18 Gerund phrase as subject

'*Recovering encrypted data requires a private key*'.

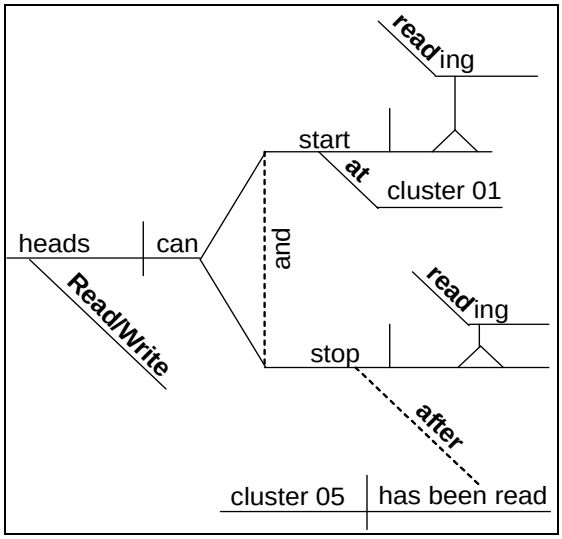


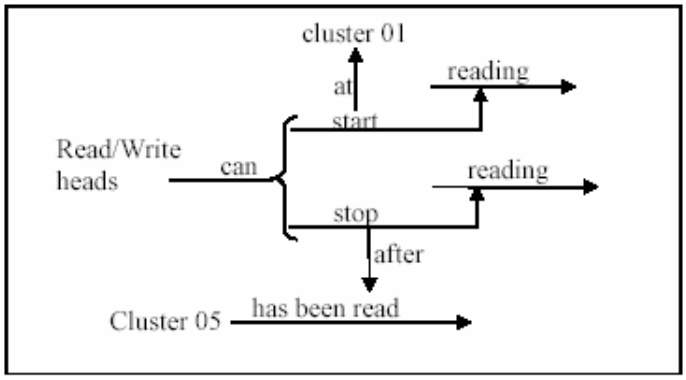


Because the subject of the verb '*requires*' is the gerund phrase '*recovering encrypted data*' and the direct object of '*requires*' is the noun '*key*'. So, in STW technique, '*requires*' stands on the arrow linking from '*recovering*' to '*key*'. The gerund '*recovering*' is used as both a verb and a noun. '*Recovering*' is put on an arrow pointing to '*data*' to express the verbal nature of '*recovering*'. The tale of the arrow containing '*requires*' is linked to the arrow containing '*recovering*' to express that '*recovering*' is a noun and a subject of '*requires*'.

19 Gerund phrase as direct object

The sentence '*Read/Write heads can start reading at cluster 01 and stop reading after cluster 05 has been read*' is ambiguous because readers don't know whether '*at cluster 01*' modifies '*start*' or '*reading*', and '*after cluster 05 has been read*' modifies '*stop*' or '*reading*'. These ambiguities will be removed in sentence diagramming or STW.

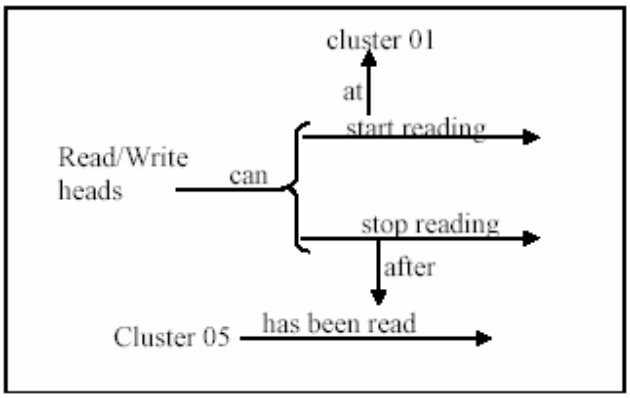




In this case, the above sentence diagram is too complicated and hard to understand. STW is simpler and easier to understand than sentence diagramming, especially with complex and long sentences.

In the above spatial sentence, the gerund '*reading*' is put on an arrow to express that '*reading*' is a verbal noun. The head of the arrows containing '*start*' or '*stop*' are linked to the arrows containing '*reading*' because '*start*' or '*stop*' are verbs of the direct objects '*reading*'. By looking at the above spatial sentence, readers can see that the adverb phrase '*at cluster 01*' modifies '*start*', and the adverb clause '*after cluster 05 has been read*' modifies the verb '*stop*'. By spatially represent the sentence like that, the writer can remove structural ambiguity because the readers can figure out easily which words modify which words.

But the formal representation of the above spatial sentence is too cumbersome; a shorthand way can be used:

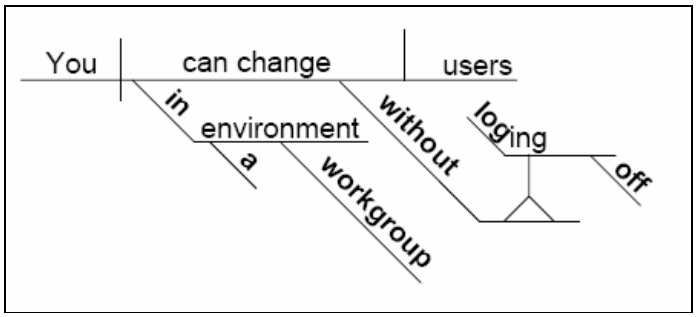


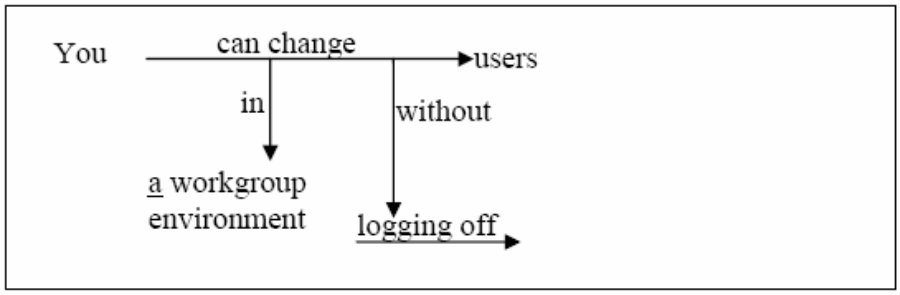
In STW shorthand, '*start reading*' or '*stop reading*' can stand on a same arrow, rather than being separated as in the formal STW. However, writers have to be careful when using STW shorthand. STW shorthand can create ambiguity if writers don't use it properly. For example, in this case, the arrow that contains the linking word '*after*' must link to the verb '*stop*', but not to the gerund '*reading*'; because '*after*' modifies '*stop*', but does not modify '*reading*'. Likewise, the arrow containing the preposition '*at*' must link to the verb '*start*', but not to the gerund '*reading*'; because '*at cluster 01'* modifies '*start*'.

Note: in STW shorthand, adverbs (or adverbial phrases) have to connect **exactly** to the verbs that they modify.

20 Gerund phrase as object of preposition

The sentence '*You can change users without logging off in a workgroup environment*' is ambiguous because readers don't know the prepositional phrase '*in a workgroup environment*' modifies '*change*', '*users*' or '*log*'.

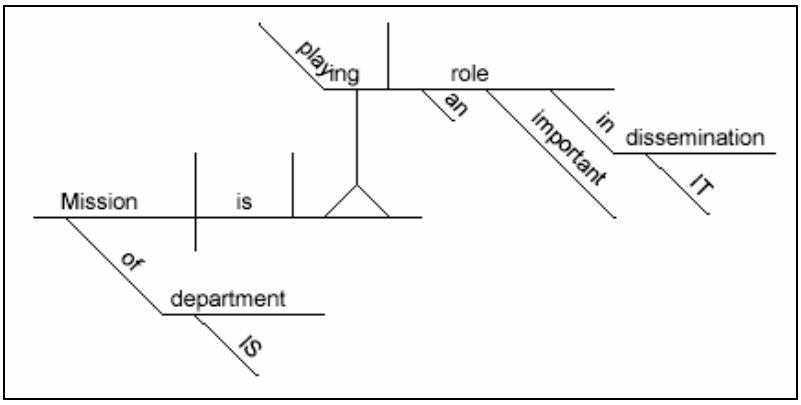


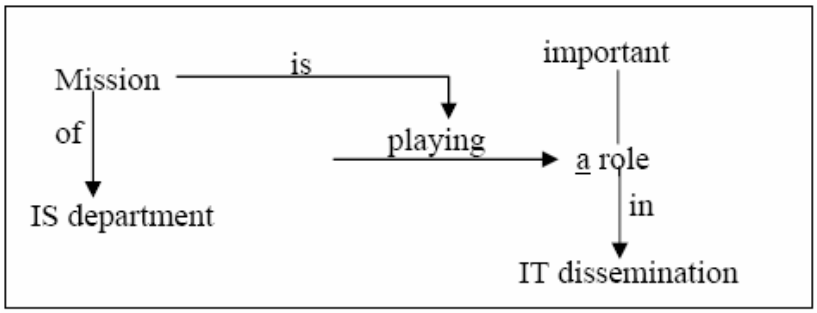


By looking at the STW sentence, readers can see clearly that '*in a workgroup environment*' modifies '*change*'. Note: the gerund phrase '*logging off*' is put on an arrow to express that '*logging off*' is a verbal noun.

21 The gerund as subject complement

The sentence '*Mission of IS department is playing an important role in IT dissemination*' is ambiguous because '*playing*' is a gerund (verb playing as a noun), or a present participle (progressive verb). In this case, because '*mission*' **can not** '*play a role*', so, '*playing*' is a gerund, not a present participle.



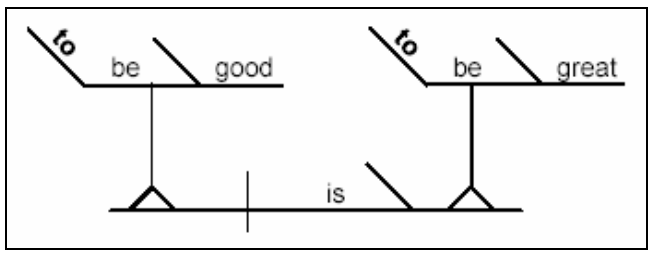


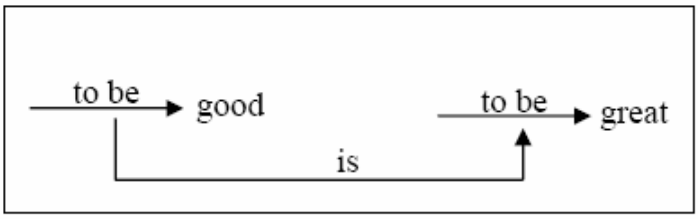
By using STW, writer can create clear grammar structures and remove thoroughly the structural ambiguity.

Note: writers can not use STW shorthand in this case because it will change the meaning of the sentence. For example, writers can not put '*is playing*' on the same arrow because readers may misunderstand '*playing*' as a present participle verb.

22 Infinitive as subject or predicate

'*to be good is to be great*'.

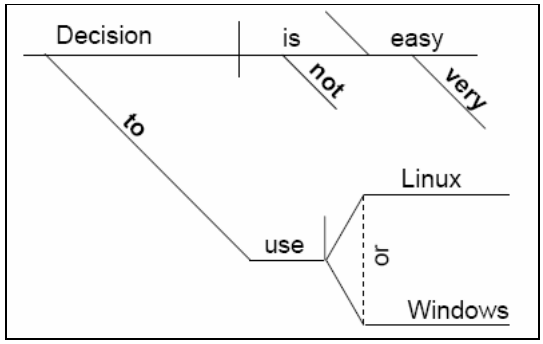


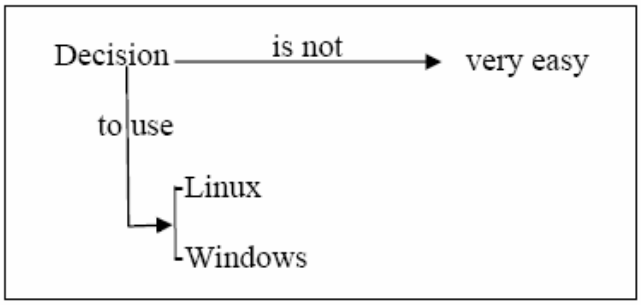


Because infinitive is a verb functioning as noun or adverb or adjective, so writers have to put infinitive on an arrow in STW.

23 Infinitive phrase acting as adjective

'*The decision to use Windows or Linux is not very easy*'.

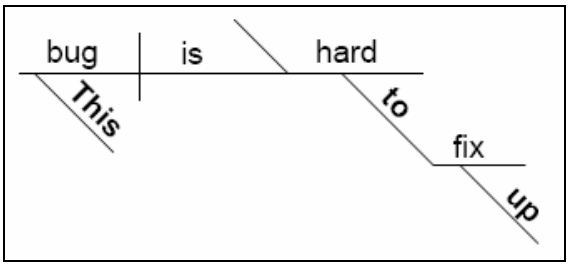


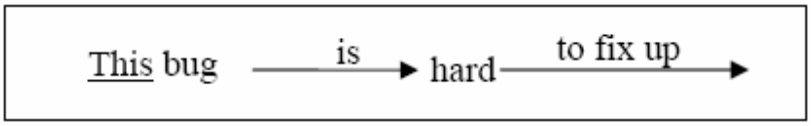


The infinitive phrase '*to use Linux or Windows*' plays an adjective role modifying the noun '*decision*'.

24 Infinitive phrase acting as adverb

'*This bug is hard to fix up*'.



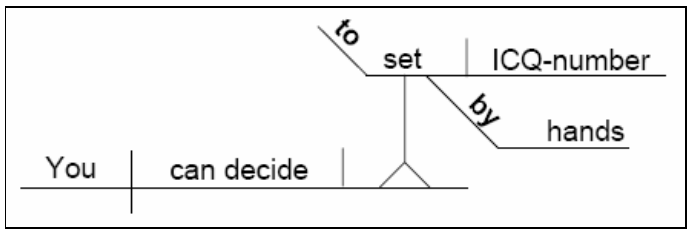


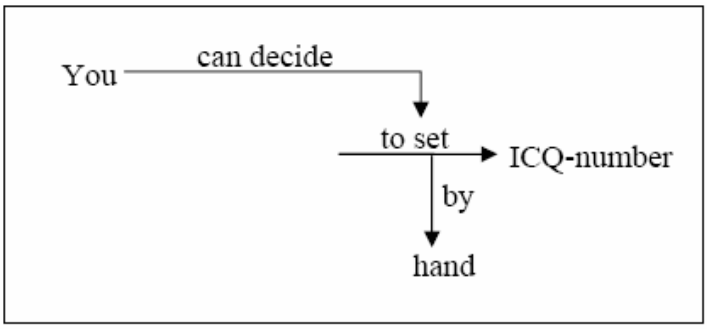
The infinitive phrase '*to fix up*' plays a role as an adverb modifying the adjective '*hard*'.

25 Infinitive phrase as direct object

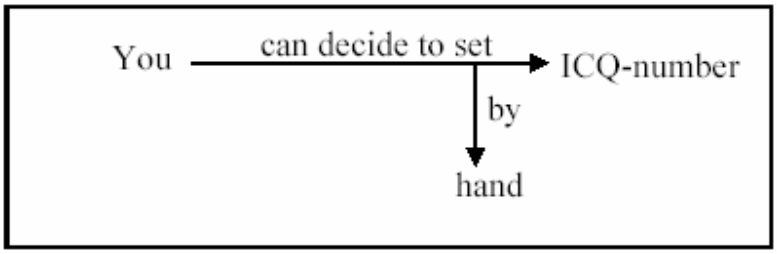
An infinitive can sometimes be ambiguous. For example, '*This theory has failed to explain the facts fully*', so '*fully*' modifies '*fail*' or '*explain*'.

'*You can decide to set IRQ-number by hands*' is ambiguous because '*by hands*' modifies '*decide*' or '*set*'. This sentence can be represented spatially as following:



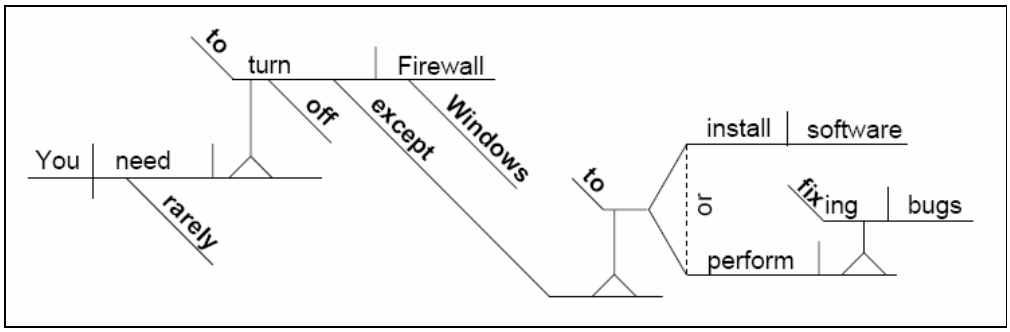


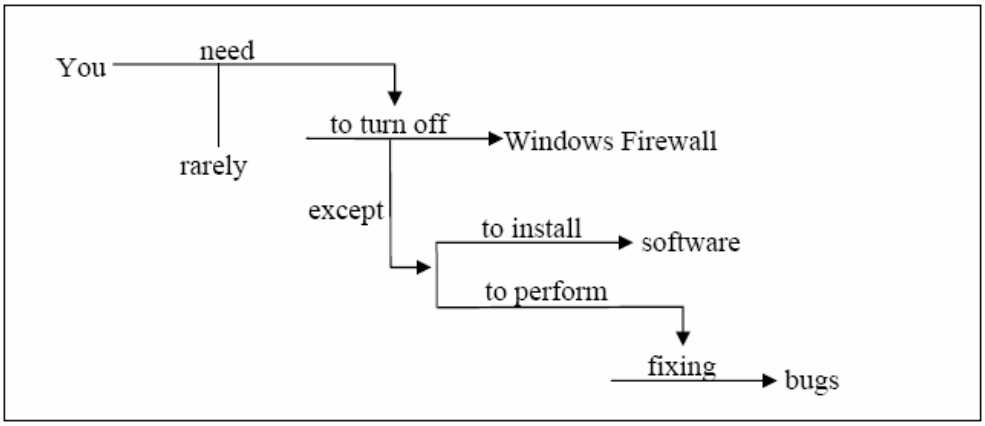
Again, sentence diagramming and STW can remove the language ambiguity that narrative word-after-word sentences do not easily do. The following is the STW shorthand of the above spatial sentence. Remember that the arrow for '*by*' must connect to the verb '*set*' not '*decide*', because '*by hand*' modifies '*set*'.



26 Infinitive phrase as object of preposition

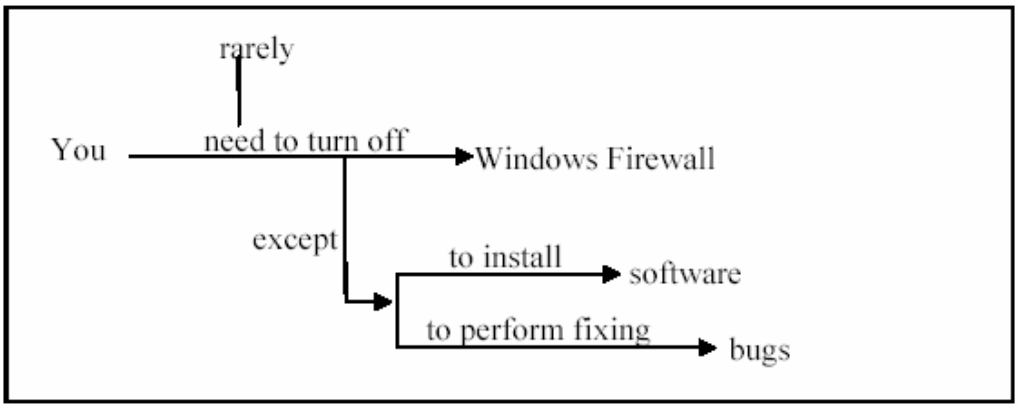
'*You rarely need to turn off Windows Firewall except to install software or perform fixing bugs*'.





The infinitive phrase '*to turn off Windows Firewall*' is the direct object of the verb '*need*'. The prepositional phrase '*except to install software or perform fixing bugs*' modifies the verb '*turn*'. The infinitive phrase '*to install software or perform fixing bugs*' is the object of the preposition '*except*'.

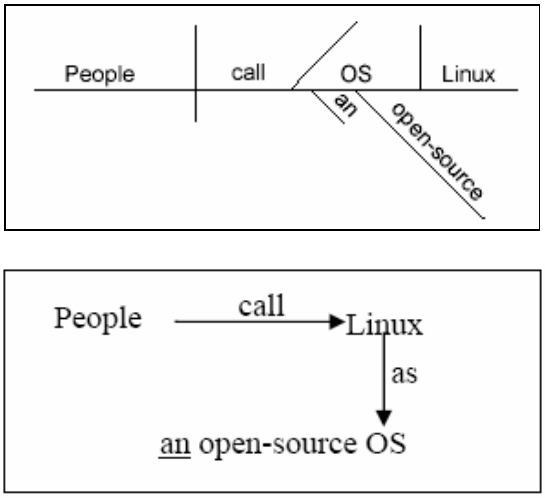
If you want to use the STW shorthand, you need to point the right arrows to the right words. The following is the STW shorthand of the above formal spatial sentence:



27 Objective complement

‘*People call Linux an open-source OS*’.

The noun phrase ‘*an open-source OS*’ is an objective complement of the direct object ‘*Linux*’.

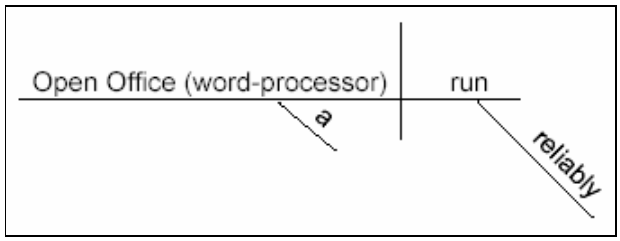


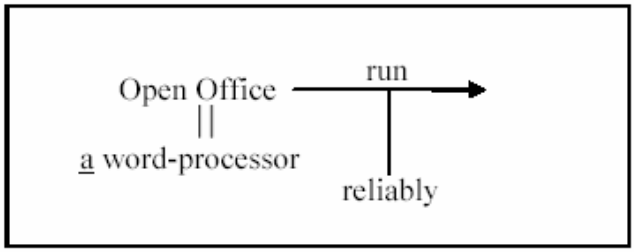
In the above sentence diagram, the objective complement ‘*OS*’ is separated from the verb ‘*call*’, though a line slanting towards the object complement, in order to show that ‘*OS*’ belongs to ‘*Linux*’ (Reed and Kellogg, 1907).

However, to represent these types of sentences in STW, writers have to convert the above sentence to ‘*People call Linux **as** an open-source OS*’, so that they can easily represent the spatial sentence. The preposition ‘*as*’ will stand next to an arrow connecting the direct object ‘*Linux*’ to its objective complement ‘*OS*’.

28 Apposition

'*Open Office, a word-processor, run reliably*'.

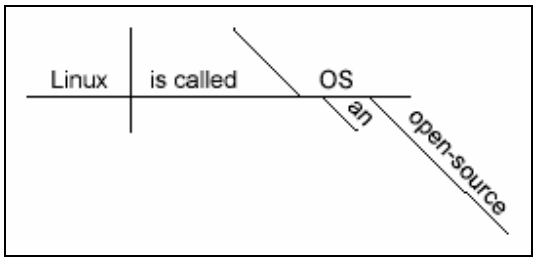


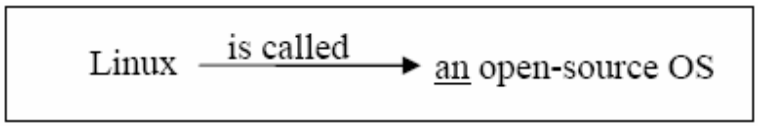


The noun '*a word-processor*' is an apposition of '*Open Office*'. In sentence diagramming, apposition is put inside the parentheses. In STW, the candidate uses the = symbol to express apposition. The = symbol can help readers to think that '*Open Office*' and '*a word-processor*' have the same function and can be permuted each other in a sentence without losing the meaning.

29 Passive Verbs

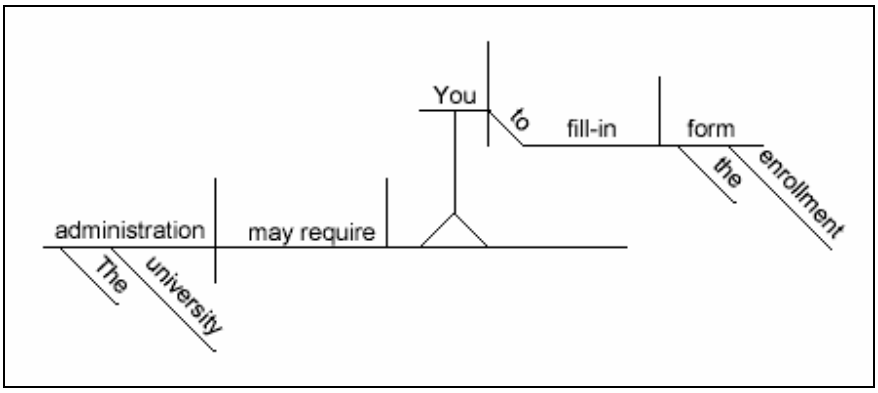
'*Linux is called an open-source OS*'.

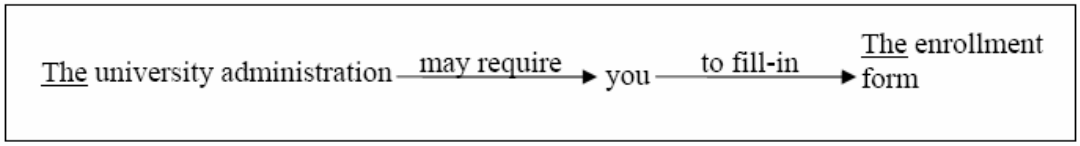




30 Infinitive as objective complement

'*The university administration may require you to fill in the enrolment form*'.

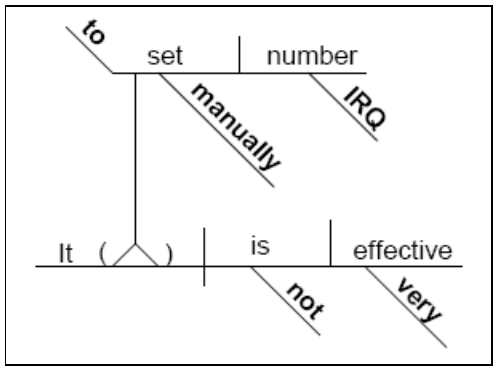


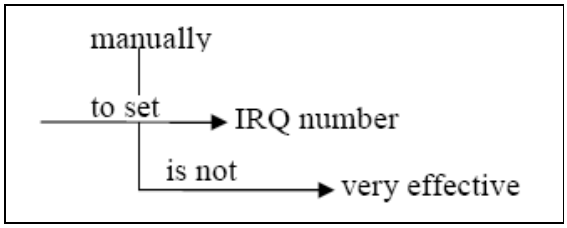


In the above spatial sentence, because '*to fill-in*' modifies '*you*', so the arrow containing '*to fill-in*' has to connect to the direct object '*you*'.

31 Infinitive as Appositive

'*It is not very effective to set IRQ number manually*'.



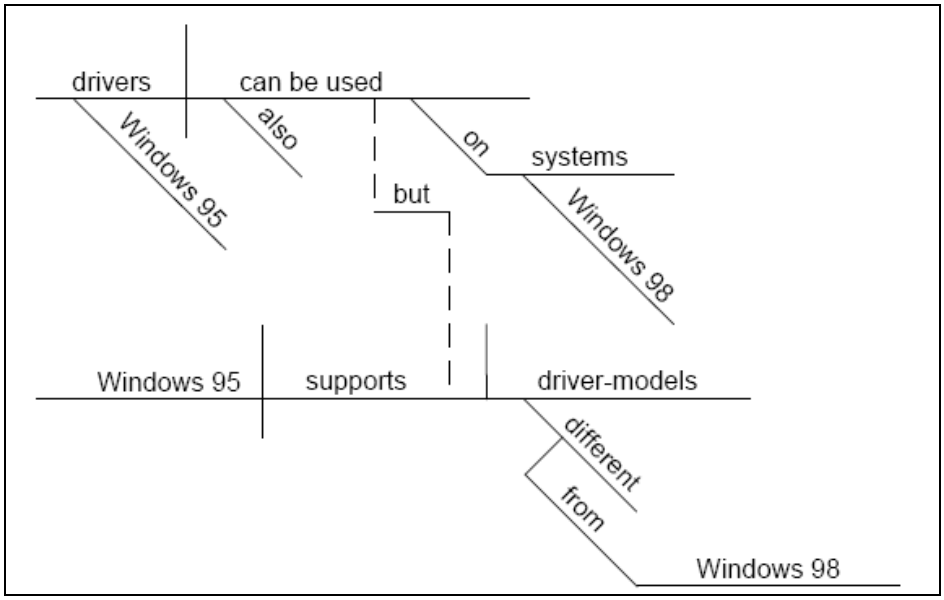


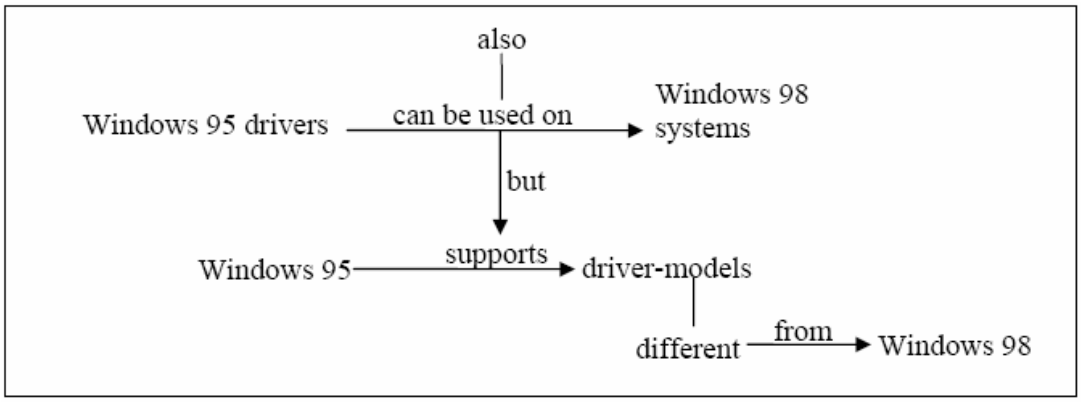
In the above narrative sentence, '*It*' is a substitute for the real subject '*to set IRQ number manually*'. Thus, the above sentence is equivalent to the sentence '*To set IRQ number manually is not very easy*'. This way of English expression is very common in English (Reed and Kellogg, 1907).

However, because STW requires the writer to explicit his/her idea, the writer will not use the substitute '*It*' in STW. The real subject must be put into the beginning of the spatial sentence. In the above spatial sentence, '*to set*' is sat on the arrow to express its verbal nature. The tail of the arrow containing '*is not*' is hooked on the side of the arrow containing '*to set*' to express that '*to set*' is the subject of '*is not*'.

32 Compound sentences

‘*Windows 95 drivers can also be used on Windows 98 systems, but Windows 95 supports different driver-models from Windows 98*’.

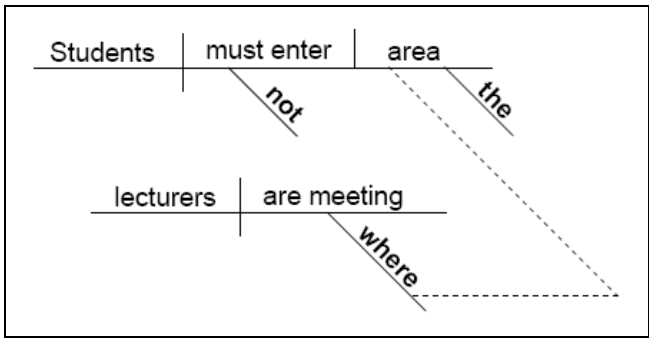


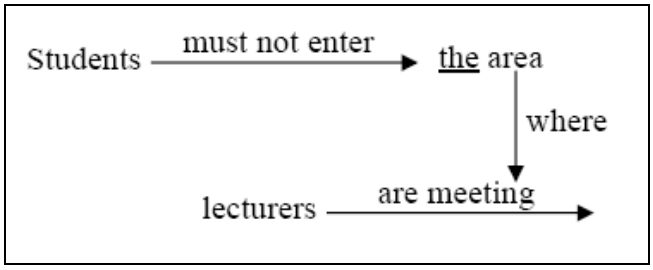


The preposition phrase ‘*from Windows 98*’ plays a role as an adverb modifying the adjective ‘*different*’.

33 Adjective clause

'*Students must not enter the area where lecturers are meeting*'.





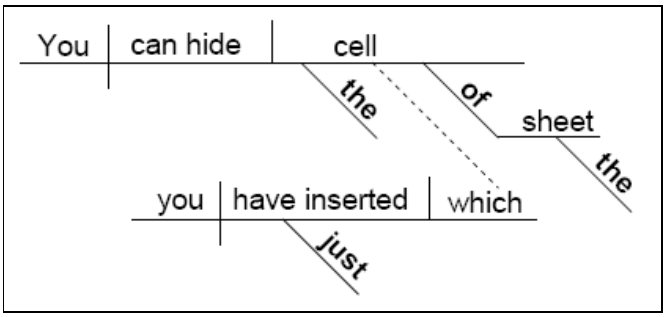
In the above narrative sentence, '*where lecturers are meeting*' is an adjective clause modifying the noun '*the area*'.

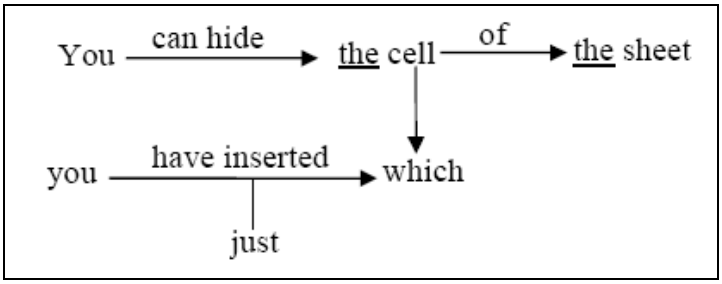
In the above sentence diagram, the line representing '*where*' is made up of two parts. The broken part represents '*where*' as a conjunction connecting the adjective clause to the noun '*the area*'. The unbroken part represents '*where*' as an adverb modifying '*are meeting*'. In this case, because '*where*' performs two functions- a conjunction and an adverb, it may be called a conjunctive adverb (Reed and Kellogg, 1907).

In STW, '*where*' stands next to the arrow connecting '*the area*' to '*are meeting*' in order to show that '*where*' modifies both '*the area*' and '*are meeting*'.

34 Adjective clause introduced by relative pronoun

'*You can hide the cell of the sheet which you have just inserted*'





The above narrative sentence is quite ambiguous because readers don't know whether the adjective clause '*which you have just inserted*' modifies '*the cell*' or '*the sheet*'. However, the ambiguity will be removed if writers diagram or spatially write that sentence. The above sentence diagram or spatial sentence show that, the adjective clause '*which you have just inserted*' modifies '*the cell*' but not '*the sheet*'.

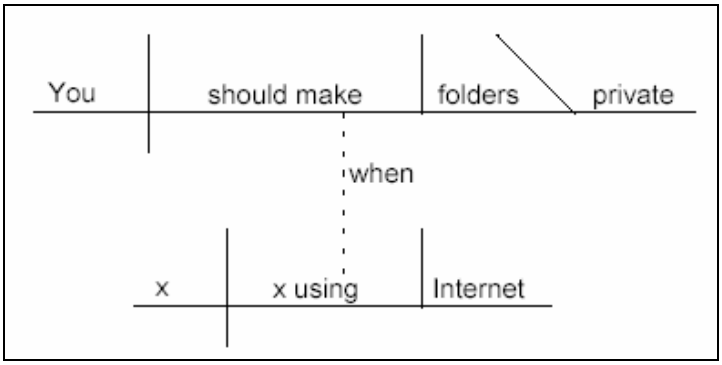
In the above sentence diagram, the pronoun '*which*' stands on the object line of the adjective clause in order to show that '*which*' functions as a direct object of that clause. As modifiers are joined by slanting lines to the words they modify, '*which*' also functions as a conjunction through a slant dotted line that connects '*the cell*' with its modifier '*which you have just inserted*' (Reed and Kellogg, 1907).

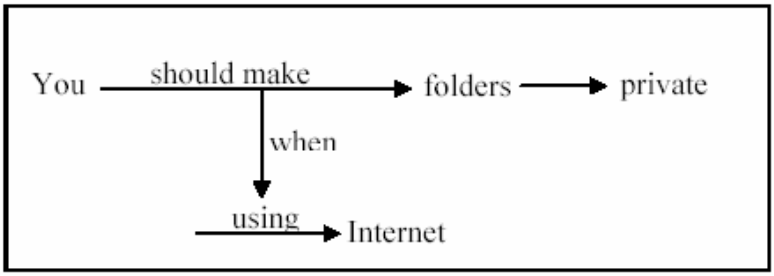
In STW, the first arrow containing '*have inserted*' points to '*which*' in order to show that '*which*' is the direct object of '*have inserted*'. The second arrow points from '*the cell*' to the conjunction '*which*' to show that the adjective clause '*which you have just inserted*' is the modifier of '*the cell*'.

35 Adverb clause

'*You should make folders private when you are using the Internet*'.

The adverb clause '*when you are using Internet*' modifies the verb '*make*'. The adjective '*private*' is the objective complement of '*folders*'.





Note: because '*when using Internet*' is a shorthand of '*when you are using Internet*'; in sentence diagramming, writers have to use the '*x*' to replace these implicated

words. A dotted line holding the adverb conjunction '*when*' connects '*make*' and '*using*' because '*when*' modifies both '*make*' and '*using*'. In STW, the arrow holding '*when*' links from '*make*' to '*using*'.

3.2.3.2 Coordinator 'And' and 'Or' in STW

As mentioned above, word-after-word narrative text represents many flaws that do not effectively limit the structural ambiguity. Unfortunately, current technical documents rely on this loosed structured narrative writing. The candidate will now display another ambiguity problem in the narrative text and how STW can solve this problem. That problem is the ambiguity of coordinator in narrative text.

Coordinators '*AND*' and '*OR*' are words that represent the conjunction or disjunction between words. '*AND*' is called conjunction and '*OR*' is called disjunction (Huddleston, 1988).

"If we join two propositions '*p*' and '*q*' by '*AND*', the resultant compound proposition '*p and q*' will be true if both component propositions are true, and false otherwise" (Huddleston, 1988, p. 195).

For example, the sentence '*Tom and Mary go to school*' will be true (*note*: '*true*' here means '*consistent with fact or reality*') if, and only if, Tom goes to school and Mary also goes to school. The sentence will be false (*note*: '*false*' here means '*not in accordance with the fact or reality or actuality*') if either Tom or Mary doesn't go to school.

Another example: the sentence, '*One teacher was young and energetic*' will be true if '*young and energetic*' are ascribed to the same teacher, whereas in '*One teacher was young and one teacher was energetic*' they are not.

The sentence '*Ed and Pat know the answer*' is logically equivalent to '*Ed knows the answer and Pat knows the answer*'. If only one of them knows the answer, then the sentence is not true.

On the contrary, if we join two propositions '*p*' and '*q*' by '*OR*' disjunction, the result of the compound proposition '*p or q*' will be depended on the disjunction types. There are two types of logical disjunctions- exclusive and inclusive disjunction (Huddleston, 1988).

For the exclusive disjunction, the resultant compound proposition '*p or q*' will be true if and **only if one** of them is true. However, if both of them are true, the proposition will be false. The proposition will also be false if both of them are false (Huddleston, 1988). For example, the sentence '*Tom or Mary goes to school*' will be true if either Tom goes to school or Mary goes to school. If both Tom and Mary don't go to school, then the sentence is not true. If both Tom and Mary go to school, the sentence is still not true.

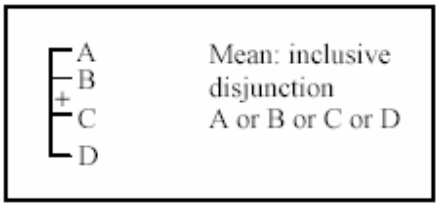
For the inclusive disjunction, the resultant compound proposition '*p or q*' will be true if **at least one** of them is true. If both of them are true, the proposition will still be true. However, the proposition will be false if both of them are false (Huddleston, 1988). For example, the sentence '*Tom or Mary goes to school*' will be true if either

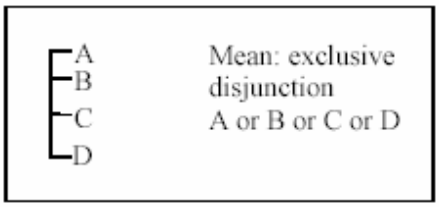
Tom goes to school or Mary goes to school. If both Tom and Mary go to school, the sentence is still true. But if both Tom and Mary don't go to school, then the sentence is not true.

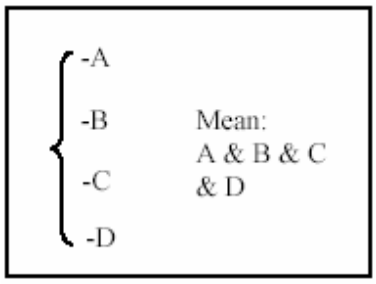
Generally, a reader has to rely on the context to distinguish the exclusive or inclusive disjunction, simply because they share the same pattern (Huddleston, 1988). However, relying on the context to distinguish the exclusive or inclusive disjunction is not suitable for technical document. Technical documents require explicit meanings. STW can help to distinguish the exclusive and inclusive disjunction; the followings explain this.

Representing spatially coordinators 'And' and 'Or' in STW

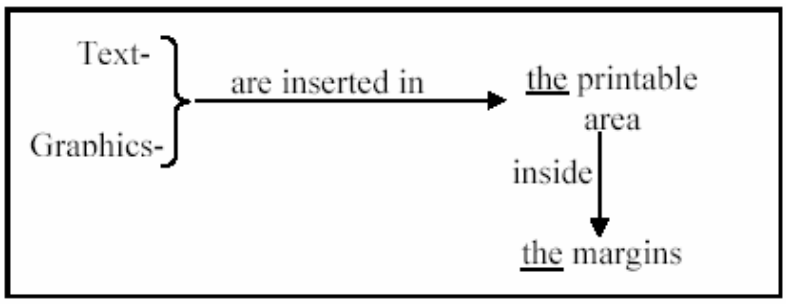
Now, the candidate will discuss how to spatially represent the coordinator 'And' and 'Or'. STW use the symbols { (brace) and | (vertical bar) to spatially represent 'And' and 'Or' respectively. The + symbol is used to refer to the inclusive disjunction; otherwise, it will be the exclusive disjunction.



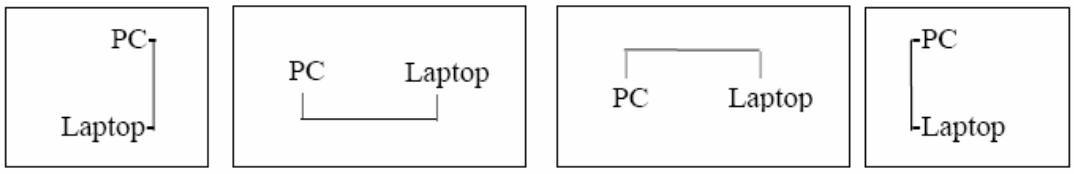




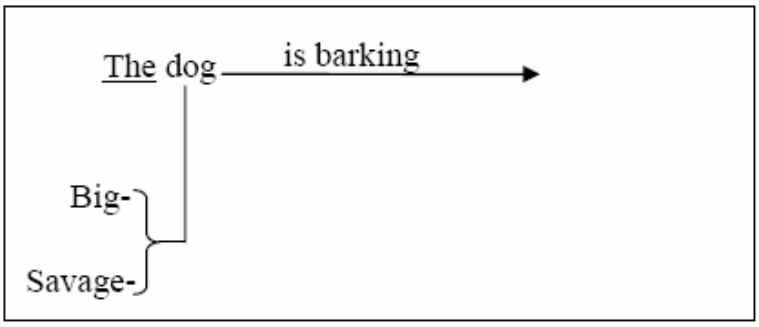
For example, the sentence '*Text and Graphics are inserted in the printable area inside the margins*' should be represented as following:



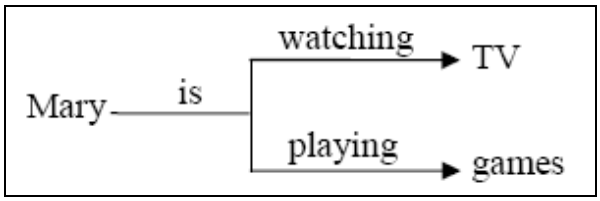
Note: The symbol { or | can be positioned in many different directions. For example, '*PC or Laptop*' can be positioned as:



The symbol { or | can also be used for adjectives or verbs. For example: '*The big and savage dog is barking*' is represented as following:



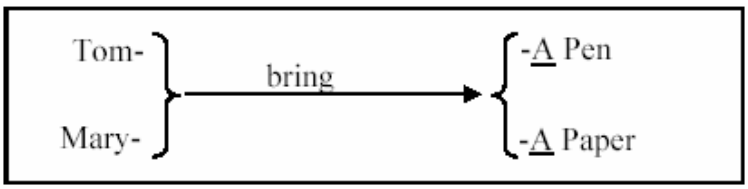
Another example: '*Mary is either watching TV or playing games*'.



The following examples distinguish the conjunction '*And*', inclusive and exclusive disjunction '*Or*':

1 Both subject and object are conjunctions

'*Tom and Mary bring a pen and a paper*':

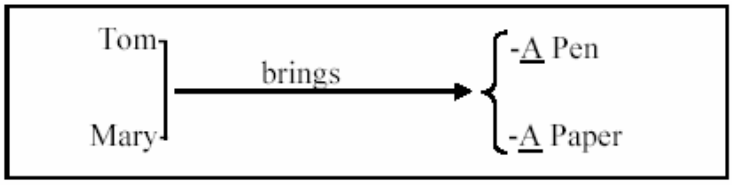


Explanation: if both of them bring both two things, then the sentence will be true. The sentence does not mean, '*Tom brings a pen and Mary brings a paper*' because readers do not know which thing belongs to which person. Readers only know that the two things altogether belong to both of them. Other cases will be false. *Note*: "other

cases" means any combination between the subjects and objects, except the combinations that have been mentioned previously. For example, the "other cases" in the above sentences, such as, '*one of them brings two things*', '*two of them bring one thing*', '*one of them brings one thing*', etc. are false. Only '*both of them bring both two things*' is true.

2 Subject is exclusive disjunction, and object is conjunction

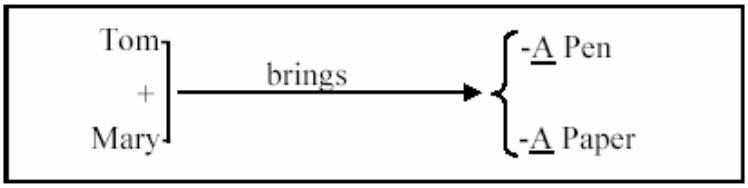
'*Tom or Mary brings a pen and a paper*':



Explanation: if only one of them brings both two things, then the sentence will be true. If both of them bring both two things, then the sentence will be false because it is an exclusive disjunction. Other cases, such as 'one of them brings one thing', 'both of them brings one thing', etc., will be false.

3 Subject is inclusive disjunction, and object is conjunction

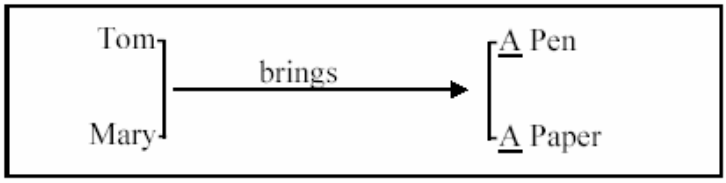
'*Tom or Mary brings a pen and a paper*':



Explanation: If only one of them brings both two things, then the sentence will be true. If both of them bring both two things, then the sentence is still true because it is inclusive disjunction. In this case, '*Tom or Mary brings a pen and a paper*' = '*Tom and Mary bring a pen and a paper*'. Other cases will be false.

4 Both subject and object are exclusive disjunctions

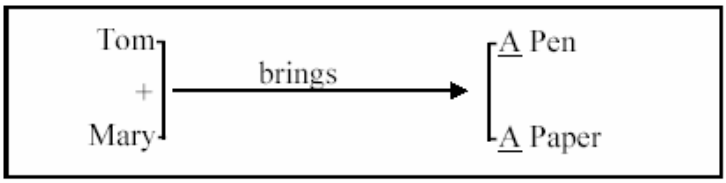
'*Tom or Mary brings a pen or a paper*':



Explanation: if only one of them brings only one thing, then the sentence will be true. Readers also do not know which thing that that person will bring. Other cases, such as 'both of them bring both two things', 'one of them brings both two things', etc., will be false.

5 Subject is inclusive disjunction and object is exclusive disjunction

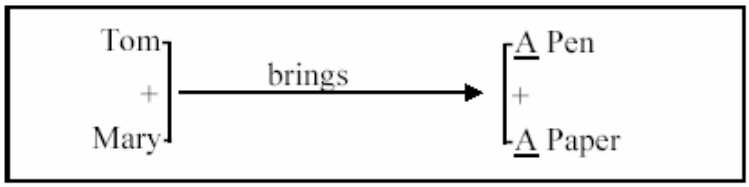
'*Tom or Mary brings a pen or a paper*':



Explanation: if only one of them brings only one thing, then the sentence will be true. If both of them bring only one thing, then the sentence is still true. Other cases will be false.

6 Both subject and object are inclusive disjunctions

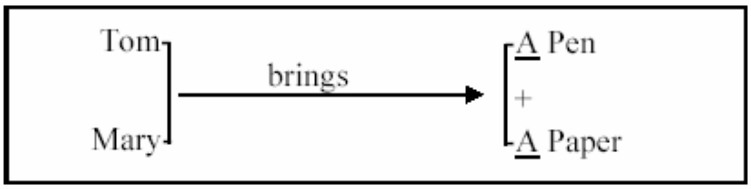
'*Tom or Mary brings a pen or a paper*':



Explanation: if only one of them brings only one thing, then the sentence will be true. If both of them bring only one thing, then the sentence is still true. If only one of them brings both two things, the sentence is still true. If both of them bring both two things, the sentence is still true. In conclusion, all the cases are true.

7 Subject is exclusive disjunction and object is inclusive disjunction

'*Tom or Mary brings a pen or a paper*':

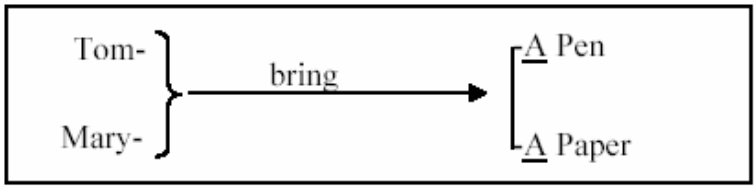


Explanation: if only one of them brings only one thing, then the sentence will be true. If only one of them brings both two things, then the sentence is still true. If both of

them bring only one thing, the sentence will be false. If both of them bring both two things, the sentence will be false.

8 Subject is conjunction and object is exclusive disjunction

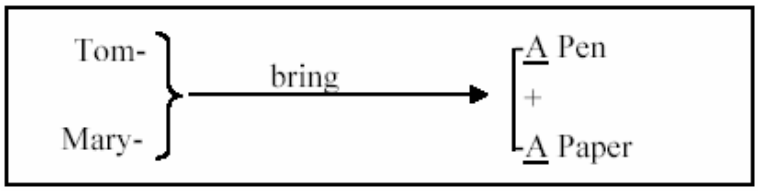
'*Tom and Mary bring a pen or a paper*':



Explanation: if both of them bring only one thing, then the sentence will be true. Readers also do not know which one thing they will bring. Other cases will be false.

9 Subject is conjunction and object is inclusive disjunction

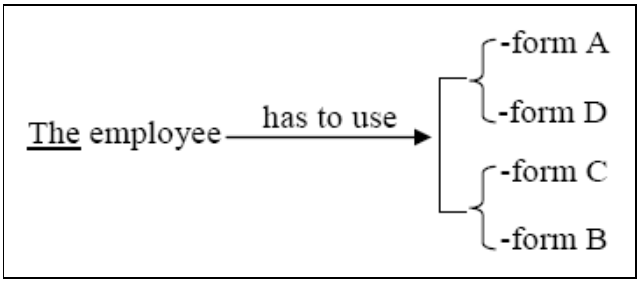
'*Tom and Mary bring a pen or a paper*':



Explanation: if both of them bring only one thing, then the sentence will be true. Readers also do not know which one thing that they bring. If both of them bring both two things, then the sentence is still true. Other cases will be false.

Spatial coordinator representation can be particularly useful in technical documents because the concepts in technical documents need to be clear and unambiguous.

Readers do not depend too much on the context to perceive the meaning. Sometimes, it is not easy to imagine the context. For example, the sentence '*The employees have to use form A and form D or form C and form B*' has structural ambiguity because readers don't know how the writer groups the nouns. By spatially representing this sentence, writers can limit that ambiguity created by the coordinators.

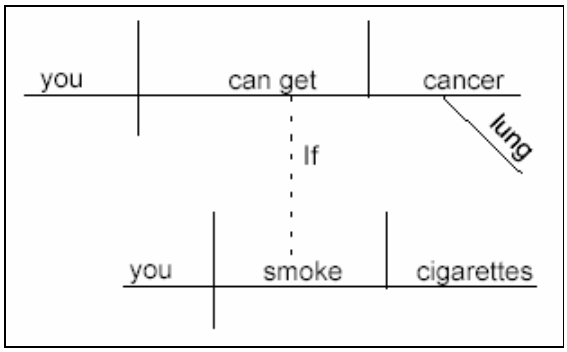


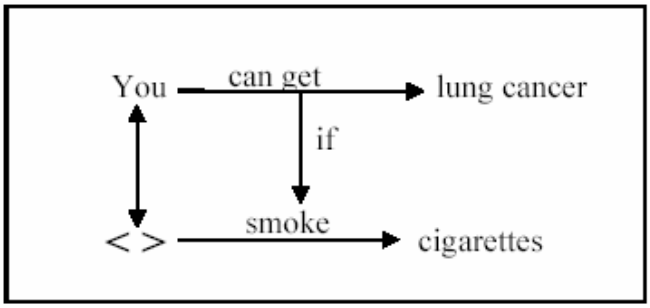
Note: sometime '*And*' and '*Or*' have a different meaning from the coordinator. For example, the sentence '*Ed was late and she was furious*' actually means '*Because Ed was late, she was furious*' (Huddleston, 1988). Thus, one important point to remember: *when writers represent spatially these sentences, writers should not base on the morphology or surface form of the words, but must base our judgements on the real meaning of the sentence.*

3.2.3.3 Condition sentence in STW

The condition sentence represents the relation between a cause and its effect. The following represents the condition sentence in sentence diagramming and in STW.

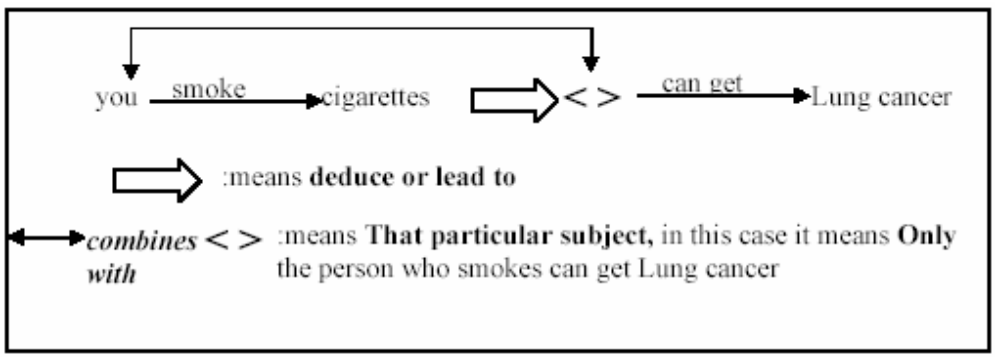
'*If you smoke cigarettes, you can get lung cancer*'.





In the above sentence diagram, '*If*' is stayed near the dotted line connecting '*can get*' and '*smoke*' because it modifies both '*can get*' and '*smoke*'. In the equivalent spatial sentence, '*If*' is stayed near the arrow connecting '*can get*' and '*smoke*'. The arrow head pointing to '*smoke*' helps readers to direct their reading. The second '*you*' is replaced by '<>' and the double arrow connecting the first '*you*' and the symbol '<>' emphasizes that that particular person who smokes cigarettes can get lung cancer.

The following is a second way to represent the above narrative sentence in STW:



In the above spatial sentence, the big arrow connects the 'cause' sentence and the 'effect' sentence. The double arrow line combined with the symbol <> specifies the particular subject in the 'cause' sentence.

The following is a warning message in Windows XP that you sometimes see when you copy a folder on your hard disk to another place:

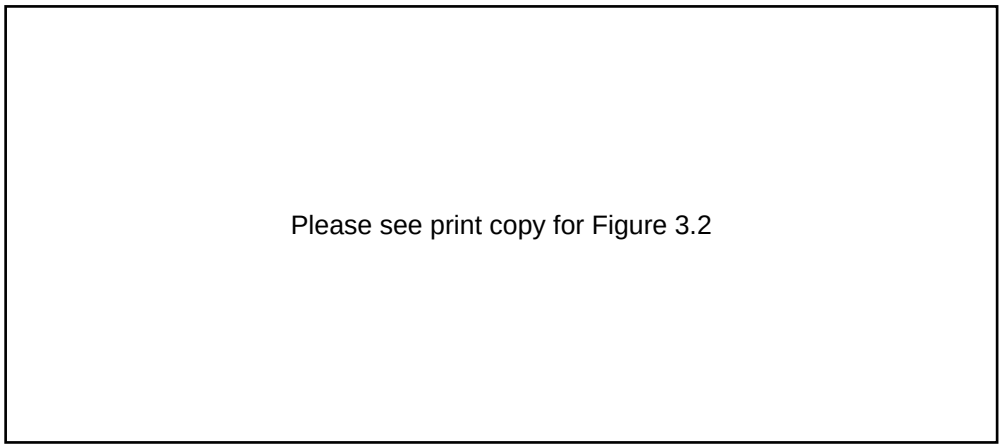
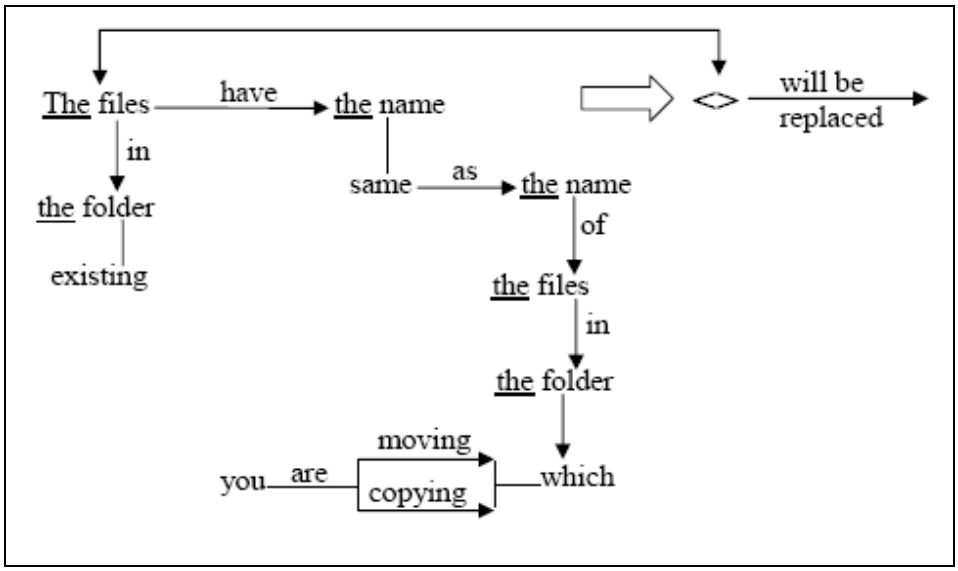


Figure 3.2: A warning message in Windows XP ("Confirm Folder Replace", 2002).

The sentence '*If the files in the existing folder have the same name as files in the folder you are moving or copying, they will be replaced*' in the above warning message, has an reference ambiguity because readers don't know whether the word '*they*' prefers to '*the files in the existing folder*' or '*files in the folder you are moving or copying*'.

Second, some words in this narrative sentence were omitted and understood by the readers. However, because STW requires the writers to explicit their ideas, writers should rewrite this narrative sentence to its fullest form before converting this narrative sentence into a spatial sentence. The above narrative sentence should be

written as following '*If the files in the existing folder have the same name as the name of the files in the folder which you are moving or copying, they will be replaced*'. The following is the spatial sentence of the rewritten narrative sentence:



Note: the adjective '*same*' modifies the first '*name*', and the adverbial phrase '*as the name of the files in the folder which you are moving or copying*' modifies '*same*'. By using the double arrow combining with the symbol <> in the above spatial sentence, writers can help readers to clearly figure out that '*the files in the existing folder will be replaced*' but not '*files in the folder you are moving or copying will be replaced*'. And, thus, writers can thoroughly remove the reference ambiguity.

3.2.3.4 Comparison sentences in STW

Comparison indicates the degrees of similarity or difference between the adjective and adverb. There are two levels of comparison:

1 Equal comparison

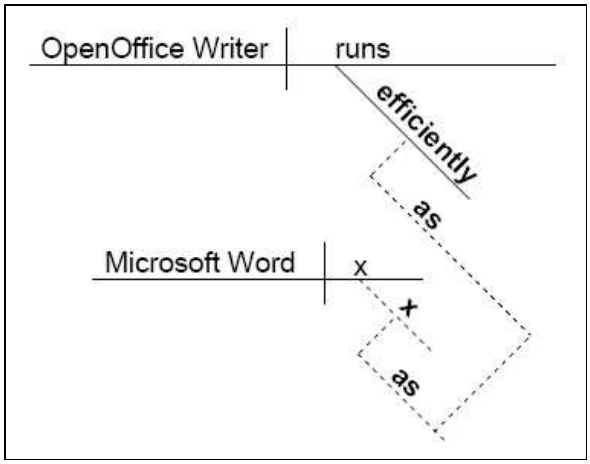
English grammar uses the "as adjective/adverb as" structure to express the equal comparison. The following example illustrates this:

Example 1: '*OpenOffice Writer runs as efficiently as Microsoft Word*'.

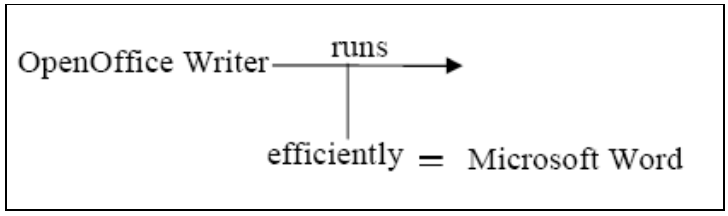
The above narrative sentence can be rewritten to its fullest form as following:

'*OpenOffice Writer runs as efficiently as Microsoft Word runs efficiently*'.

The adverb clause '*as Microsoft Word*' modifies the first '*as*' which is an adverb modifying the adverb '*efficiently*'. The first '*as*' is an adverb because it answers the questions "efficiently to what extent or degree?". The second '*as*' modifies both the first '*as*' and the second omitted adverb '*efficiently*', so it plays role as a conjunction and an adverb. In this case, '*as efficiently as*' means '*efficiently in the degree in which*' (Reed and Kellogg, 1907). The above narrative sentence is diagrammed as following:

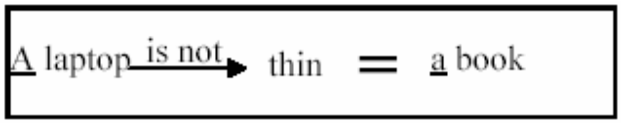


In sentence diagramming, the omitted word is expressed by using '*x*'. The dotted line is used to express the conjunction (Reed and Kellogg, 1907). However, because diagramming the equal comparison structure in English is too complicated and very difficult for a typical reader to understand, the candidate adopted the symbol (=) in STW to replace the "as adjective/adverb as" narrative structure. The candidate uses the = symbol because it can help readers to think about the equal comparison in English grammar. That way of representation is short, simple, and intuitive. The readers can quickly accept this way of representation. The above narrative sentence is written spatially as following:



In the above spatial sentence, the = symbol is put next to the adverb '*efficiently*' and replaces all the symbols that otherwise can be used to represent the structure "*as…as*" as in the above equivalent sentence diagram.

Example 2: '*A laptop is not as thin as a book*' is written spatially as following:



2 Unequal comparison

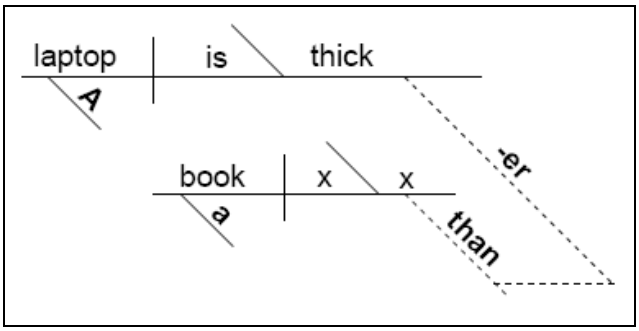
English grammar uses the "-er", "more", or "less" to express the unequal comparison. The following example illustrates this:

Example 1: '*A laptop is thicker than a book*'.

The above narrative sentence can be rewritten to its fullest form as following:

'*A laptop is thicker than a book is thick*'.

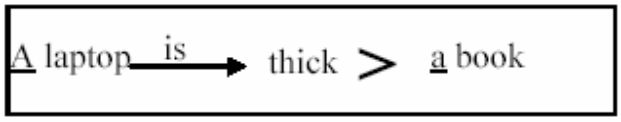
The narrative sentence is diagrammed as following:



'*Thicker*'= '*thick beyond the degree*', '*than*' = '*in which*'. The above narrative sentence equals '*A laptop is thick beyond the degree in which a book is thick*'. '*Is thick*' is omitted after '*than*'. '*Than*' modifies the second omitted '*thick*' and connects the clause '*a book is thick*' to '*thicker*'. '*Than*' is therefore a conjunctive adverb (Reed & Kellogg, 1907).

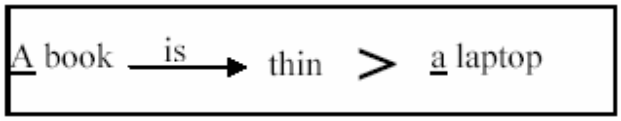
In the above sentence diagram, '*than*' modifies both the second omitted '*thick*' and '*er*' which is an adverb modifying the first '*thick*'. However, that way of diagramming

sentence in English unequal comparison structure is too complicated for a typical reader to understand. Hence, the candidate adopted the symbol (>) for greater comparison and (<) for lesser comparison in STW because they are simple, intuitive and can make readers think about the greater comparison in English grammar. The above narrative sentence is written spatially as following:

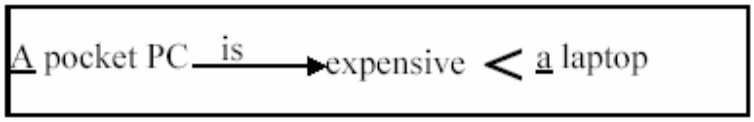


In the above spatial sentence, the > symbol is put next to the adjective '*thick*' and replaces all the symbols that otherwise can be used to represent the structure '*-er than*' as in the above equivalent sentence diagram.

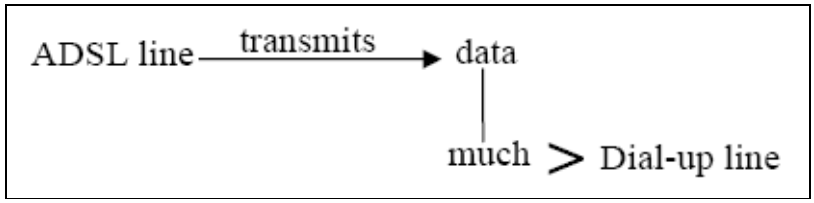
Example 2: '*A book is thinner than a laptop'*.



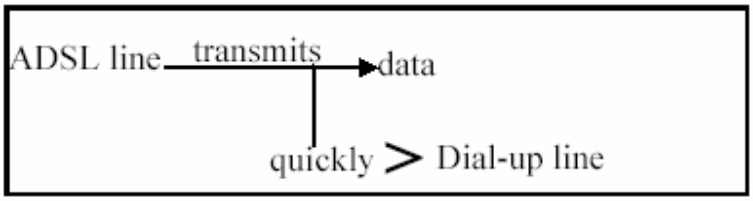
Example 3: '*A pocket PC is less expensive than a laptop*'.



Example 4: '*An ADSL line transmits more data than a Dial-up line*'.



Example 5: "*An ADSL line transmits data more quickly than Dial-up line*".



*Note***:** the comparison symbol (>, <, =) should be put near the word that it modifies.

3 Intensified unequal comparison

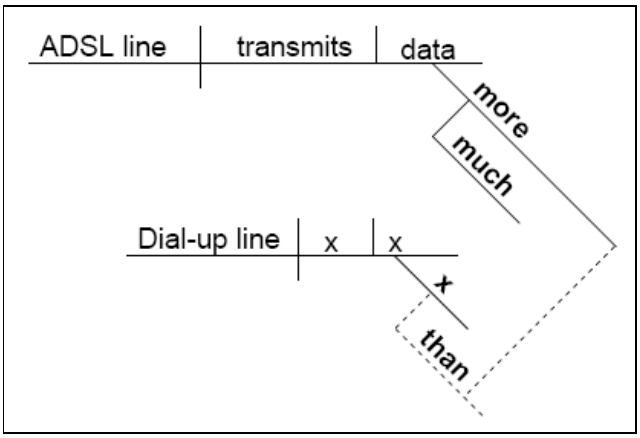
In English grammar, "much" or "far" is put before the unequal comparison to express the intensified unequal comparison. The following example illustrates this:

Example 1: '*ADSL line transmits much more data than Dial-up line*'.

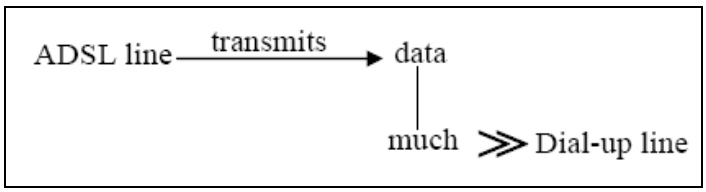
The above narrative sentence can be rewritten to its fullest form as following:

'*ADSL line transmits much more data than Dial-up line transmits much data*'.

The narrative sentence is diagrammed as following:

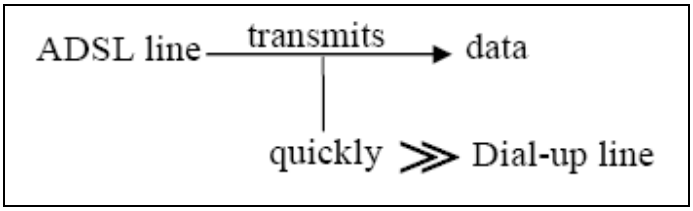


In the above narrative sentence, we can see that the adjective '*more*' is the comparative form of the adjective '*much*'. The first '*much*' word modifying '*more*' is an adverb. The conjunctive adverb '*than*' modifies both the adjective '*more*' and the omitted second '*much*' word which is an adjective. However, that way of diagramming sentences in the intensified unequal comparison structure in English is too complicated for a normal reader to understand. Thus, the candidate adopted the symbol (>>) for the intensified greater comparison and (<<) for the intensified lesser comparison in STW because they are simple and the twofold comparison symbols can make people think about the higher intensive comparison. The above narrative sentence is written spatially as following:



In the above spatial sentence, the >> symbol is put next to the noun '*data*' and replaces all the symbols that otherwise can be used to represent the structure '*much more…..than*'.

Example 2: "*An ADSL line transmits data much more quickly than Dial-up line*".



3.2.3.5 General and specific reference in STW

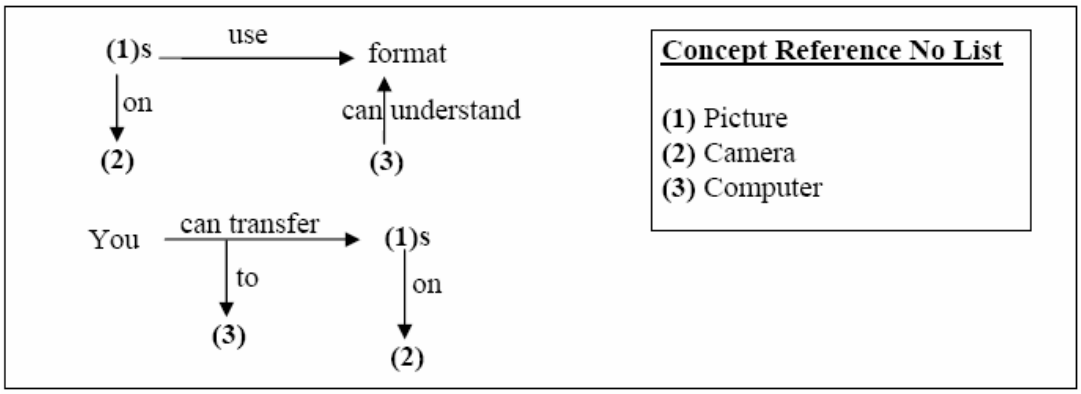
One of the problems of narrative text is the reference ambiguity. For example, the following paragraph has a reference ambiguity because readers do not know whether the phrase '*these clients*' refers to '*Windows NT 3.1 clients*' or '*Windows NT 3.5 clients*' or both:

'*Windows NT 3.1 clients do not support the Point-to-Point Protocol (PPP) introduced in Windows NT 3.5 clients. You can also configure these clients to use scripts that completely automate the logon processes*'.

This problem can be solved by applying reference numbers discussed as following.

That is, each important *Noun* word in STD can be given a reference number.

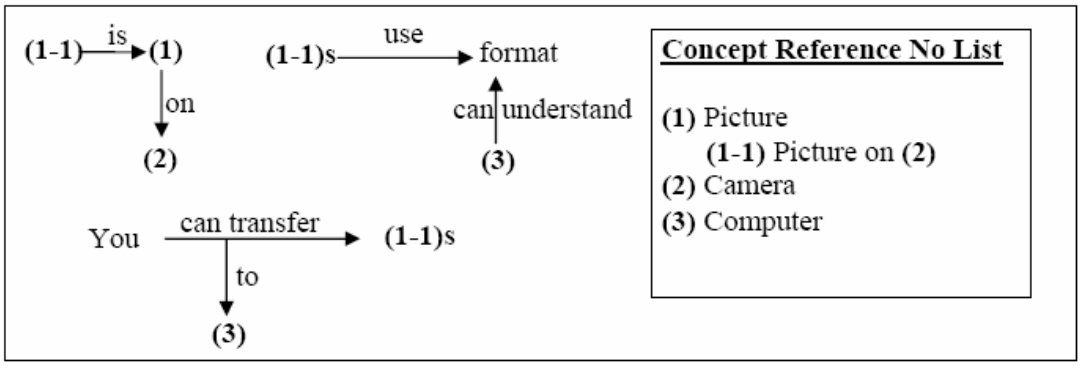
For example, the spatial text (text developed by STW) of '*Pictures on camera use format that a computer can understand. You can transfer pictures on a camera to a computer*' can be represented as following:



Spatial text example 1

In the above spatial text which contains many spatial sentences, all important nouns such as '*picture*', '*camera*', and '*computer*' are given a reference number (**1**), (**2**), and (**3**), respectively. The concept reference number refers to a general noun, for example (**1**) refers to '*Picture*'. If writers want to represent the plural, using **s,** for example (**1**)**s** mean '*Pictures*'. If writers want to represent the singular noun, using 'A or the' with an underscore, for example, '*A* ***(1)***' means '*A picture*'. These reference numbers and general nouns are put into a concept reference number list. A reader just needs to look at this list to figure out what the number refers to. When a writer wants to point to a concept mentioned previously, he/she just needs to create a unique number for that previous concept and then uses that unique number for the sentence he/she wants to write. However, this requires the writer to refer to the right words and the right numbers; otherwise the concept list can make the readers confused.

For example, the sentence '*Pictures on camera use format that a computer can understand. You can transfer these pictures to a computer*' can **also** be represented as following:



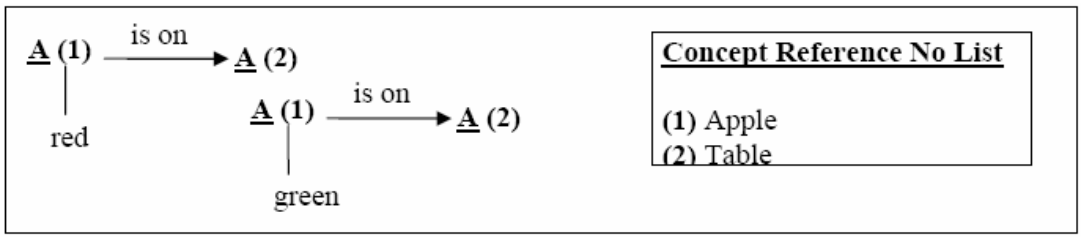
Spatial text example 2

***Note*:** Number (**1**), (**2**), (**3**) in the spatial text example 1 and 2 are called **general reference number** because it just mentions a general concept. For example, **(1)** refers to a general '*Picture*' of any type. On the contrary, number (**1-1**) in example 2 is called a **specific reference number** because it points to a specific concept. (**1-1**) refers only to pictures that are on the camera, no other types of pictures. Normally, in STW, **specific reference number** plays the same role as a noun that goes with a definite article '*the*', or with a demonstrative such as '*this*, *that*, *these*, *those*, or *such*' in a narrative text. The **general reference number** plays the same role as a noun that goes with no article, or with an indefinite article such as '*a*, *an*' in a narrative text.

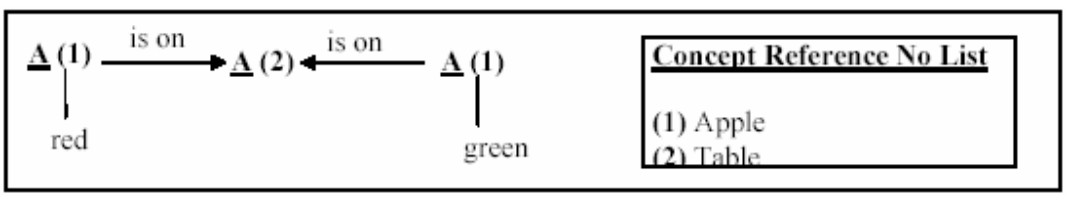
Specific concept reference without number:

Let see the following example of the **specific reference without number**:

Example 1: '*A red apple is on a table. A green apple is on a table*'. There are two tables in this example.



Example 2: '*A red apple is on a table. A green apple is on that (the) table*'. There is only one table in this example.



The example 2 uses a **specific reference without number;** because the arrow points to the specific concept directly, without creating a new specific reference number.

By using reference number in STD, writers can remove the reference ambiguity problem often existing in narrative documents, because each important noun is either tagged with a unique number or referred to a current number mentioned previously. In addition, if this reference number technique can be integrated into the STW software, the readers can have a good tool for manipulating the concepts. The candidate will discuss the STW software in the "Future Work" chapter.

3.3 Exploratory study

As mentioned in Chapter 1, because of the limited research fund, the candidate can not implement a full-scale experiment that will demonstrate thoroughly the research question stated in chapter 1.

Instead, a small exploratory study will be used to test how students reflect to the STW technique. The exploratory study will not test all aspects of the STW technique and research question raised in chapter 1, but it will be used for refining the STW technique later in the future.

The exploratory study uses a pilot experiment based on some basic quantitative and qualitative measurements to identify key issues for further investigation of STW technique in the future.

In the future, a full-scale experiment should be implemented to answer the research question. That full-scale experiment will test whether STW can help to remove structural ambiguity and facilitate the concept manipulation.

The pilot experiment is a combination of a quantitative and qualitative measurements. The quantitative measurement is the main, while the qualitative measurement is the supplement to the experiment. Only relying on one method (quantitative or qualitative) is not good for evaluating the item (Patton, 1980).

3.3.1 Quantitative research

3.3.1.1 What is a quantitative experiment?

A quantitative experiment is an investigation of the relationship between two things (two variables) in which the experimenter manipulates one variable and ascertains the effects of the manipulated variable on the other variable. The experimenter also controls all relevant variables to keep the experiment as truthful and free of bias as possible (Solso & Johnson, 1989).

3.3.1.2 Reason for doing the pilot experiment

As mentioned above, the traditional technical writing technique still suffers from the essential problems of the narrative text, such as language ambiguity and inefficient concept manipulation. The question of this thesis is whether or not it is possible to create a new technical writing technique that has its structure similar to the sentence

diagramming technique, but is simpler for readers to understand, and can help readers to efficiently manipulate concepts in a text like a concept map.

If a new technical writing technique, which has the both advantages of concept map and sentence diagramming, is developed; then people can have a good tool for solving the structural language ambiguity and inefficient concept manipulation problem that exist in the traditional narrative technical document.

The candidate has already developed STW technique which is mainly based on sentence diagramming technique. STW can help to remove the structural language ambiguity in the traditional narrative text. Writers can use STW to create STD. Concepts in STD are graphically and clearly linked together, which can help readers to manipulate efficiently the concepts in STD. However, we still do not know how a typical reader reflexes to STW technique.

Hence, this pilot experiment has been developed to investigate how a typical reader reflexes to STW technique. The pilot experiment will help the candidate to identify key issues of STW technique for further investigation in the future.

3.3.1.3 Definitions of key words

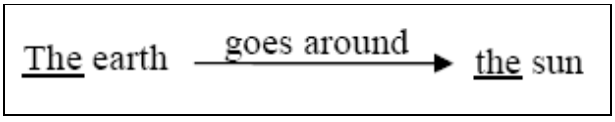
To keep it simple for experiment participants, in this thesis, the candidate uses the phrase ‘narrative text’ (NT) instead of ‘traditional technical writing text’, and ‘spatial text’ (ST) instead of ‘text developed by STW’.

The technical text is the text which is written in an easy-to-be-understood format to facilitate readers in understanding that text quicker.

The narrative technical text uses a word-after-word narrative representation of sentences.

The spatial technical text uses a spatial representation of sentences. It is developed by using STW technique.

For example, the narrative text: '*The earth goes around the sun*'.

The spatial text: 

3.3.1.4 Experiment title

Comparing the reading comprehension performance of readers on a traditional narrative technical text and a novel spatial technical text.

3.3.1.5 Experiment design

This section discusses the experiment design before implementing an actual pilot experiment.

Independent variable (IV): is the variable manipulated by the experimenter (Robson, 1973, p.19). In the pilot experiment, the 'type of technical text' is IV. Because there are two types of text (spatial technical text and narrative technical text), so there will

have two experimental conditions, or two levels of the independent variable (Solso & Johnson, 1989, p.15).

Dependent variable (DV): is "a variable which is observed in order to see whether changes in the IV have any effect on it" (Robson, 1973, p.19). In the pilot experiment, DV is the number of correct answers that subjects can achieve in the reading comprehension test. The reading performance of the narrative and spatial text is compared based on the numbers of correct answers that each subject achieves after finishing the test.

Subjects (S): are people or animals participating in the experiment (Robson, 1973, p. 22). In the pilot experiment, Wollongong University students (not including postgraduate students) are subjects.

Experimental group: "Experimental group of subjects is the group that receives the experimental treatment or manipulated by experimenter" (Solso & Johnson, 1989, p. 15). So, the group who receives the spatial-technical-text test in the experiment is the experimental group.

Control group: "The control group of subjects is treated exactly like the experimental group except that they do not receive the experimental treatment" (Solso & Johnson, 1989, p. 15). So, the group who receives the normal-narrative-technical-text test in the experiment is the control group.

Confounding variables: are variables (other than IV) that can affect the DV (Solso & Johnson, 1989, p. 59). The confounding variables are the subject variables, the order effect variables, the task variables and the environmental variables:

> The subject variables are variables which depend on the characteristics of the subjects. For example, intelligence, gender, ability, background, etc. are subject variables. If one of the two groups has an IQ level higher than the other, then that group may achieve more correct answers. This can distort the experimental result (Solso & Johnson, 1989, p. 61).
>
> Order effect variables are things like practice and fatigue. Previous practice in the repeated-measure design experiment is a confounding variable. If a subject takes two tests in an experiment, the subject can inherit some practical experience in the first test, and then he or she can do better in the second test (Solso & Johnson, 1989, p. 19). The order effect is also caused by human brain characteristics. For example, a student’s brain is quite fresh in the first test, but he/she can feel boredom, fatigue, etc. when he/she starts to do the second one (Robson, 1973).
>
> Task variables are such things as instructions and materials used. The difficulty level of the first test in the experiment group and the second one in the control group is a task variable. The two tests must be **identical** in length, complexity and difficulty. The final result can be distorted if the two tests do not have the same difficulty level (Robson, 1973, p.116).

> Environmental variables are things like the experimental laboratory setting, noise, light, etc. which can affect the experiment result. For example, if the experiment room does not have enough light or is too noisy, then students cannot do the test properly (Robson, 1973, p. 116).

All the confounding variables will be controlled in my experiment. The following section shows that.

Selection of experiment design methods

The candidate will first go through all the experiment design methods and then discuss their advantages and disadvantages. Finally, the candidate will decide which method is suitable for the pilot experiment.

Method 1: Independent-subjects design

All subjects will be allocated randomly into two or more groups based on the experimental conditions (Robson, 1973, p. 23). For example, if 16 subjects are used in the pilot experience, they will be allocated randomly into two groups of eight.

Allocation of subjects in independent-subjects design (Robson, 1973, p. 23):

Spatial Text	Narrative text
S1	S3
S2	S6
S4	S7
S5	S8
S9	S10
S12	S11
S13	S15
S14	S16

The spatial and narrative text will both have the same meaning, except that they have different ways of text representation. The questions in each type of text are the same as the other.

However, the final result of the experiment may not be reliable if this method was chosen, because the subject variables such as intelligence, gender, background, etc. can affect the DV. This kind of experiment error is called a constant error (Robson, 1973, p. 29).

So, the candidate will not choose this method.

Method 2: Matched-subjects design

As a part of the literature review research, it is predicted that gender, computer skill and English ability are subject variables which can affect the dependent variable. The reason is that there is evidences that men's and women's brains treat textual information differently in the reading process (Saltus, 1995). Boys often score lower than girls in reading test, especially in middle and high school (Graham & Hardy, 2006). Thus, gender will be one of subject variables in the pilot experiment. Second, because the computer knowledge is used in the experiment, computer skill will be the second subject variable. People who have more computer skills may achieve a better experiment result, simply because they already know that computer knowledge before. Third, because the experiment questions are written in English, people with different English ability can achieve the different results. Some subjects can misunderstand the questions if they do not have a good English ability.

Subjects are divided into many pairs. For example, 16 subjects can be organized into eight subject pairs.

However, two subjects in each pair must have a similar subject variable. The two members in each pair must be allocated randomly to find out who will take the spatial text and who will take the narrative text (Robson, 1973, p. 25). For example, in the pilot experiment, two women who do not know much about computer skills will be matched into one pair. Two men whose English are their mother tongue will be put into one pair.

In method 2, the spatial and narrative text test will be similar to the method 1. Both have the same meaning, except that they have different ways of text representation.

Allocation of subjects in the matched-subjects design (Robson, 1973, p. 24):

Spatial Text	Narrative text
S1B	S1A
S2A	S2B
S3A	S3B
S4B	S4A
S5A	S5B
S6B	S6A
S7A	S7B
S8B	S8A

S1A stands for subject A in the first matched pair, S1B stands for subject B in the first matched pair, S2A stands for subject A in the second matched pair and so on.

By applying method 2, the constant errors of method 1 can be reduced. However, the subject variable problems still exist in the method 2. That is, the intelligence and experience of each person is unique even though they have the same sex, same

background, and same English ability. For example, if an experimenter wants to have a perfect experiment result in method 2, he/she has to match two same people into one pair. It means they must have the same ability, attitudes, health states, etc. (Robson, 1973, p. 31). This is impossible.

Method 3: Repeated-Measures Design

Repeated-measures design, or within-subject design, "is characterized by each subject being exposed to two or more experimental conditions", or each subject will participate in both groups (Solso & Johnson, 1989, p. 63).

Allocation of subjects in repeated-measures design (Robson, 1973, p. 24):

Spatial Text	Narrative text
S1	S1
S2	S2
S3	S3
S4	S4
S5	S5
S6	S6
S7	S7
S8	S8

By applying this method, the experimenter can gather more data (Solso & Johnson, 1989, p. 64). The experimenter can also solve the complex problem of matching two people who have the same intelligence, characters, etc. as in method 2. So, this method is very robust in terms of limiting the subject variable problem.

However, this method still confronts some other serious problems. That is, previous practice and experience can distort the experiment result in this method (Solso & Johnson, 1989, p. 19). For example, the candidate can not use one spatial text and one

narrative text like method 1 and method 2. In method 1 and 2, both spatial and narrative text will have the same meaning and the same questions, except that they have different ways of text representation. This is because students were already familiar with the meaning of the spatial text and the questions in the first test in the experimental group. In the control group, if they repeated reading the narrative text which has the same meaning as the spatial text, they can answer the questions better because they had experience previously in the first test.

Hence, to solve the previous experience problem in this method, the candidate has to design spatial text and narrative text which both convey two different meanings. And, thus, the questions of the spatial text must be different from the narrative text ones.

However, at this time, another problem arises. That is, how the bias on each type of text can be removed. It will not guarantee that the difficulty level of the spatial text will be equal to the narrative text, simply because the two types of text convey two different meanings.

One more thing, because students will not know how to read the spatial text by themselves, the candidate has to instruct them to distinguish the difference between the two text types and how to read and understand the spatial text. The instruction paper for explaining the spatial text and narrative text will be given to students. The instruction paper will be designed as simply as possible. It will have nothing that can give a hint for students in the test. This will help to limit the task variables mentioned above.

Then, the solution chosen for the pilot experiment is:

Combination of the repeated-measures design and matched-subjects design

The candidate will choose the combination of the repeated-measures design and matched-subjects design for the pilot experiment. The pilot experiment will be implemented as following:

Two sets of test questions were developed. One is called test A, the other is called test B. Test A will contain the narrative text 2 and spatial text 1. Test B will contain the narrative text 1 and spatial text 2.

The spatial text 1 (ST1) and narrative text 1 (NT1) both convey the same meaning; they are just different in their text representation. The multiple-choice questions for ST1 are the same as NT1.

The same is true for spatial text 2 (ST2) and narrative text 2 (NT2). They both have the same meaning, but have different representation. The multiple-choice questions for ST2 are the same as NT2.

Because of limited resources, only 16 students will be recruited from Wollongong University. 16 subjects are a common number of subjects in many similar experiments. The candidate will test the small number of subjects first to see whether or not the experiment meets the significance level before doing experiment with more subjects to collect more accurately data (Robson, 1973, p. 35). Postgraduate students

are not allowed to participate in the experiment because they can sympathize with the experiment purpose.

Students are allocated randomly in the experiment as following.

Spatial Text	Narrative text
S1A-ST1(first)	S1A-NT2(second)
S2A-ST2(second)	S2A-NT1(first)
S3B-ST1(first)	S3B-NT2(second)
S4B-ST2(second)	S4B-NT1(first)
S5C-ST1(first)	S5C-NT2(second)
S6C-ST2(second)	S6C-NT1(first)
S7D-ST1(first)	S7D-NT2(second)
S8D-ST2(second)	S8D-NT1(first)
Etc.	

S1A-ST1: Subject 1 who has characters A, taking the spatial-text 1 test

S1A-NT2: Subject 1 who has characters A, taking the narrative-text 2 test

S2A-ST2: Subject 2 who has characters A, taking the spatial-text 2 test

S2A-NT1: Subject 2 who has characters A, taking the narrative-text 1 test

And so on …

The decision whether S1A will take ST1 or ST2 will be selected randomly.

S1A and S2A are the two subjects of one matched pair.

A, B, C, D or etc. are referred to the shared characters of each subject in one matched pair. For example, A stands for a woman whose first language is English and has a non-computer background; B stands for a woman having English as a second language

and who has a non-computer background; C stands for a man whose first language is English and has a non-computer background; D stands for a man having English as a second language and who has a non-computer background; and so on. As long as two people have the same sex, same background, and same English ability; they will be grouped into one matched pair.

The candidate will now use the counterbalancing technique to limit the **order effect** problem that was created by the repeated-measures design method (Robson, 1973, p. 27). That is, half of the subjects will do the spatial-text test first, and the other half will do the narrative-text test first.

By utilizing the combination of the repeated-measures design with matched-subjects design, the candidate can limit the subject variable problem above, collect more data and limit the order effect problem.

3.3.2 Qualitative research

Only relying on quantitative data can lead to an inaccurate evaluation in studying item. So, it is better if researchers should get more data collection from qualitative research (Patton, 1980). Patton (1980) gave a case example which shows the comparison of two research types as following:

A school in The United State developed an accountability system that can rate the skill of teachers. A questionnaire with 10 closed questions and one opened question is given to teachers to ask them whether or not they like the accountability system. For the closed question (quantitative questions); most teachers say that the system does

not support their teaching jobs and is not useful at all. However, after hearing their own words (the opened questions) about the system, people can see that the main reason teachers do not like the system is because they don't want to be accountable by a machine, not because the system is not useful (Patton, 1980).

This can happen in the pilot experiment. There could be a quantitative result where many students will not get good marks for the spatial text, but they can still think that spatial text is a useful technique. Qualitative measure can help to get more information about the STW technique usability.

The quantitative measures are closed, systematic, the part, countable data, succinct, objective, while the qualitative measures are opened, holistic, the whole, collected data is quite long, subjective and can not count as a number. The purpose of open-ended question is to capture the point of view of the participants without forcing them to answer the predetermined questions of the researchers. Generally, qualitative research aims to find out what participants say about the being-studied item ‘in their own words’ in a certain research or experiment. Quantitative data consists of "detailed descriptions of situations, events, people, interactions, observed behaviours, direct quotations from people about their experiences, attitudes, beliefs and thoughts; and excerpts or entire passages from documents, correspondence, records, and case histories" (Patton, 1980, p. 22).

Unlike quantitative research which collects the answers of closed questions, direct quotations are a basic source of raw data in a qualitative measurement (Patton, 1980).

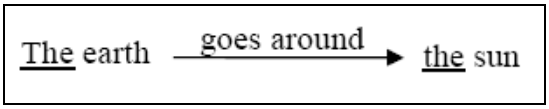
Although participant observation is the most comprehensive in qualitative research (Patton, 1980); the candidate only collects the qualitative comment data of participants, but the candidate will not collect the participant observation data in the pilot experiment due to the limitations of research time and budget.

Beside, the comparison between ST and NT is complicated because the DV is affected by so many confounding variables. A small number of quantitative questions will not help researcher to see depth in the matters. Qualitative research looks at problems at a whole with the assumption that nothing is trivial and that everything has a potential for giving a clue that can help to understand more thoroughly the issues being studied (Bogdan & Biklen, 1998).

3.3.3 Experiment instrument

As mentioned above, there will have test A and test B in the pilot experiment. Test A contains NT2 and ST1, test B contains ST2 and NT1. ST1 and NT1 both convey the same meaning; but they are different in their text representation. For example:

The normal narrative text: '*The earth goes around the sun*'.

The equivalent spatial text: 

All the words, grammar structures, tenses, prepositions, etc. in the spatial text will be exactly like the words, grammar structures, tenses, prepositions, etc. in the narrative text. The only difference is the way of representing the text. No extra words or hints

will be added into the spatial text. This will keep the experiment bias free as much as possible. The length of the spatial text may be a bit longer because it occupies more spaces, but its meaning is the same as the narrative text's. The multiple choice questions for ST1 are the same as NT1.

The same is true for ST2 and NT2. They both have the same meaning but have different representation. The multiple-choice questions for ST2 are the same as in NT2.

The length of NT1 and NT2 will be kept the same. It means half of an A4 page. The instruction paper will explain how to read the narrative and spatial sentences which students might see in the test. As mentioned above, no hints will occur in this instruction paper. The meaning of the examples in the instruction paper will completely differ from the ones in the actual test.

Note: the section "Development of STW technique" concentrates on displaying only one statement at a time, because that section only shows how to write spatially many different types of English grammatical structures. However, as mentioned elsewhere in the thesis, STW can be used to replace the traditional word-after-word writing. That means the writer will write spatially all the sentences in a document in STW format. The final output of this process will be the STD which consists of all spatial sentences written by applying STW.

The knowledge of the text used in the test is synthesised from some areas in Windows 2000 Help. The narrative text containing that computer knowledge is not copied

directly word for word from the Windows 2000 Help, but is written in a very structured format layout that looks similar to the equivalent spatial text. The simple reason is that, if the narrative text and spatial text do not match each other, the experiment can be unfair because the spatial text is too structured while the narrative text has a weak-structured.

The following section explains carefully NT1 and its equivalent ST1.

This is the technical narrative text 1:

Volume has 2 types: basic volume & dynamic volume. Volume is formatted with FAT or FAT32 or NTFS.

Basic volume has 5 types:
-System partition
-Boot partition
-Primary non-system partition
-Extended partition
-Logical drive

Basic volume can not be extended.

Dynamic volume has 5 types
-Simple volume
-Spanned volume
-Striped volume
-Mirrored volume
-RAID-5 volume
    *Simple volume has 3 types:
        +Simple system volume
        +Simple boot volume
        +Simple non-system volume

If Basic volume is upgraded to Dynamic volume, then:

> System partition & Boot partition in basic volume will become Simple system volume & Simple boot volume in dynamic volume respectively. Both Primary Non-system Partition or Logical Drive in basic volume will become Simple non-system volume in dynamic volume. These simple system volume, simple boot volume & simple non-system volume can be installed W2K, but they can not be extended.

If dynamic volume is formatted with FAT or FAT32, that dynamic volume can not be extended.

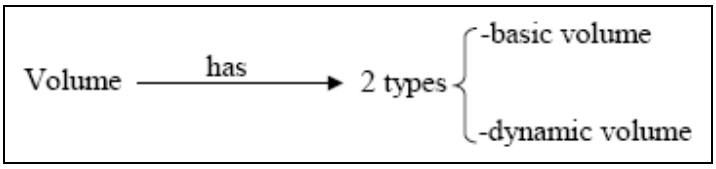
Simple non-system volume, Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can be created in Dynamic volume.

Spanned volume can be extended. Striped volume, Mirrored volume & RAID-5 volume can not be extended. Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can not be installed W2K.

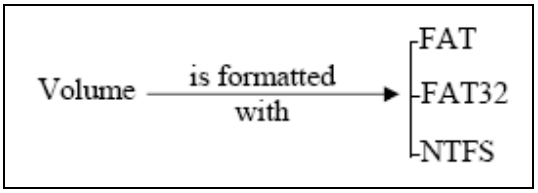
If Simple non-system volume is created in Dynamic volume, then that Simple non-system volume can be extended but can not be installed W2K (revised Dynamic Disk in Windows 2000 Help).

The following shows the equivalent spatial sentence of each narrative sentence in NT1:

Sentence 1: '*Volume has 2 types: basic volume & dynamic volume*'.

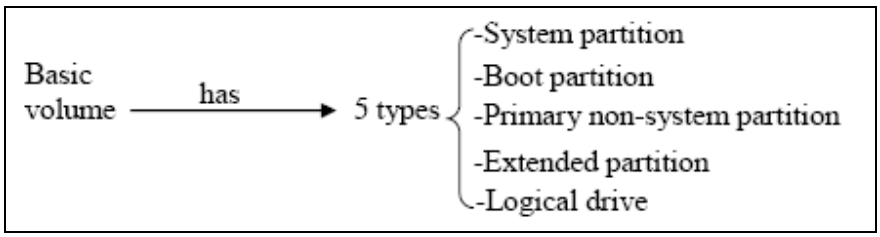


Sentence 2: '*Volume is formatted with FAT or FAT32 or NTFS*'.

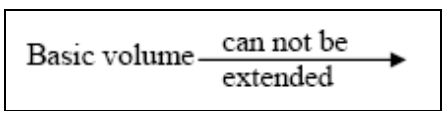


Sentence 3:

'*Basic volume has 5 types:*
-System partition
-Boot partition
-Primary non-system partition
-Extended partition
-Logical drive'

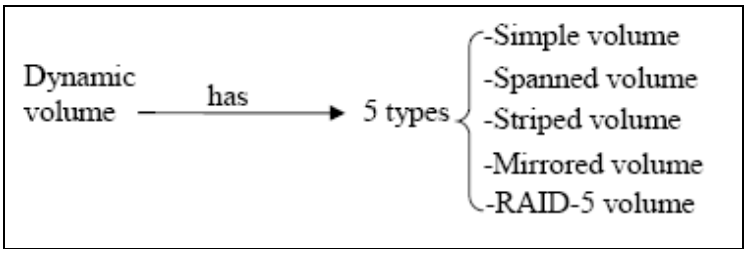


Sentence 4: '*Basic volume can not be extended*'.



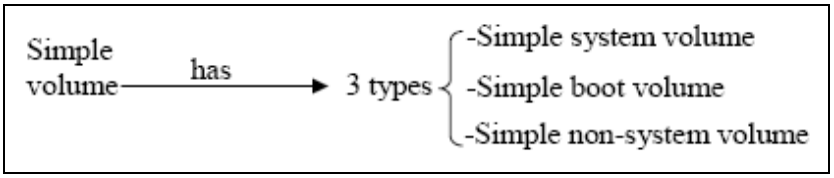
Sentence 5:

‘*Dynamic volume has 5 types*
-Simple volume
-Spanned volume
-Striped volume
-Mirrored volume
-RAID-5 volume’



Sentence 6:

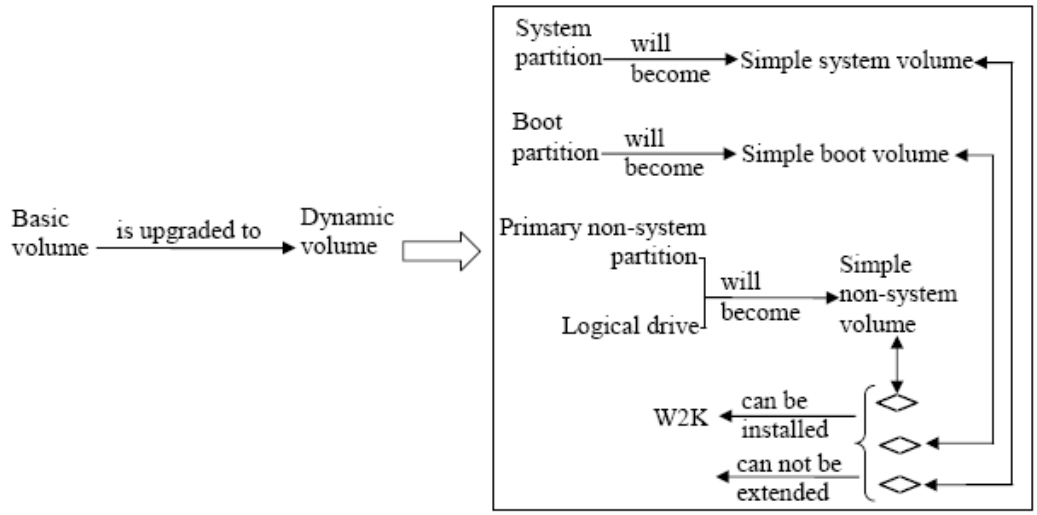
‘*Simple volume has 3 types:*
+Simple system volume
+Simple boot volume
+Simple non-system volume’



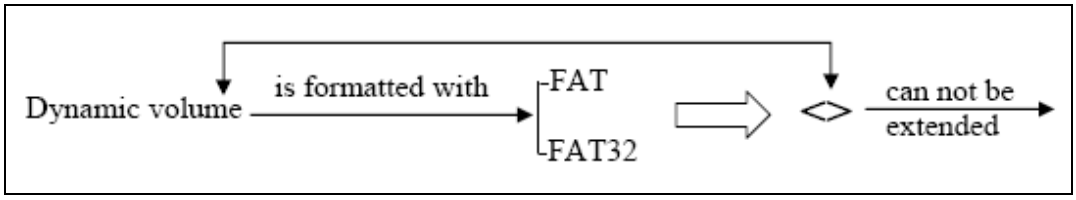
Sentence 7:

‘*If Basic volume is upgraded to Dynamic volume, then:*

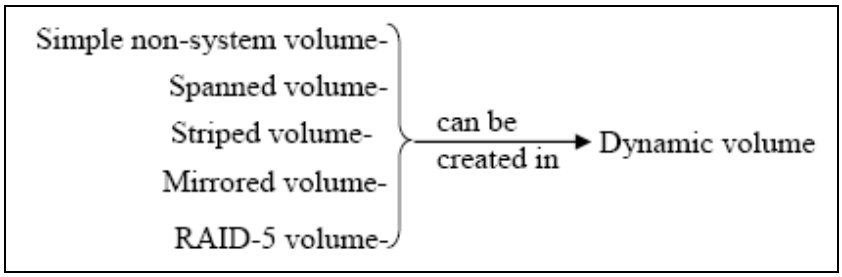
System partition & Boot partition in basic volume will become Simple system volume & Simple boot volume in dynamic volume respectively. Both Primary Non-system Partition or Logical Drive in basic volume will become Simple non-system volume in dynamic volume. These simple system volume, simple boot volume & simple non-system volume can be installed W2K, but they can not be extended.’



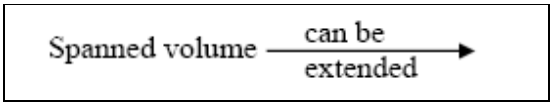
Sentence 8: '*If dynamic volume is formatted with FAT or FAT32, that dynamic volume can not be extended.*'



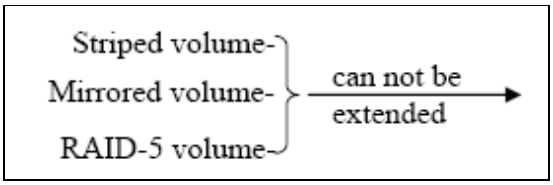
Sentence 9: '*Simple non-system volume, Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can be created in Dynamic volume.*'



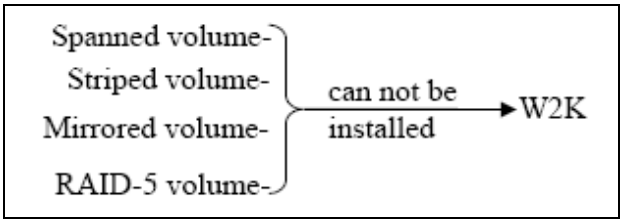
Sentence 10: '*Spanned volume can be extended.*'



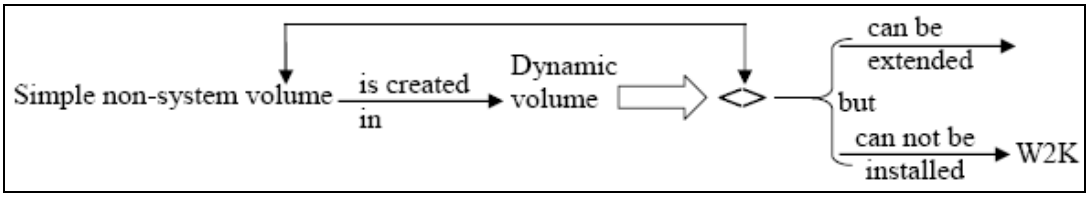
Sentence 11: '*Striped volume, Mirrored volume & RAID-5 volume can not be extended.*'



Sentence 12: '*Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can not be installed W2K.*'



Sentence 13: '*If Simple non-system volume is created in Dynamic volume, then that Simple non-system volume can be extended but can not be installed W2K.*'



These above spatial sentences only represent the individual narrative sentence one by one. They have to be aggregated in order to create a STD. In addition, the reference numbers were also applied when these spatial sentences are combined together. The following is the ST1:

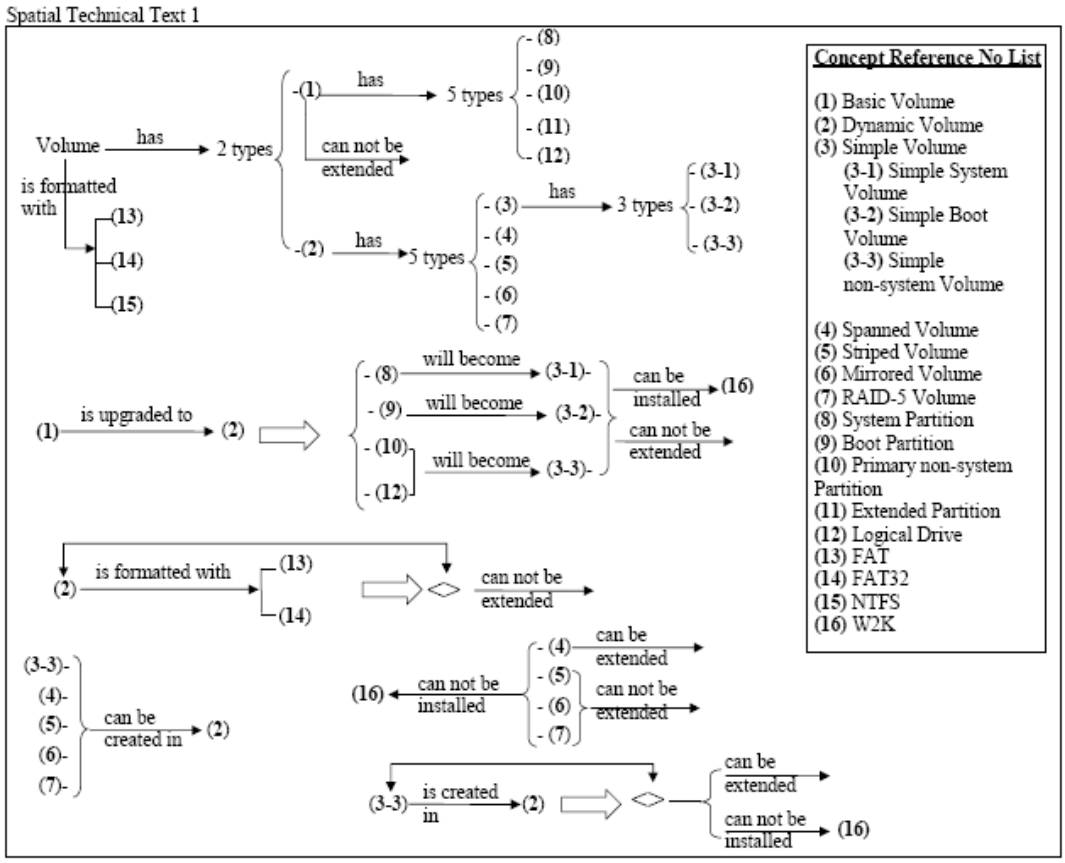


Figure 3.3: The spatial technical text 1 used in the pilot experiment.

Next is the narrative text 2 (see next page). Unlike NT1, NT2 uses many different sentence structures.

This is the technical narrative text 2:

If a volume is formatted by FAT or FAT32 or NTFS, then that volume can become FAT volume or FAT32 volume or NTFS volume respectively.

A volume contains files and folders. Only files or folders on NTFS volumes can be either compressed or encrypted.

If you copy a compressed file or folder to a FAT volume or FAT32 volume, that file or folder will be uncompressed.

If you copy a compressed or uncompressed file on a NTFS volume to a folder which is on that same NTFS volume or on a different NTFS volume, that file will inherit the attribute of that folder.

For example, if a compressed file is copied to an uncompressed folder, the file will be uncompressed.

If you move a compressed or uncompressed file on a NTFS volume to a folder on that same NTFS volume, the file will retain the attribute of itself.

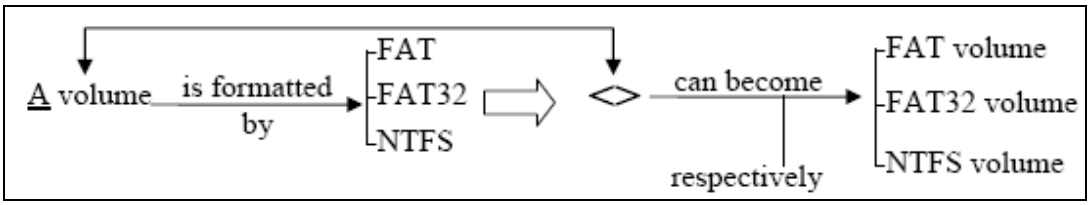
For example, if a compressed file is moved to an uncompressed folder on the same NTFS volume, the file will still be compressed.

If you move a compressed or uncompressed file on a NTFS volume to a folder on a different NTFS volume, that file will inherit the attribute of that folder.

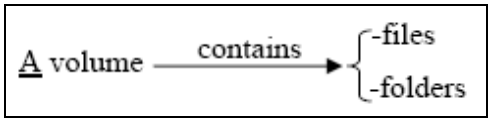
The following represents the equivalent spatial sentence of each narrative sentence in

NT2:

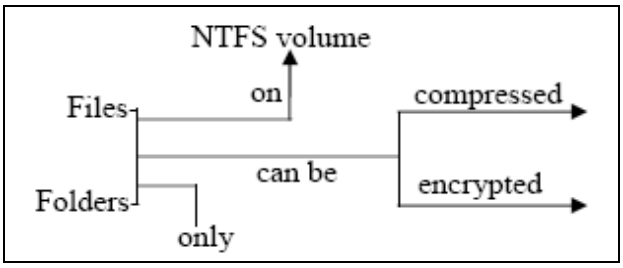
Sentence 1: '*If a volume is formatted by FAT or FAT32 or NTFS, then that volume can become FAT volume or FAT32 volume or NTFS volume respectively.*'



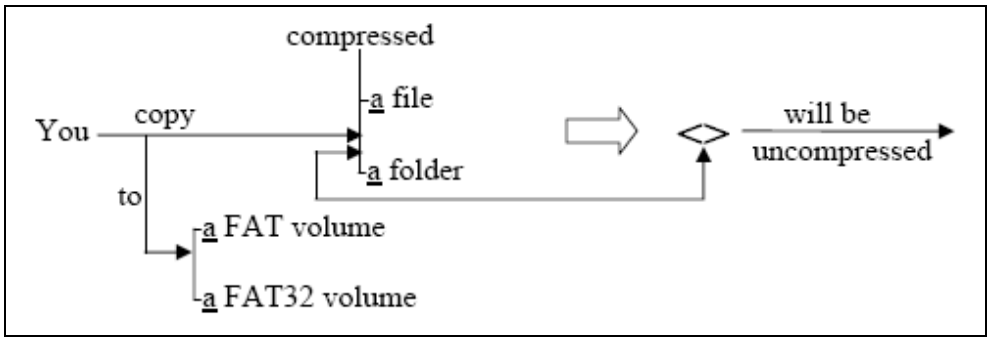
Sentence 2: '*A volume contains files and folders.*'



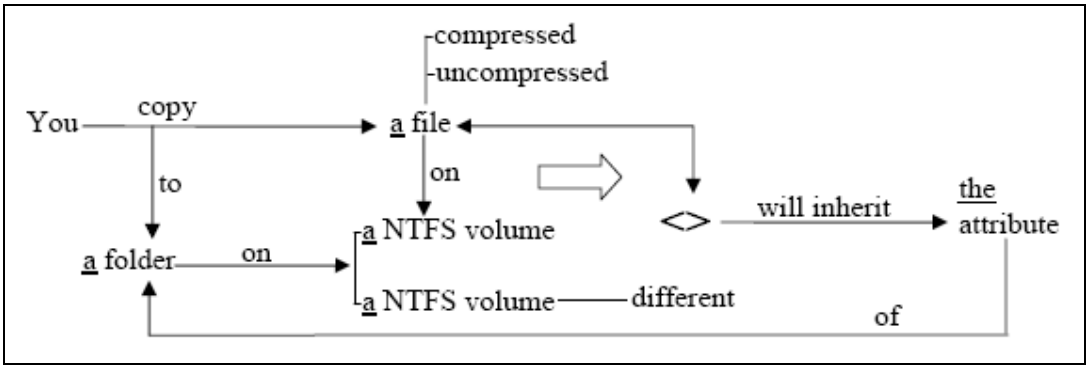
Sentence 3: '*Only files or folders on NTFS volumes can be either compressed or encrypted.*'



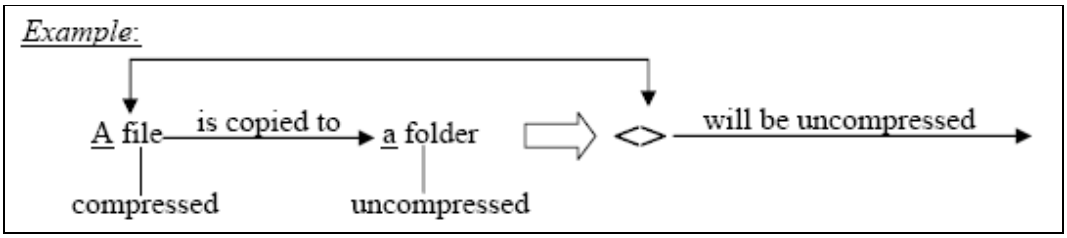
Sentence 4: '*If you copy a compressed file or folder to a FAT volume or FAT32 volume, that file or folder will be uncompressed.*'



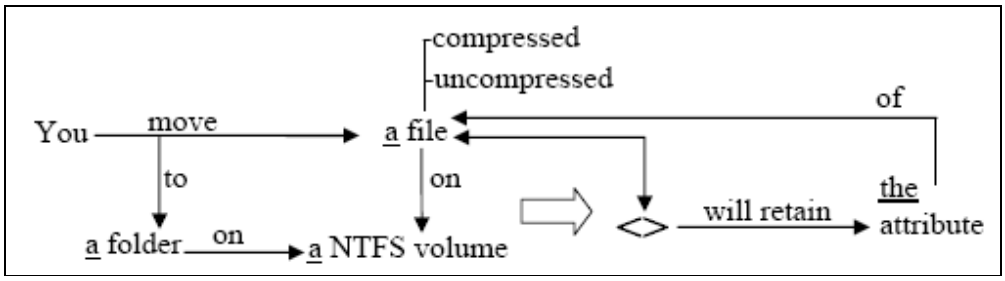
Sentence 5: '*If you copy a compressed or uncompressed file on a NTFS volume to a folder which is on that same NTFS volume or on a different NTFS volume, that file will inherit the attribute of that folder.*'



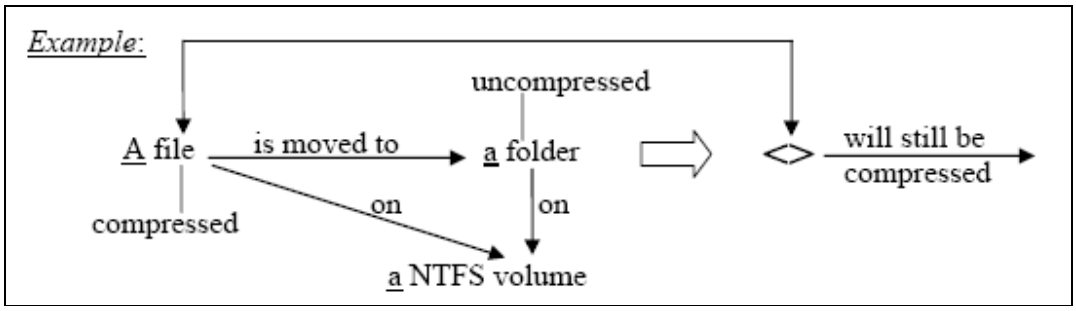
Sentence 6: '*For example, if a compressed file is copied to an uncompressed folder, the file will be uncompressed.*'



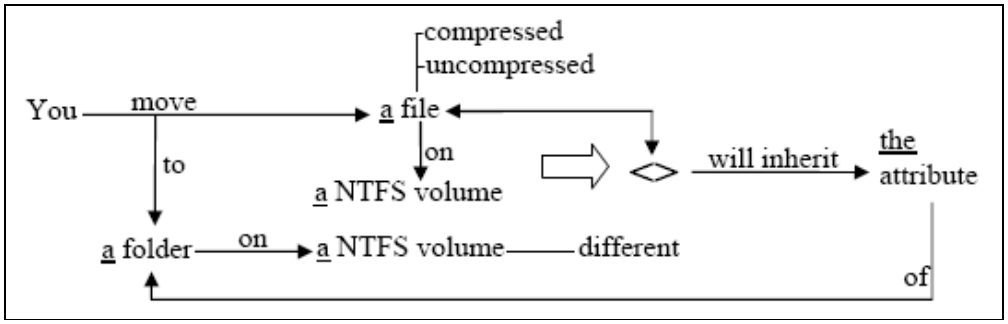
Sentence 7: '*If you move a compressed or uncompressed file on a NTFS volume to a folder on that same NTFS volume, the file will retain the attribute of itself.*'



Sentence 8: '*For example, if a compressed file is moved to an uncompressed folder on the same NTFS volume, the file will still be compressed.*'



Sentence 9: '*If you move a compressed or uncompressed file on a NTFS volume to a folder on a different NTFS volume, that file will inherit the attribute of that folder.*'



After aggregating these above spatial sentences, we will have the following ST2:

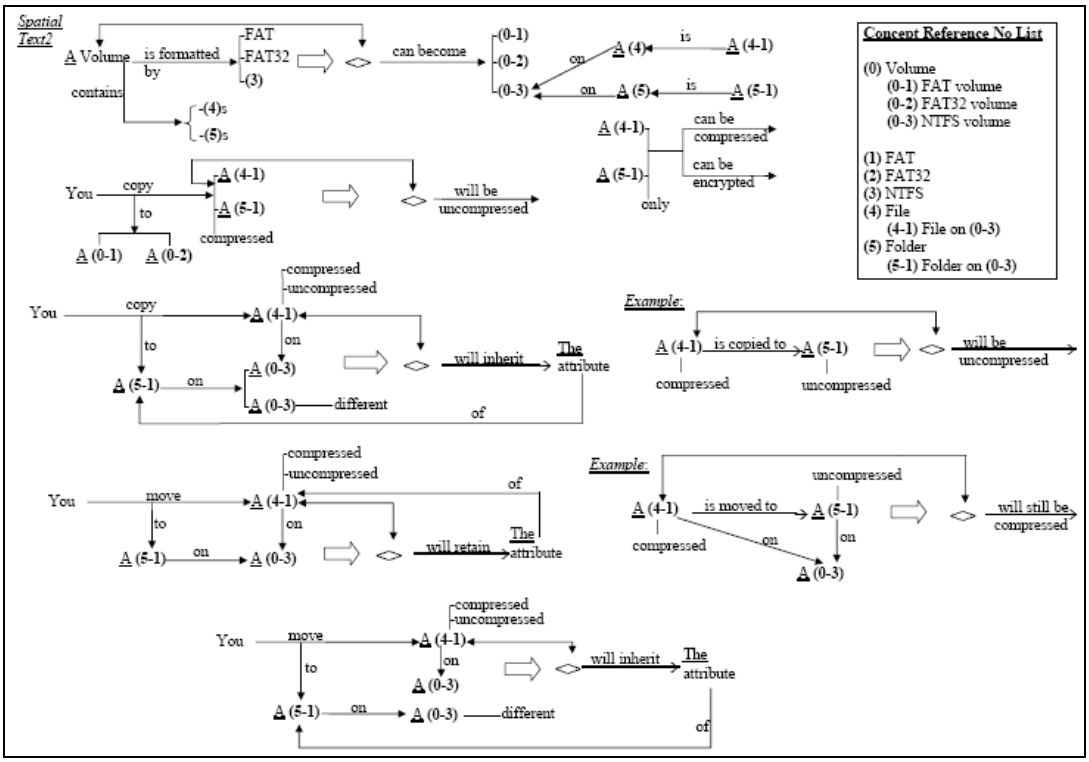
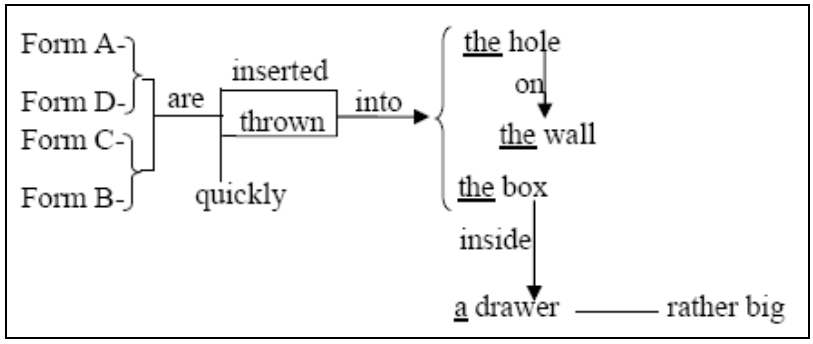


Figure 3.4: The spatial technical text 2 used in the pilot experiment.

The next instrument used in the experiment is the opinion questions asking students to compare narrative text and spatial text (see **Appendix I**). Students are given this narrative text:

'*Form A and Form D or Form C and Form B are inserted or thrown quickly into the hole on the wall and the box inside a rather big drawer*'.

And the following equivalent spatial text:



Based on the above example, students are required to answer these two questions:

1-Please rank the type of text by choosing one of these letters.

A. The narrative text is **very much easier to understand** than the spatial text.

B. The narrative text is **rather easier to understand** than the spatial text.

C. The narrative text is **a little easier to understand** than the spatial text.

D. The narrative text is **a little harder to understand than** the spatial text.

E. The narrative text is **rather harder to understand than** the spatial text.

F. The narrative text is **very much harder to understand than** the spatial text

Note: "very much easier" means "a lot easier"; "rather easier" means "quite easier"; and "a little easier" means "just a little bit easier". The ease degree of "very much easier" is higher than the one of "rather easier". In turn, the ease degree of "rather easier" is higher than the one of "a little easier".

2-Please give your comment about the spatial text and the narrative text.

In this question, students then are required to write down their own comments about the spatial and narrative text.

(Please see the instruction paper, NT1, ST1, NT2, ST2, the question set for NT1/ST1 and NT2/ST2, and the opinion question in **Appendix B, C, D, E, F, G, H and I** respectively).

3.3.4 Experiment planning

The undergraduate student participants will be recruited via the University of Wollongong's physical notice board. The reason for selecting undergraduate students is that they will not sympathize to the experimenter. If they are postgraduate students, they may sympathize or please the experimenter and thus create a bias to the result. The experimental procedures will be done in a room in the Commerce Research Centre, or in Building 40. The advertisement will require students to send out their information including gender, computer ability, and English ability to the researcher's email. The advertisement will state that students do not need to send their real names as a part of their information; and students can use their nick names to contact the researcher. All of the student information will be kept safely in the locked file cabinet and will be destroyed in two years. Only the experimenter can identify the student information; no other people can access the student information.

Out of the students who sent their information to me, 16 students will be selected and grouped into 8 matched pairs in such a way that each pair will have two students who have similar characteristics (such as gender, computer ability, English ability). This will limit the effect of confounding variables on the DV. The number of males and females within the selected students will be equal, i.e. 8 males and 8 females.

On the experiment day, 16 selected students will be invited to the experiment room. Before doing the test, the candidate will give students the instruction paper, explain the difference between the two types of text to them, and instruct them how to read and understand the narrative and spatial text. The instruction paper will represent all examples of reading the narrative and spatial sentences, which they might see in the test. The meaning of the examples in the instruction paper will completely differ from the ones in the actual test. No hints or clues in the instruction paper can help students to guess the answers in the real test. The instruction time will last 15 minutes. Students can ask the candidate any questions relating to the test in this instruction time.

Next, each student in each matched pair will be given randomly either test A or test B. If the first student in the matched pair does the test A, then the other in the matched pair will do the test B; and vice versa. The knowledge of the text will relate to the detailed computer technical knowledge. Test A contains the spatial text 1 (ST1) and narrative text 2 (NT2). Test B contains the spatial text 2 (ST2) and narrative text 1 (NT1). The ST1 and NT1 both convey the same meaning, except that they are different in their text representation. The same is true for ST2 and NT2.

Then, each student will read both the narrative text and the spatial text in the test in different order so that the order effect on the result can be controlled as mentioned above. For example, Test B can be randomly given to student 1 in the first pair, and then randomly give NT1 or ST2 for him/her to read first. If student 1 will do Test B, and reads NT1 first before reading ST2; then student 2 will do Test A and read ST1

first before reading NT2. The students will also have to answer the multiple choice questions after finishing reading each type of text.

The time for reading and answering the narrative text is 15 minutes; the spatial text is 15 minutes.

Finally, after finishing and returning the second text, each student will be given an evaluation form which requires him/her to comment and rank the type of text that he/she prefers. This will last 5 minutes. The purpose of this evaluation form is to collect some qualitative data for the experiment. It will be the supplement data in addition to the quantitative data which was mentioned above.

To be able to participate in the experiment, each student must sign off the consent form which allows the candidate to access his/her experiment result. They can withdraw the experiment at anytime if they want. A delicious chocolate package will be given to each participant student to encourage him/her for his/her experimental participation.

3.3.5 The details of the actual experiment process

Note: the experiment design '*comparing the comprehension of readers on a traditional text with a novel spatial text*' was approved by the HUMAN RESEARCH ETHICS COMMITTEE on 01-September-2005.

Although the experiment design stated that the candidate would find students through an advertising board, it was extremely difficult in the real world due to students being

very busy. Moreover, the chocolate packages did not attract students very much. Thus, the candidate increased the award fee to 10$, and delivered the advertising papers hand-to-hand to students. Students directly filled their personal information in the information collection form. All this information will be kept secretly. Although the candidate wanted 16 people with 8 females, only 14 people with only 2 women wanted to attend. Although the experiment was supposed to be held on one day and in one room, the actual experiment was carried out in the commerce resource centre and based on the available time of each student because students were very busy. But, this also brought some benefits because there were only a few students on one experiment day, and the candidate could properly check the comment writing of each student. This checking was very useful because some students did not write clearly their comments. In addition, some students misunderstood the meaning of ST and NT method, and thus chose the wrong answers in the ranking questions. But, because only a few students attended in each experiment day, the candidate could ask students what they wrote in the comment and ask them to correct their misunderstanding and misspelling. The candidate could not check and correct the students' misunderstanding and misspelling if all students took the test on one day, because it is impossible to check all 14 comments at once, as students just wanted to leave the experiment room as soon as possible. In fact, in the real experiment, the candidate required some students to correct their misreading of the ranking questions.

Before participating in the experiment, each student was given an information collection form which required them to fill in their nick name, gender, English ability, computer ability and background. This information will be used to group students into

7 pairs. The rule for grouping is how to match student skills as closely as possible; however this is very relative because it is very difficult to know the actual ability of each student. Some students can say that they have high computer skills, but actually they only have basic computer skills.

Note: although there were some changes in the real experiment as mentioned in the previous paragraphs, other things in the real experiment were exactly the same as the ones described in the experiment design and plan.

The following table is a list of participant students. Those students who have the similar characters were grouped into a pair.

Table 3.1: Participant information table.

Participant	Gender	English ability	Computer ability	Background
Student1	male	Quite well	Quite well	Computer
Student2	male	Just enough for basic use	Quite well	Information Systems
Student3	male	Just enough for basic use	Quite well	Computer
Student4	male	Very little	Rather Deeply	Computer
Student5	male	Just enough for basic use	Quite well	Business and management
Student6	male	Quite well	Just enough for basic use	Computer
Student7	male	Quite well	Quite well	Information Systems
Student8	male	Quite well	Quite well	Engineering
Student9	male	Just enough for basic use	Quite well	Information Systems
Student10	Male	Quite well	Rather Deeply	Information technology
Student11	Female	Just enough for basic use	Just enough for basic use	Tourism
Student12	Female	Just enough for basic use	Just enough for basic use	Foreign Trade
Student13	Male	Quite well	Rather Deeply	Computer
Student14	Male	Quite well	Rather Deeply	Computer

Note: first, all students are required to use their anonymous name in the consent form before taking the reading test. Second, the difficulty degree of English ability and computer ability of each student is measured into 4 levels: very little, just enough for basic use, quite well, rather deeply. '*Very little*' is the lowest ability, while '*rather deeply*' is the highest ability.

The following table shows the matched pairs of students and the order of the texts that they have to do in the test:

Table 3.2: Student matching table.

Pair No	**The first student in the pair**	**Order of the texts in the test for the first student**		**Order of the texts in the test for the second student**	**The second student in the pair**
Pair 1	Student1	ST1-NT2		NT1-ST2	Student2
Pair 2	Student3	ST2-NT1		NT2-ST1	Student4
Pair 3	Student5	NT1-ST2		ST1-NT2	Student6
Pair 4	Student7	NT2-ST1		ST2-NT1	Student8
Pair 5	Student9	NT1-ST2		ST1-NT2	Student10
Pair 6	Student11	NT2-ST1		ST2-NT1	Student12
Pair 7	Student13	ST1-NT2		NT1-ST2	Student14

Note: the first line in table 3.2 shows that the student Student1 and Student2 in the pair 1 will do 'ST1-NT2' and 'NT1-ST2' test, respectively. 'ST1-NT2' order for student Student1 in the test means that Student1 will read and answer the questions in ST1 first before reading and answering the questions in NT2; ST1 and NT2 belong to test A. 'NT1-ST2' order for student Student2 in the test means that Student2 will read and

answer the questions in NT1 first before reading and answering the questions in ST2; NT1 and ST2 belong to test B. The similar explanation will be applied for the rest of the lines in table 3.2.

The experiment days are from 04/10/2005 to 19/10/2005:

Table 3.3: Student participating date table.

Participant nick name	**Participant date**
Student10	04/10/2005
Student5	04/10/2005
Student12	04/10/2005
Student1	05/10/2005
Student9	05/10/2005
Student4	07/10/2005
Student2	07/10/2005
Student6	11/10/2005
Student3	12/10/2005
Student7	13/10/2005
Student13	15/10/2005
Student11	15/10/2005
Student8	16/10/2005
Student14	19/10/2005

Students did the experiment in the Commerce Research Centre at Wollongong University. The test environment, such as table, chairs, light, air conditioner, is extremely good. In addition, the Commerce Research Centre is very quiet and very suitable for taking the test. So, the environment confounding variables was limited to a minimum level. Each matched pair will do two tests as discussed in the section ”Experiment planning”. The candidate managed to give the same instructions and control the correct test time for each student.

The information in table 3.1, 3.2 and 3.3 is gathered from the participant information collection forms and the signed consent forms of 14 students.

3.4 Summary of this chapter

This chapter has discussed the overall research method used in this thesis in order to answer the research question. The research method was divided into two phrases. The first phrase was to develop a new technical writing technique called “spatial technical writing” (STW). STW has its syntax structure similar to but simpler than the sentence diagramming technique. STW forces writers to consistently show clear relationships among concepts in a spatial text created by applying STW. A spatial text, thus, can have characters like a concept map. The second phrase was to implement a small exploratory study for testing how students reflect to the STW technique. The exploratory study used a small pilot experiment based on some basic quantitative and qualitative measure methods. The result of this exploratory study will be used for further investigation of STW technique in the future. Finally, the details of what actually happened in the real experiment were discussed.

Chapter 4: Result and Discussion

4.1 Introduction to this chapter

The result section in this chapter discusses the result analysis of the actual pilot experiment. The quantitative data is analysed by measuring central tendency and dispersion to compare the reading performance between the narrative text and the spatial text written by STW. The student comment qualitative data is broken out into the comment codes to analyse how students evaluate the STW technique. The discussion section in this chapter then investigates the research method's shortcomings which are deduced from the result analysis. The discussion section also suggests how the future experiment should be implemented in order to limit these shortcomings.

4.2 Result

The candidate has already developed the STW technique and has implemented a pilot experiment to test how a typical student responses to STW in chapter 3. The candidate will now analyse the results of the pilot experiment in order to get more information for further investigation of STW technique in the future.

4.2.1 Quantitative results

The following is the mark of different types of text of each student gathered from the multiple-choice answers of 14 students (see **Appendix J**)**:**

Table 4.1: Student mark result table.

Student (nick name)	**ST1**	**NT1**	**ST2**	**NT2**
Student1	4			4
Student2		2	5	
Student3		7	1	
Student4	6			8
Student5		9	5	
Student6	7			5
Student7	5			8
Student8		8	4	
Student9		7	6	
Student10	6			5
Student11	8			5
Student12		9	5	
Student13	8			10
Student14		5	4	
Total Marks	**44**	**47**	**30**	**45**
The average mean mark	**6.29 (=44/7)**	**6.71 (=47/7)**	**4.29 (=30/7)**	**6.43 (=45/7)**

There are two types of descriptive statistics which summarize the certain aspects of the results. One is the measure of central tendency (most typical value) and other is the measure of dispersion (variability or spread) (Robson, 1973).

4.2.1.1 Measure of central tendency

1 The arithmetic mean

The arithmetic mean is the average of total scores. It is calculated by adding the sum of all scores together and dividing by the number of scores (Robson, 1973).

Mean = total of all scores/ total number of scores.

Mean = $(X1 + X2 + \ldots.. + Xn)/N = (\Sigma X) / N$

Based on table 4.1, the chart comparing the average mean mark of the different types of text was produced as the following:

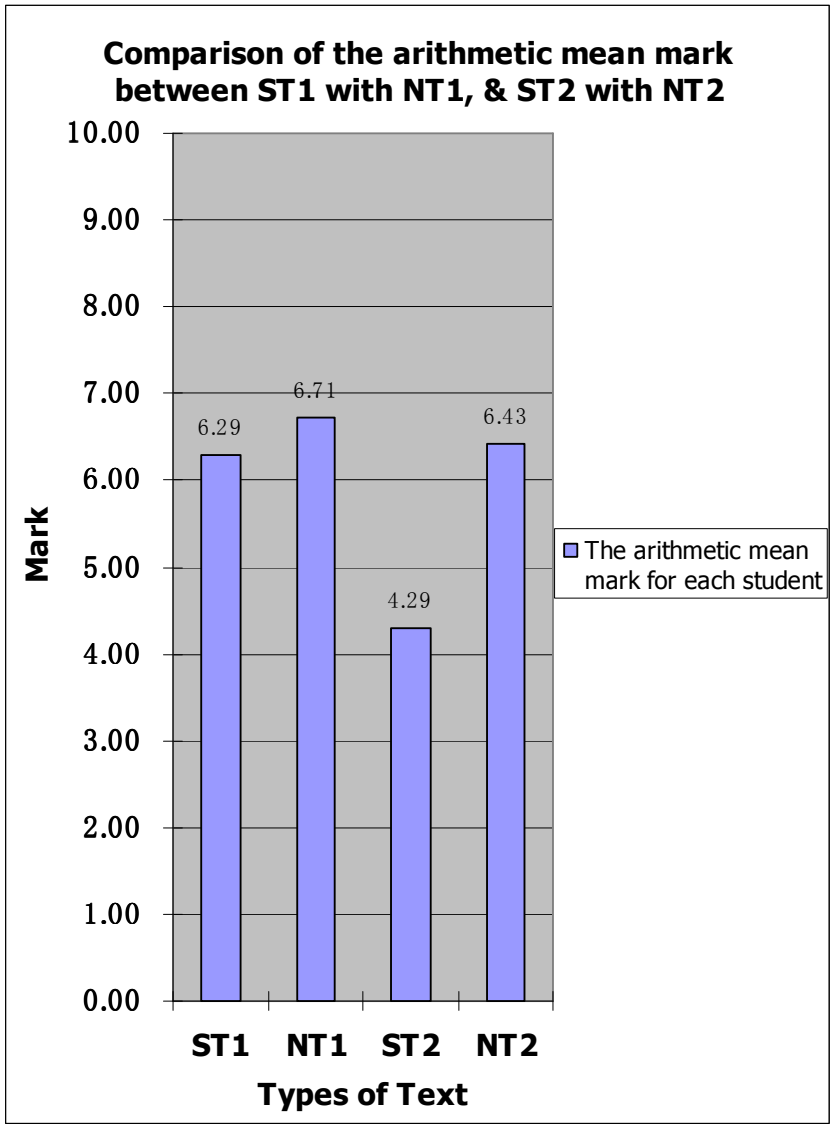


Figure 4.1: Comparison chart of the mean mark of ST1 with NT1, and ST2 with NT2.

Looking at Figure 4.1, we can see that there is not much difference between the average mean mark of each student doing ST1 and NT1. However, the average mean

mark of each student doing NT2 is 2.14 (6.43-4.29) higher than the mean mark of each student doing ST2.

2 The median

The median "is a value chosen so that it has as many scores above it as it has below it" (Robson, 1973, p. 23). To get the median score: first the scores are placed in order of size. Then, if the total number of the scores is odd, the median is the central value. If the total number of the scores is even, then the median is the average of the two middle scores.

From table 4.1 above, a table sorting the mark for each type of text in ascending order was created as following:

Table 4.2: Table of student marks sorted in ascending order.

ST1	NT1	ST2	NT2
4	2	1	4
5	5	4	5
6	7	4	5
6	**7**	**5**	**5**
7	8	5	8
8	9	5	8
8	9	6	10

Looking at table 4.2, because there are 7 marks, the median will be the middle mark. The median of ST1 is 6, NT1 is 7, ST2 is 5, and NT2 is also 5. The candidate then can create a chart (see Figure 4.2) which compares the median mark of ST1 with NT1, and ST2 with NT2.

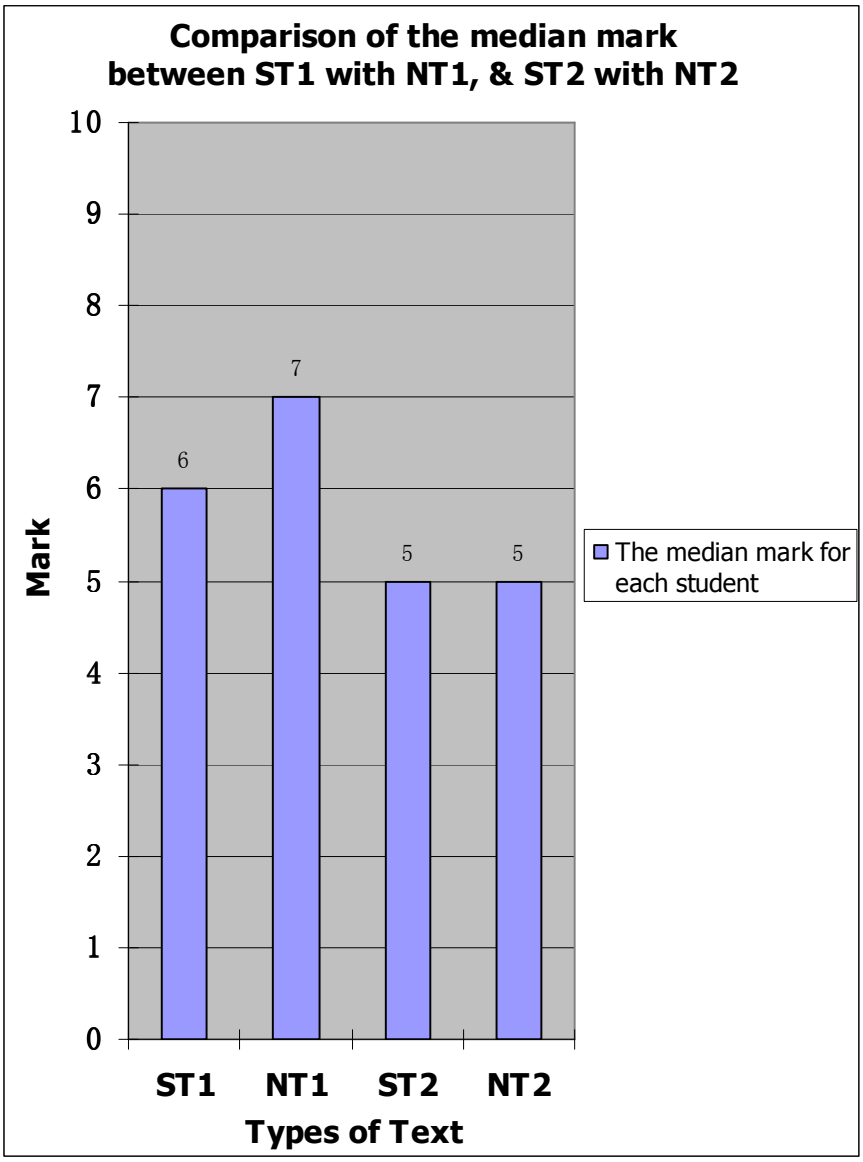


Figure 4.2: Comparison chart of the median mark of ST1 with NT1, and ST2 with NT2.

For the median measure, the median NT1 mark is 7 which is 1 mark higher than ST1. But, there is no difference for NT2 and ST2. The median mark of NT2 is 5, ST2 is also 5.

3 The difference between mean and median

The arithmetic mean is used to obtain the exact typical value of a set of scores. This is because the mean extracts most information from the sample. Any changes in a single score will affect the mean; the mean depends on the value of each score in a sample. On the other hand, the median may be unaffected by changing the value of a number of scores. It is also not affected by an extremely high score or extremely low score. An arithmetic mean would be unsuitable if it can be affected by the highest or lowest score. Let see this example, suppose we got this result: 1, 2, 2, 3, 4, 5, 5, 6, 277. The mean = 33.8 which is very unsuitable. The median of 4 is suitable (Robson, 1973).

For the arithmetic mean measure, the mean marks between NT1 and ST1 are not much different, but NT2 achieved a much higher mark than ST2. But, why is NT2 mean mark much higher than the ST2 mean mark?

The answer is, if we look at the mark of each student doing ST2 and NT2 in table 4.1, we can see that one student achieved only a mark of 1 on ST2 and another student achieved a mark of 10 on NT2. This may be that one student did not do the ST2 test seriously, so he only has 1 mark. In addition, another student achieved a full mark for NT2, maybe because he was already familiar with the knowledge stated in NT2. That is why the mean mark of NT2 is only 4.29, while the mean mark of ST2 is 6.43. It can be concluded that the mean mark of NT2 and ST2 is affected strongly by the extreme mark. Hence, the mean measure for NT2 and ST2 is not suitable in this case. The median measure for NT2 and ST2 (each had median mark of 5) is more suitable than the arithmetic mean measure.

4.2.1.2 Measure of dispersion

The statistic of the mean or median is not sufficient; the variability or spread in the data also needs to be calculated. For example, the following set of scores: 17, 32, 34, 58, 69, 70, 98, 142 have the mean of 65. Another set of scores: 61, 62, 64, 65, 66, 68, 69 also have the mean of 65 (Robson, 1973).

1 Range

The simplest way to compute the variability in the data is using 'range'. Range is just the difference between the highest and lowest scores (Robson, 1973).

By looking at the extreme mark in table 4.2, we can calculate the range of NT1 is 4 (=8-4); ST1 is 7 (=9-2); NT2 is 5 (=6-1); ST2 is 6 (=10-4).

However, range does not give an exact calculation of variability in the data because it just depends on the two extreme score values. Hence, range is not a popular way to measure the variability in the data. The most widely used measure of variability is 'the standard deviation' (Robson, 1973).

2 Standard deviation (SD)

This is the formula of SD (Robson, 1973):

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$$

Where: ***S*** is standard deviation, x_i is the individual score, $\overline{x}$ is the mean score, N is the total number of scores, ∑ means 'the sum of', $\sqrt{\ }$ means "take the square root of".

The following table computes the SD of ST1, NT1, ST2, and NT2 (N=7) (see next page).

Table 4.3: Standard deviation table of ST1, NT1, ST2, and NT2.

The individual mark = x_i	**ST1**	**NT1**	**ST2**	**NT2**
x_1	4	2	5	4
x_2	6	7	1	8
x_3	7	9	5	5
x_4	5	8	4	8
x_5	6	7	6	5
x_6	8	9	5	5
x_7	8	5	4	10
Total marks = $\sum x_i$	44	47	30	45
$\overline{x}$ **= (Total marks) / N**	**6.29**	**6.71**	**4.29**	**6.43**
Difference(D) = $(x_i - \overline{x})$	**ST1**	**NT1**	**ST2**	**NT2**
$\mathbf{D_1}$	-2.29	-4.71	0.71	-2.43
$\mathbf{D_2}$	-0.29	0.29	-3.29	1.57
$\mathbf{D_3}$	0.71	2.29	0.71	-1.43
$\mathbf{D_4}$	-1.29	1.29	-0.29	1.57
$\mathbf{D_5}$	-0.29	0.29	1.71	-1.43
$\mathbf{D_6}$	1.71	2.29	0.71	-1.43
$\mathbf{D_7}$	1.71	-1.71	-0.29	3.57
Squared differences = $(D)^2$	**ST1**	**NT1**	**ST2**	**NT2**
$(D_1)^2$	5.22	22.22	0.51	5.90
$(D_2)^2$	0.08	0.08	10.80	2.47
$(D_3)^2$	0.51	5.22	0.51	2.04
$(D_4)^2$	1.65	1.65	0.08	2.47
$(D_5)^2$	0.08	0.08	2.94	2.04
$(D_6)^2$	2.94	5.22	0.51	2.04
$(D_7)^2$	2.94	2.94	0.08	12.76
Sum of squared difference = $\sum (D)^2$	**13.43**	**37.43**	**15.43**	**29.71**
Variance = $(\sum (D)^2) / (N-1)$	**2.24**	**6.24**	**2.57**	**4.95**
Standard deviation (*s*) = $\sqrt{\text{variance}}$	**1.50**	**2.50**	**1.60**	**2.23**

By looking at the standard deviation (*S*) in table 4.3, we can see that *S* of ST1 is only 1.50, *S* of ST2 is 1.60. This means the variability in the marks of the students doing ST1 or ST2 is small. This can be explained because the spatial text is too new to students; so, the various levels of understanding the spatial text by each student do not vary much. And, hence, the marks of the students doing ST1 or ST2 did not vary

much. On the contrary, ***S*** of NT1 is 2.50 and ***S*** of NT2 is 2.23. This means the variability in the marks of the students doing NT1 and NT2 is large. This can be explained that because everyone already knew the narrative text before doing the test, the various levels of understanding the narrative text by each student depends on his or her previous English reading comprehension experience. Some students have good narrative reading skills, so they achieved very high marks in the narrative text. Others did not have good reading skills, so they achieved low marks in the narrative text. That is a main reason why the marks of the students doing NT1 or NT2 varied a lot.

4.2.1.3 Significant analyses

Based on the table 3.2 and 4.1, a matched subject pair mark table was produced as following:

Table 4.4: Matched subject pair mark comparison for ST1 and NT1.

Pair Number	ST1	NT1	Comparison
Pair1 (Student1-Student2)	4	2	+
Pair2 (Student4-Student3)	6	7	–
Pair3 (Student6-Student5)	7	9	–
Pair4 (Student7-Student8)	5	8	–
Pair5 (Student10-Student9)	6	7	–
Pair6 (Student11-Student12)	8	9	–
Pair7 (Student13-Student14)	8	5	+

L = frequency of the less frequent sign.

T= total frequency of both pluses and minuses.

p= probability of by chance obtaining L out of T.

Based on table 4.4, we can see that L = 2 and T = 7 because the frequency of the less frequent sign (pluses in this case) is 2 and total pluses and minuses is 7. From the Probability Table which shows the value of the *probability* of obtaining L out of a total of T (Robson, 1973), we can have p = 0.454 (L = 2, T = 7). If the significance level = 0.05, then it can be concluded that the result of the table comparing ST1 and NT1 is not significant at the 5% level, i.e. a certain confounding variable strongly affected the dependent variable.

Table 4.5: Matched subject pair mark comparison for ST2 and NT2.

Pair Number	ST2	NT2	Comparison
Pair1 (Student2-Student1)	5	4	+
Pair2 (Student3-Student4)	1	8	–
Pair3 (Student5-Student6)	5	5	0
Pair4 (Student8-Student7)	4	8	–
Pair5 (Student9-Student10)	6	5	+
Pair6 (Student12-Student11)	5	5	0
Pair7 (Student14-Student13)	4	10	–

Based on table 4.5, we can see that L = 2 and T = 5 because the frequency of the less frequent sign (pluses in this case) is 2 and total pluses and minuses is 5 (ignoring zero). From the Probability table, we can have p = 1 (L = 2, T = 5). Like table 4.4, it can be concluded that the result of the table comparing ST2 and NT2 is not significant at the 5% level, i.e. a certain confounding variable strongly affected the dependent variable.

General comparison between ST and NT:

Table 4.6: Matched subject pair mark comparison table between ST and NT.

ST	NT	Comparison
4	2	+
6	7	–
7	9	–
5	8	–
6	7	–
8	9	–
8	5	+
5	4	+
1	8	–
5	5	0
4	8	–
6	5	+
5	5	0
4	10	–

L = 4, T = 12, p = 0.388.

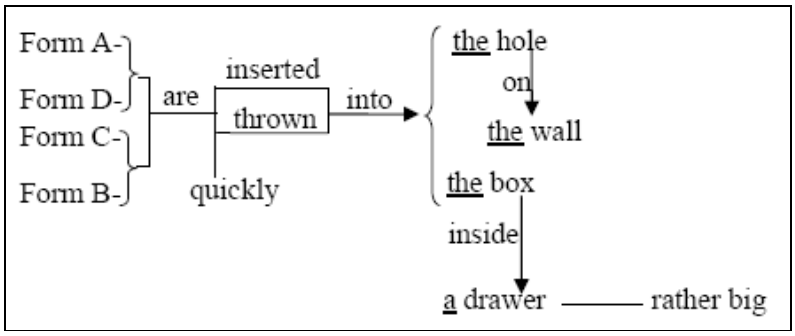
The result is not significant at the 5% level, because p = 0.388 > 0.05, so it can be said that the confounding variable impacted the dependent variable. If there were 2 pluses and 10 minuses (L = 2, T = 12, p = 0.038), then it can be concluded that NT is easier to understand than ST. However, table 4.6 shows that the number of minuses is 8, the number of pluses is 4; it was hard to say whether or not NT is better than ST, though students achieved better results on NT. The candidate will discuss this issue later after analysing the qualitative data.

4.2.2 Qualitative results

The following opinion questions are used to ask students to compare narrative text and spatial text (see **Appendix I**). Students are given this narrative text:

'*Form A and Form D or Form C and Form B are inserted or thrown quickly into the hole on the wall and the box inside a rather big drawer*'.

And the equivalent spatial text:



Based on the above example, students are required to answer these two questions:

1-Please rank the type of text by choosing one of these letters.

A. The narrative text is **very much easier to understand** than the spatial text.

B. The narrative text is **rather easier to understand** than the spatial text.

C. The narrative text is **a little easier to understand** than the spatial text.

D. The narrative text is **a little harder to understand than** the spatial text.

E. The narrative text is **rather harder to understand than** the spatial text.

F. The narrative text is **very much harder to understand than** the spatial text.

2-Please give your comment about the spatial text and the narrative text.

Table 4.7 gathers the ranking opinion answers from 14 students:

Table 4.7: The ranking result table.

Student	Ranking answer
Student1	A
Student2	C
Student3	A
Student4	D
Student5	B
Student6	D
Student7	F
Student8	A
Student9	D
Student10	B
Student11	E
Student12	B
Student13	C
Student14	E

From the information in table 4.7, the students are divided into two groups: group supporting NT, and group supporting ST. These are showed in table 4.8.

Table 4.8: Classified ranking result table.

	Student	Ranking answer
Students who stated that NT is easier for them to understand than ST	Student1	A
	Student3	A
	Student8	A
	Student5	B
	Student10	B
	Student12	B
	Student2	C
	Student13	C
Students who state that ST is easier for them to understand than NT	Student4	D
	Student6	D
	Student9	D
	Student11	E
	Student14	E
	Student7	F

Table 4.9: Percentage ranking result table.

Degree	Selection	% selection
A	3	21.43%
B	3	21.43%
C	2	14.29%
D	3	21.43%
E	2	14.29%
F	1	7.14%
Total	**14**	**100%**

Table 4.9 stated the percent of students' ranking selection. The figures in table 4.9 are transferred into the following chart:

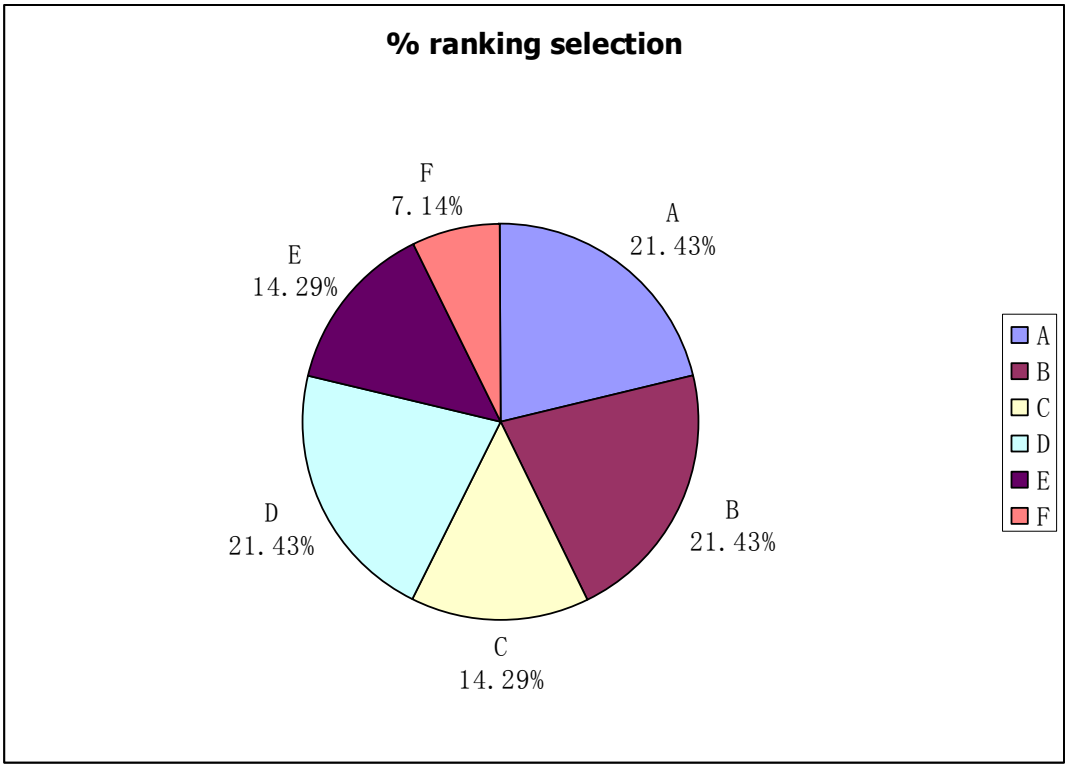


Figure 4.3: Percentage ranking result chart.

Figure 4.3 represents the same figures as in Table 4.9, but in a pie graph. A, B, and C supports NT; while D, E, and F supports ST.

The selection of the extreme (A, F), i.e. those who think that the text type they prefer is very much better than the other text type.

The selection of the moderate (B, E), i.e. those who think that the text type they prefer is rather better than the other text type.

The selection of the mild (D, C), i.e. those who think that the text type they prefer is just a little bit better than the other text type.

42.86% (7.14% + 14.29% + 21.43%) of students support ST, while 57.14% (21.43% + 21.43% + 14.29%) of students support NT. The percentage of students who strongly confirm that NT is much easier to understand than ST is very high 42.86% (21.43% + 21.43%). The percentage of students support ST is also quite high 35.75% (14.29% + 21.43%), but they weakly confirm that ST is easier to understand than NT.

These are the list of students' real comments gathered the comment opinion answers of 14 students:

Student1 (A for ranking): "Basically the narrative text is much easier to understand because everyone can easily understand it. But to understand the spatial text you have to be an expert about it and have to know the syntax very carefully. A person can not understand the spatial text at first seen. So, I think narrative will be better for several reasons".

Student2 (C for ranking): "For narrative, it is using long sentence that will be harder to read and understand. For spatial text, because user needs to transfer to logical

thinking, that will be a little bit harder to user to do the test at first time. If I learn spatial text more, that will be easier to understand the complex question, like ER-diagram".

Student3 (A for ranking): "The narrative text is much easier to understand than spatial text. Anyone can understand anything, whatever written by narrative text, on the other hand spatial text needs to understand a lot about signs, which are complicated".

Student4 (D for ranking): "Spatial text is quickly for people to explain the meaning, but it is little difficult for reader to read".

Student5 (B for ranking): "The symbols of spatial text take a little time to adapt, some symbols are quite easy to follow, some should be improved to be more easily understand. When I do the test, I need to find where the spatial no character to locates according to its sign (1, 2, 3)".

Student6 (D for ranking): "Both of them are a bit confusing but equivalent spatial I understood what's going on".

Student7 (F for ranking): "A picture can be better than 1000 words. It's a fact and some with the spatial text. It is way easier than the narrative text".

Student8 (A for ranking): "The equivalent spatial text is very complicate. It's hard to remember the equivalent meaning of symbols. But in case of narrative text, it can be understood straight away".

Student9 (D for ranking): "First, the user should know all the meaning of the symbols. After they learn it is quite easy to understand the meaning of the sentence by the diagram. I think it is a good way in the technical aspect, there is no confused meaning because by grammar or something".

Student10 (B for ranking): "the spatial text is using so many symbols, hence a bit hard to understand. Reducing symbols can change the way at much easier".

Student11 (E for ranking): "ST easier to understand and simple number table to make people understand the harder sentences".

Student12 (B for ranking): "The narrative text can be easily understood what the meaning is about. The two actions are very clear for comparing. The spatial text is a little confused, it is hard to understand they are two actions, and the comparison is also not very clear. The narrative text can be got the meaning after one time reading".

Student13 (C for ranking): "Spatial text is not straight forward little abstract, but if you get used to it sometimes you can find out the answer more easily but not very good on understanding more complicated stuff, narrative text is more common and easy to understand. For different things, sometimes is too redundancy".

Student14 (E for ranking): "Narrative text is rather harder to follow than the spatial text because of wordings. Too much wording with the same vocabularies. But the spatial text gives much easy to follow directions to answer questions. Except, some notations used needs to be learned over time".

Explanation of student comments

Student1: Although Student1 said that NT is much easier to understand; his NT result is not high, but only equal to the ST result.

Student2: Student2 achieved very low marks in NT and an average mark in ST. However, he still believes that NT is a bit easier. Later, he added that if he can learn more ST then it will be easier to understand ST, like the ERD diagram. This is an interesting point: although the ERD diagram is much easier to understand than the ST, students still have to spend at least 1 month, or even take a course to realize it. Hence, ST also needs to be trained properly to students.

Student3: Student3 had a good mark in NT, but a very poor mark in ST. It is not surprising that he ranks NT on top. It is also possible that he did not do the ST test seriously.

Student4: Student4 achieved a mark of 6 in ST and a mark of 8 in NT. He also has a rather high level of computer knowledge (see table 3.1). This can be a reason why he achieved a good mark in NT. He judges that ST is a bit better than NT, but he contrasts that ST is difficult to read.

Student5: Student5 had business background but he know computer quite well (see table 3.1), he achieved nearly full mark in NT and an average mark in ST. He chose that NT is rather easier to understand than ST. However, he still gave some positive judgments about ST such as “some symbols in ST are quite easy to follow”. He

suggested ST needs to be improved, especially reference number; because he had to spend more time to locate the reference number with its meaning in the ST test.

Student6: Student6 achieved quite a good mark in ST and an average mark in NT. He stated that both types of text are a bit confusing, but ST is a bit easier because he can figure out the meaning.

Student7: Student7 achieved a very good mark in NT and an average mark in ST. Surprisingly, he ranked ST much better than NT with a reason that a picture is better than words.

Student8: Student8 achieved a mark of 4 in ST, but a very good mark in NT. He gave the top rank for NT. He thought that the ST symbols are hard to understand.

Student9: Student9 had 7 for NT and 6 for ST, but he thought that ST was a bit better. He stated that after understanding ST symbols, it was quite easy to understand the meaning in ST. He also stated that ST was good in the technical aspect because there is no confused meaning.

Student10: Although Student10 had 6 for ST, and 5 for NT, he still scored NT easier than ST. He reasoned that there are too many symbols in ST, and this make ST hard to understand. He also said that reducing the symbol can make ST easier to understand.

Student11: Student11 is a female without a computer background, she achieved a very good mark in ST, and an average mark in NT. Undoubtedly, she gave a high rank

for ST because she thought that the reference number table can help readers to understand harder sentences.

Student12: Student12 is also a female without a computer background. She nearly achieved full mark in NT and an average mark in ST. This demonstrated that to achieve a good mark in the test, student don't need to understand the computer jargon used in the test such as FAT, NTFS, basic volume, etc. Unsurprisingly, she supported NT. She must be very good at narrative text reading comprehension. She said NT is easy for readers to see the structure of a sentence while ST is not. Actually, ST is devised to help people to clearly see the sentence structure, while the word-after-word narrative text can cause language ambiguity.

Student13: Student13 achieved very good results,10 for NT, and 8 for ST. He also has a high level of computer knowledge (see table 3.1); this can help him to understand quickly the computer technical words, and thus he can answer the questions easily. For him, ST is abstract and not straightforward. This countered the basic goal of ST, which is straightforward and unambiguous. However, he criticized that the redundancy in NT is not good for understanding. He also stated that ST can help to find out answers easily, but not for understanding. He chose to support NT.

Student14: Student14 only achieved a 4 in ST and 5 in NT. He chose E to support ST. Like Student13, Student14 stated that redundant wording makes NT harder to understand. ST could help to answer the questions quickly. ST needs to be learned to be useable.

Qualitative analysis

The qualitative data is quite unsystematic, so how can these above qualitative data be analysed?

Bogdan & Biklen (1998) stated that qualitative data analysis is a process of systematically arranging, organizing, and breaking down qualitative data into manageable units. Qualitative data analysis must help to discover what is important and what is to be learned.

The next step is to classify and divide the qualitative data into many themes or subjects, which can be used to answer the research goals. In order to limit the interference in analysis due to the human language problem, researchers have to break down the qualitative data into countable units or categories like in close-ended questions. Researchers need to clarify the specific words of the participants into many manageable themes so that the research result can be seen clearly (Bogdan & Biklen, 1998).

Or in other words, the open-ended data should be sorted or 'coded' into several categories. Codes are simply mnemonics labels for the categories. For example, the category 'attitude toward the network' could become 'at-netw'. Everything that belongs to one category should be grouped together so that the researchers can read all comments relating to 'at-netw', for instance (Tesch, 1990).

The categorized comments must be based on the goals of the experiment. The purpose of comment categorizing is to help to answer the research question. It also helps to

focus the analysis to achieve the research goals (Patton, 1990). Because the pilot experiment goal is to compare ST and NT, the student comments are categorised into three groups 'supporting NT', 'supporting ST', 'suggestion for ST' (see table 4.11).

The following table 4.10 breaks the raw qualitative data above into a so-called '**comment code**'. The purpose of comment code is to help counting and categorising the qualitative data just like the quantitative data.

Table 4.10: Comment code table.

Comment Code	The real comment of student
Student1Comment1	"Basically the narrative text is much easier to understand because everyone can easily understand it".
Student1Comment2	"But to understand the spatial text you have to be an expert about it and have to know the syntax very carefully".
Student1Comment3	"A person can not understand the spatial text at first seen".
Student1Comment4	"So, I think narrative will be better for several reasons".
Student2Comment1	"For narrative, it is using long sentence that will be harder to read and understand".
Student2Comment2	"For spatial text, because user needs to transfer to logical thinking, that will be a little bit harder to user to do the test at first time".
Student2Comment3	"If I learn spatial text more, that will be easier to understand the complex question, like ER-diagram".
Student3Comment1	"The narrative text is much easier to understand than spatial text".
Student3Comment2	"Anyone can understand anything, whatever written by narrative text".
Student3Comment3	"on the other hand spatial text needs to understand a lot about signs, which are complicated".
Student4Comment1	"Spatial text is quickly for people to explain the meaning".
Student4Comment2	"but it is little difficult for reader to read".
Student5Comment1	"The symbols of spatial text take a little time to adapt".
Student5Comment2	"some symbols are quite easy to follow".
Student5Comment3	"some symbols should be improved to be more easily understand. When I do the test, I need to find where the spatial no character to locates according to its sign (1, 2, 3)".
Student6Comment1	"Both of them are a bit confusing but equivalent spatial I understood what's going on".

Student7Comment1	“A picture can be better than 1000 words. It’s a fact and some with the spatial text. It is way easier than the narrative text”.
Student8Comment1	“The equivalent spatial text is very complicate”.
Student8Comment2	“It’s hard to remember the equivalent meaning of symbols”.
Student8Comment3	“But in case of narrative text, it can be understood straight away”.
Student9Comment1	“First, the user should know all the meaning of the symbols”.
Student9Comment2	“After they learn it is quite easy to understand the meaning of the sentence by the diagram”.
Student9Comment3	“I think it is a good way in the technical aspect, there is no confused meaning because by grammar or something”.
Student10Comment1	“the spatial text is using so many symbols, hence a bit hard to understand”.
Student10Comment2	“Reducing symbols can change the way at much easier”.
Student11Comment1	“ST easier to understand and simple number table to make people understand the harder sentences”.
Student12Comment1	“The narrative text can be easily understood what the meaning is about. The two actions are very clear for comparing”.
Student12Comment2	“The spatial text is a little confused, it is hard to understand they are two actions, and the comparison is also not very clear”.
Student12Comment3	“The narrative text can be got the meaning after one time reading”.
Student13Comment1	“Spatial text is not straight forward little abstract”.
Student13Comment2	“but if you get used to it sometimes you can find out the answer more easily”.
Student13Comment3	“but not very good on understanding more complicated stuff”.
Student13Comment4	“narrative text is more common and easy to understand”.
Student13Comment5	“For different things, sometimes is too redundancy”.
Student14Comment1	“Narrative text is rather harder to follow than the spatial text because of wordings. Too much wording with the same vocabularies”.
Student14Comment2	“But the spatial text gives much easy to follow directions to answer questions”.
Student14Comment3	“Except, some notations used needs to be learned over time”.

This is a comment classification table based on Table 4.10:

Table 4.11: Comment classification table.

	Student1Comment4	
	Student3Comment1	
	Student12Comment1	
	Student12Comment2	
	Student8Comment1	
	Student13Comment1	
	Student13Comment3	
		Student1Comment1
		Student3Comment2
		Student13Comment
		Student8Comment3
	Because NT is more common	Student12Comment
	Because people can not understand the ST the first time	Student1Comment3
		Student2Comment2
		Student8Comment2
		Student1Comment2
		Student2Comment3
		Student3Comment3
		Student4Comment2
		Student5Comment1
		Student9Comment1
		Student9Comment2
	Because people must understand all the ST symbols before reading ST	Student10Comment
NT is easier to understand than ST		Student14Comment 3
	Student2Comment1	
	Student4Comment1	
	Student5Comment2	
	Student6Comment1	
	Student7Comment1	
	Student9Comment3	
	Student13Comment2	
	Student11Comment1	
	Student14Comment2	
		Student13Comment
ST is easier to understand than NT	**Because redundancy make NT hard to understand**	Student14Comment 1
	Student5Comment3	
Suggestion for ST	Student10Comment2	

There are a lot of comments (24 comments) that support NT in the table 4.11. Out of these 24 comments, 5 comments said that NT is easier because NT is more common, 3 comments said people can not understand ST the first time, and 9 comments said that people must understand ST thoroughly before reading ST.

There are 11 comments supporting ST in which 2 comments stated the redundancy in language making NT harder to understand.

There are 2 comments suggesting that ST needs to be improved to become useful.

Note: the comments of a student are not always corresponding to his or her quantitative result, or the ranking choice answers. A student may have a poor mark on ST, but still give positive comments to ST.

4.3 Discussion

Based on table 4.6 and table 4.11, the candidate understands that there are many shortcomings in the pilot experiment method, which can not be solved easily.

As stated in table 4.6, because $p = 0.388 > 0.05$ so the quantitative results are not significant; this means that certain confounding variables strongly affect the independent variable. We can not see clearly what confounding variable strongly impacted the dependent variable until we read the student comments in table 4.11.

The first shortcoming of the experiment method was that it could not limit one of the strongest confounding variables, '**the previous experience**'. Students used narrative text for many years, but they only had 15 minutes to learn the spatial text before doing

the ST test. As a result, it was very hard for students to understand ST. This would significantly effect the evaluation of students. Although the candidate instructed students carefully 15 minutes before they did the tests, it was not very easy for them to realize a new spatial technical writing language different from the traditional narrative language just in 15 minutes. These were demonstrated in table 4.11, a lot of students stated that they need to understand ST carefully before doing the test. They also confirmed that NT is more popular, and they can understand it straight away. This gave too many advantages for NT, and that is why students achieved better results on the NT test.

The second shortcoming was that, the STW symbols used in the test are just a very small part out of all developed STW symbols. Thus, the candidate could not check all the STW symbols. Beside, people spend years and years realizing the narrative text. Then, 'how can people achieve the expert level of ST as they achieved the expert level of NT?' is a big question.

Third, the design of STW symbols may not be good enough. Some students complain that the STW reference numbers can make it hard for them to understand because they have to spend quite a lot of efforts in matching the reference numbers with the concepts in the concept reference list table in the spatial text.

In addition, because the candidate managed to keep the pilot experiment as fair as possible, in the 15 minute instruction, the candidate did not explain the ability of STW in limiting the structural language ambiguity (as stated in section 'STW grammar') to

students. That is also one of the main reasons why students have not seen the advantages of ST.

Moreover, the low experiment budget also contributes to these shortcomings. The ten dollar reward only attracted a few students to spend 50 minutes for the experiment. It would cost more if students are required to spend more time in the experiment.

Next, as discussed in the section "Development of STW technique", not all English grammar structures can be represented by the current STW technique. For example, how can a writer represent interrogatives such as '*who, what, when, etc*' or conjunctions such as '*however, hence, thus, etc*' in STW?

In fact, it is quite difficult to analyse some complex English grammar structures by sentence diagramming or STW. However, because STW inherits the good characters of the traditional narrative writing such as using simple sentences and clear grammar structures, STW forces writers to use simple and short English sentences to create a STD. Thus, all spatial sentences in a STD should be as simple as possible. In addition, because writers may not know how to write spatially a complex sentence in STW, they may prefer to write spatially simple STW sentences. This can be good for readers, because readers prefer to read simple sentences.

Finally, as mentioned in chapter 1, STW is only feasible if it is supported by a software. This so-called STW software will help writers to create STD, and then readers can efficiently manipulate concepts in this STD by using functions of STW software. However, because of the limited research fund, the candidate could not

create a such STW software. The spatial texts used in the pilot experiment were designed manually by hand on the paper. As a result, students do not have a tool for effectively manipulating the concepts in these spatial texts. This is one of the main reasons why students have not seen the benefits of STW.

However, if you look at Figure 4.1 and Figure 4.2 which compare the mean and median mark of ST and NT, you can see that the quantitative results are not too negative. Although students only have 15 minutes to get acquainted with ST, they did the ST test quite well. For example, the median mark of ST2 is the same as NT2, while the median mark of ST1 is just 1 mark lower than NT1.

Moreover, although a lot of students can achieve a better mark on NT, many of them gave positive comments to ST, as stated in table 4.11. That was enough encouragement to continue the research in the future.

The final conclusion is that because the quantitative result is not significant, the candidate can not approve that ‘ST is easier to understand than NT’, but also can not reject it. Although Table 4.11 figures stated that many students didn’t like ST, this may not be because ST is not good but because they have not thoroughly understood the ST symbols. So, a more thorough experiment should be implemented to evaluate the questions of this thesis. In that experiment, students must be trained in ST properly, and all the ST symbols must be checked. That future experiment will certainly need a lot of budgets and time.

4.4 Summary of this chapter

This chapter outlined the result analysis and discussion of the actual pilot experiment. The quantitative data was analysed by measuring central tendency and dispersion to compare the reading performance between the narrative text and the spatial text written by STW. The student comment qualitative data was broken out into the comment codes to analyse how students evaluate the STW technique. The discussion section then investigated the research method's shortcomings withdrawing from the result analysis. The discussion section also suggested how the future experiment should be implemented in order to limit these shortcomings.

Chapter 5: Future Work

As mentioned in chapter 4, the exploratory study implemented in this thesis showed that there were many shortcomings that prevented the pilot experiment significant. The followings are the list of these shortcomings:

- The previous narrative reading experience of students could help them to achieve better scores on narrative test.

- Only small numbers of all developed STW symbols were used in the test.

- The design of STW symbols may not be good enough.

- The ability of STW in solving the language ambiguity has not been explained to students.

- The time to instruct STW symbols to students was too limited.

- Not all English grammar structures can be represented by STW technique.

- There is no software supporting STW technique.

The goal of STW is to help writers to produce spatial technical documents that does not have language ambiguity and can help readers to efficiently manipulate the concepts. To be able to achieve this goal, in the future work, the candidate has to solve all the shortcomings mentioned above.

The followings are the summaries of all works the candidate needs to do in the future research:

First, STW needs to be expanded to be able to represent all basic English grammar structures.

Second, STW technique needs to be modified and redesigned based on the comments from the students in the current exploratory study.

Third, STW software needs to be developed to help writer to create STD, and help reader to efficiently manipulate the concepts in STD.

Finally, a realistic full-scale experiment should be conducted to test whether STW can help to remove the language ambiguity and efficiently manipulate concepts in STD.

5.1 STW software

The STW technique mentioned in this thesis is just a theoretic foundation, but STW will not be feasible if it is not supported by a so-called STW software. The STW writers can not use Microsoft word or the likes to create 'spatial technical document' (STD) because that would be very laborious and time-consuming. Second, concept map software or sentence diagramming software can not be used to create STD. Sentence diagramming softwares such as Sendraw or ConceptDrawV are only used for drawing sentence diagrams; and other concept map softwares such as CMap tools or Inspiration are only used for drawing concept maps. These softwares use a lot of heavy graphical components. There are thousands of sentences in a technical

document and it will be impossible to use any sentence diagramming software or concept map software to create a very big STD. These graphical softwares can run very slowly when it is used to draw too many STW sentences. In addition, because STW syntax is quite different from sentence diagramming syntax or the spatial representation of concept map, it will be very awkward and difficult to draw STW sentences on sentence diagramming software or concept map software.

Hence, a software that can do all the hard work for STW writers should be developed to make STW technique feasible. STW software should be used to write (not draw) spatially all sentences in a technical document. That STW software should also limit the drag-and-drop graphical components as much as possible, so that it can be run smoothly even though it contains many STW sentences.

Moreover, STW only solves the structural ambiguity, but not the lexical ambiguity. The lexical ambiguity problem can only be solved by integrating a dictionary utility into the STW software. The following explains this clearer.

5.1.1 The Dictionary Utility on the STW software

The STW technique can be implemented on software which integrates the *dictionary utility*. The writer can map all words in the STW diagram to an exact specific meaning in the dictionary utility. In that case, the readers can clearly see the meaning of the unfamiliar or ambiguous words, and thus it can help to limit the lexical ambiguity.

For example: the word '*bank*' is ambiguous because readers don't know if '*bank*' means '*the side of the river*' or '*the place to store money*'. If the STW software has a

dictionary utility, then it can help writers to remove this lexical ambiguity. When a STW writer writes a spatial sentence in STW software, he/she has to match or refer all words in that spatial sentence to the exact meanings in the dictionary utility. This word-matching job will be done by the writer. The readers just need to point the mouse cursor to the word to check what real meaning the writer wanted to give to the word. Let see this hypothetic STW software:

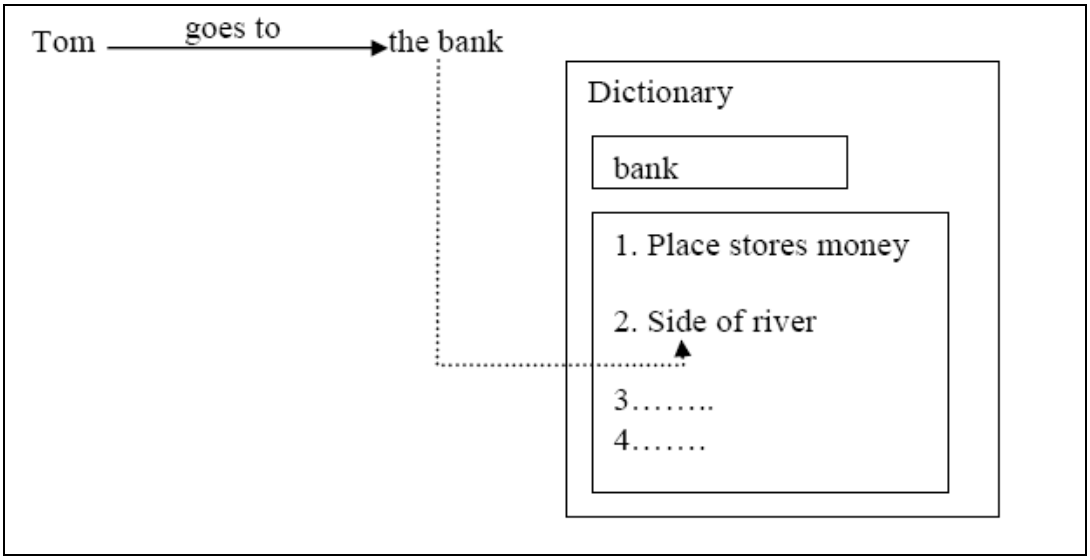


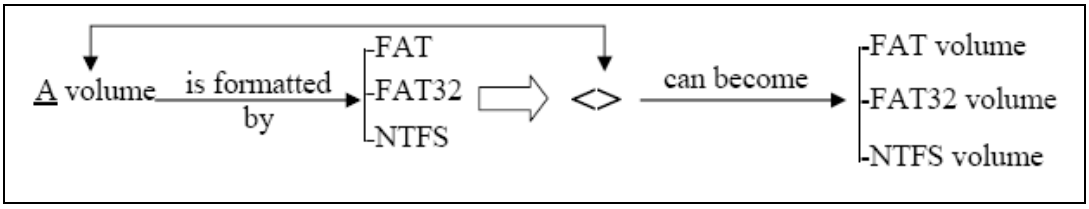
Figure 5.1: A figure showing how a word is matched with a meaning in a dictionary in the hypothetic STW software.

In this case, when the reader moves the mouse cursor to the word '*bank*', the STW software will point to the specific meaning of the word '*bank*'. The readers will know that the writer meant '*the bank*' as '*the side of river*', but not '*the place to store money*'.

Second, if a dictionary does not contain a word that a technical document wants to refer to; the writer has to add that new word with its meanings to the integrated

dictionary. If a current word in the integrated dictionary does not have an additional meaning that a technical document wants to refer to; the writer has to add that new additional meaning to that current word in the dictionary. The dictionary utility must have a function that allows writers to add new words or new meanings of a word into the dictionary. For example, if a technical document wants to mention a computer word '*bank*' which means "*The collection of memory chips or modules that make up a block of memory*" (quoted from *http://www.ontrack.com/*) ("Term and Definition", n.d.), the writer has to add that new meaning of the word '*bank*' into the integrated dictionary if the current word '*bank*' in the dictionary has not yet included that new meaning.

Third, one important point that STW writers should keep in mind is that, the writer must match very specifically a word in a STD to a specific meaning of a word in the dictionary. For example, the sentence '*If a volume is formatted by FAT or FAT32 or NTFS, then that volume can become FAT volume or FAT32 volume or NTFS volume respectively*' is spatially written as following:



When a reader moves the mouse cursor to the first '*volume*' word of the above spatial sentence, the dictionary utility in STW software has to show the meaning of that word as: "*An area of storage on a hard disk. A volume is formatted by using a file system, such as FAT or NTFS, and has a drive letter assigned to it. You can view the contents*

of a volume by clicking its icon in Windows Explorer or in My Computer. A single hard disk can have multiple volumes, and volumes can also span multiple disks" ("Volume Definition", 2002). The following hypothetic STW software shows that:

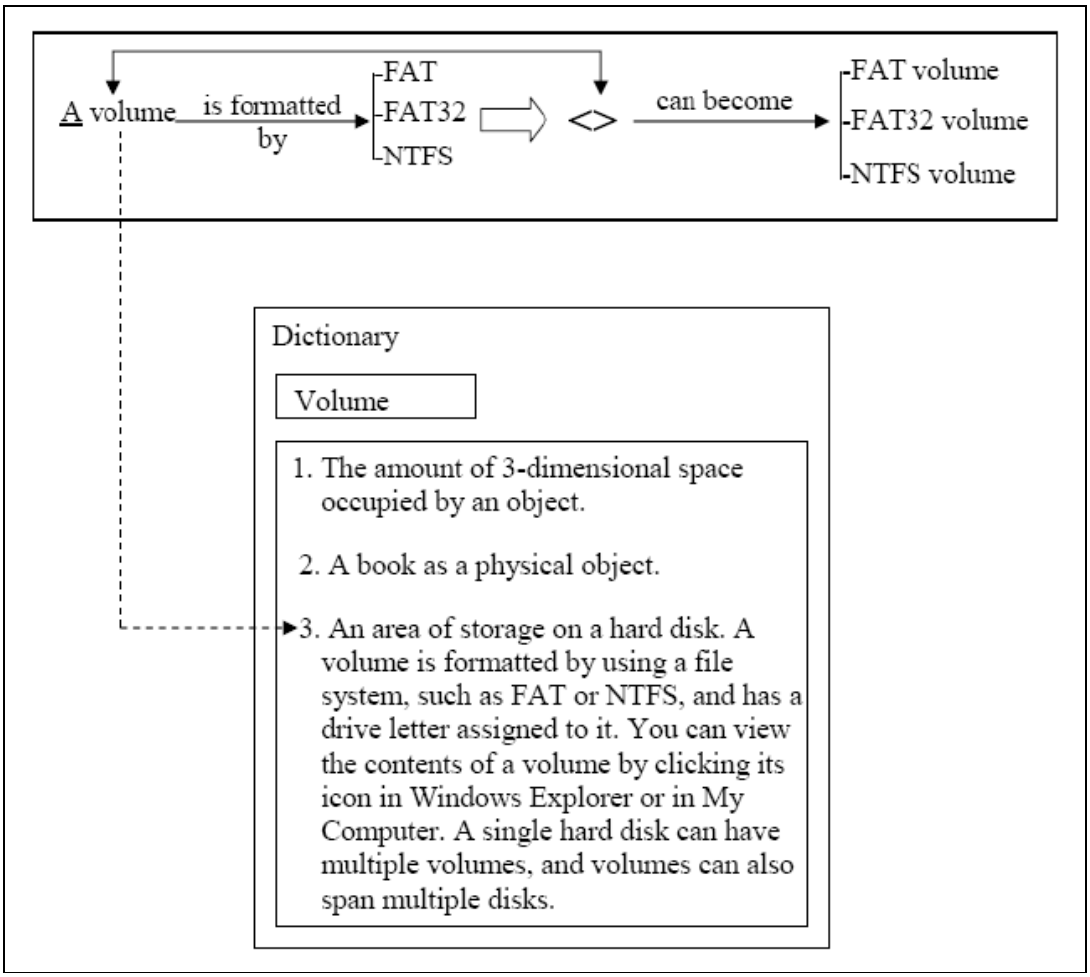


Figure 5.2: A figure showing how word is specified in the hypothetic STW software.

The writer should not match the first '*volume*' word of the above spatial sentence to a general meaning "*the amount of 3-dimensional space occupied by an object*" of that '*volume*' word in the dictionary. This is because the writer wants to mean '*volume*' as "*an area of storage on a hard disk*", so he/she must match very specifically the word

'*volume*' in the spatial sentence to the specific meaning in the dictionary utility. If the writer does that properly, he/she can help readers to manipulate efficiently the word '*volume*' in the dictionary. When readers search for '*volume*' with meaning "*an area of storage on a hard disk*", they can see a list of concepts refers to that meaning.

Nevertheless, when a reader point the mouse cursor to the word '*FAT volume*'; the dictionary utility must show specifically to an explanation for the '*FAT volume*' word (see the below Figure 5.3), but not show the meaning of the first '*volume*' word as the above case. To sum up, the writer must be as specific as possible in word matching job, because this will be very important for readers to manipulate the concepts efficiently.

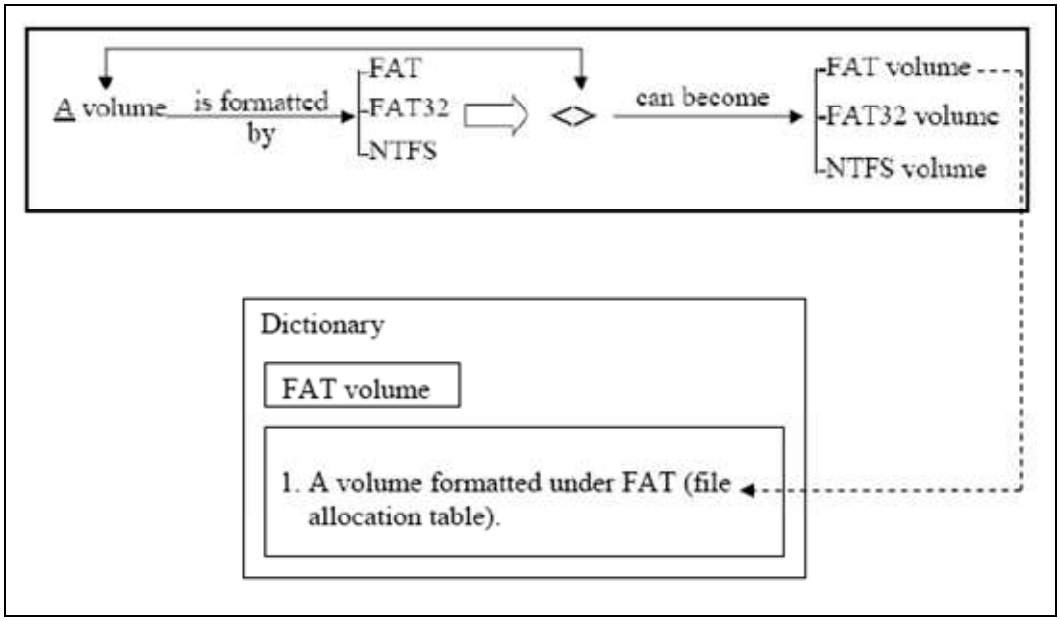


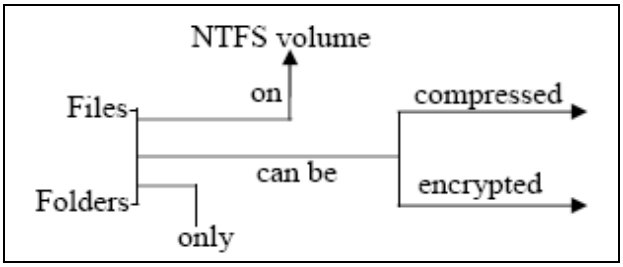
Figure 5.3: A figure showing how word should be matched as specifically as possible in the hypothetic STW software.

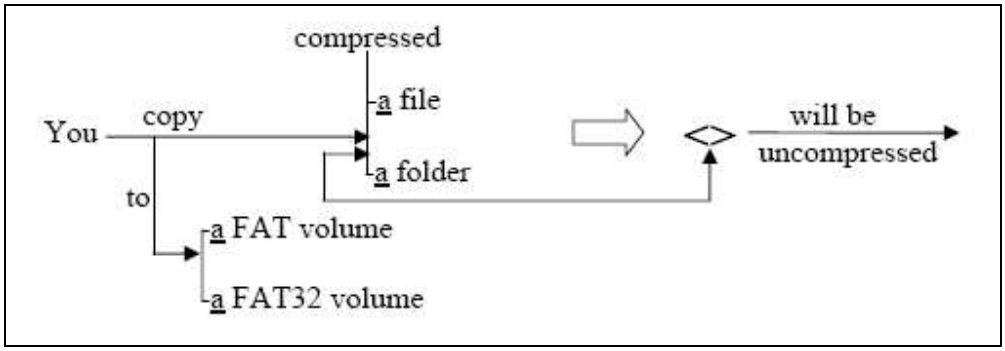
Beside, if a STD is written by many technical writers, then all writers have to consistently control the words or concepts in the STD. That is, two or more different words that share the same meaning should be referred to only one sharing meaning in the dictionary. For example, sometimes the word '*program*' is written as '*application*', '*software*', or '*system*' by other writers. All these words ('*program*', '*application*', '*software*' and '*system*') have to refer to one sharing meaning (for example, '*instructions that tell a computer what to do*') in the integrated dictionary; this sharing meaning may belong to the word '*program*'. If this requirement is well performed, it will be very useful for readers to manipulate and control the concepts in the STD. For example, when a reader clicks the meaning '*instructions that tell a computer what to do*' of the word '*program*' on the dictionary in a specific STD, STW software can search and list every spatial sentence that contain at least one of these words ('*program*', '*application*', '*software*' and '*system*'). The readers will have a full list of a knowledge block mentioning '*program*' in that particular STD. To sum up, writers have to base on the real meanings of the words, but not on the morphology of the words.

5.1.2 The function of STW software in removing the language reference ambiguity problem

As mentioned in the "Result and Discussion" chapter, although the reference number was devised in order to solve the reference ambiguity problem of language, many students complained that the STW reference numbers that proposed early in the current research can make them confused when reading the STD. One of the

characters of language is its implication. For example, these two sentences '*Only files or folders on NTFS volumes can be either compressed or encrypted. If you copy a compressed file or folder to a FAT volume or FAT32 volume, that file or folder will be uncompressed.*' are written spatially as following:





In the narrative text, the readers have to deduce that the word '*compressed file*' in the second sentence is '*the file on NTFS volume*'. However, in STW, because STW requires writer to explicit his/her ideas, the writer has to somehow let the readers know that the words '*compressed file*' in the second sentence is '*the file on NTFS volume*' mentioned in the previous sentence. Because reference number is good for solving the reference ambiguity problem in language, the candidate will not abandon reference number technique being adopted early in this thesis. However, the candidate will use the reference number in a different way. The candidate can solve this reference ambiguity problem by using reference number or a kind of identification

(ID) for each word, and then using that ID to remove the implication as much as possible.

For example, when a reader move the mouse cursor to the word '*file*' in '*compressed file*' in the second sentence, the STW software will pop-up the unique ID of the word '*file*' in '*the file on NTFS volume*' in the first sentence. Let see this hypothesis STW software.

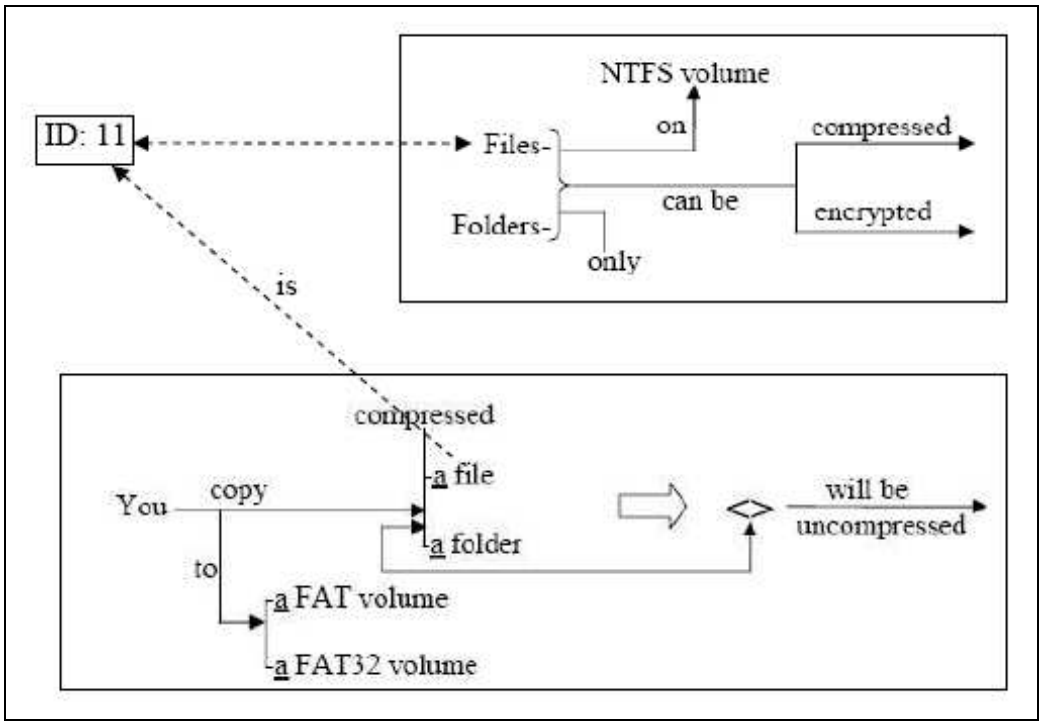


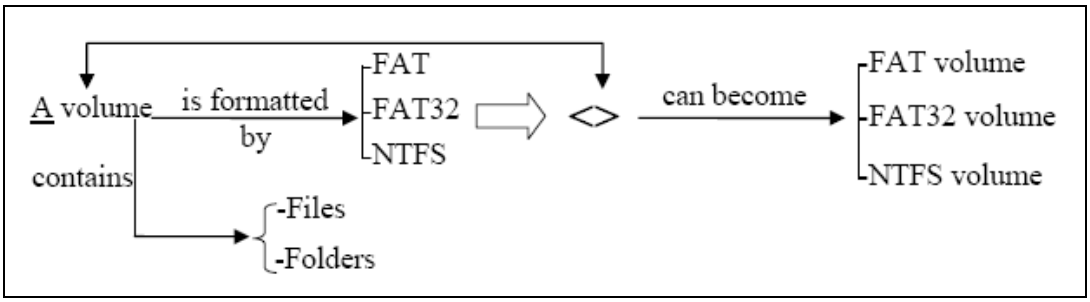
Figure 5.4: A figure showing how reference ambiguity is resolved in the hypothetic STW software.

The dashed double arrow show that the word '*files*' in the first sentence can be replaced by the ID 11, or the ID 11 stands for that word. The dashed single arrow,

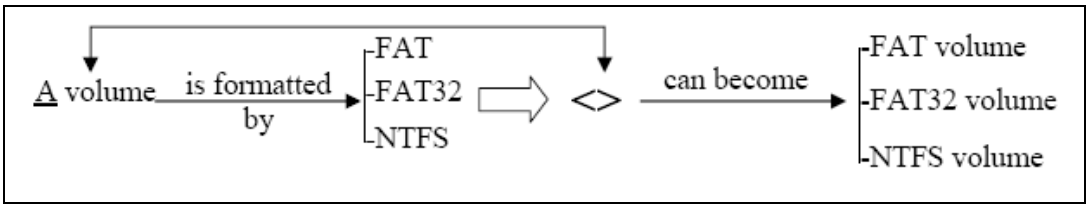
which links from the word '*file*' in the second sentence to the ID 11, means that that second word '*file*' has the same meaning as the first word '*file*'.

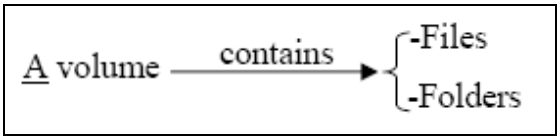
Note: the ID is different from the general meaning of a word in dictionary, because the meaning of the ID equals sum of all meanings connecting to the word with that ID. For example, the ID 11 means *'the file on NTFS volume that can be compressed or encrypted*'. When writing a spatial sentence, a writer should always ask the question "what is this word means specifically?". To sum up, in the future research, concept list will not be used like it was in the early pilot experience because the concept list can confuse the readers. However, the language reference problem can still be solved by forcing the writers to assign a unique ID for the word he/she wants to refer to like the above instruction.

Another important point in revising the STW technique is that, each spatial sentence needs to express one and only one thought (a thought = a sentence). That means each subject in a STW should only have one verb, no subject is allowed to have more than one verb. For example, the following STW sentence using early in the current thesis contains two thoughts because the subject '*A volume*' has two verbs '*is formatted by*' and '*contains*'.



The above spatial sentence should be separated into two sentences like the following:





By expressing each spatial sentence for each thought like this, a writer can limit some confusion for readers because readers prefer to understand completely one thought before moving to the other thought.

In addition to the main functions such as referring the words to the dictionary utility and controlling the concepts as mentioned above, STW software can integrate other supplementary functions that help writers to limit spelling and grammar errors in technical documents as much as possible, just like spelling and grammar checking function in Microsoft Word. For example, when a writer create a spatial sentence of '*These gooses cost 500 dollars*'; STW software will generate an error message require him/her to change '*gooses*' to '*geese*' because the plural of '*goose*' is '*geese*' not '*gooses*'. With the support of the spelling and grammar checking functions, writers can save a lot of time in producing spatial technical documents.

Finally, after STW technique was improved to able to represent all basic English sentences, and after the candidate has already developed a first basic STW software

that underlines STW technique; the candidate has to do a full-scale experiment to test the usefulness of STW technique.

5.2 The future experiment

As mentioned in chapter 1, because of the limited research fund, the candidate could not implement a full-scale experiment in order to test whether STW technique can help readers to efficiently manipulate the concepts and to remove the structured ambiguity existing in the narrative text? The current exploratory study implemented in this thesis has not answered that question yet. The only purpose of the exploratory study (but using the basic quantitative and qualitative method) is to test how students reflect to the STW technique, and it will be used for refining the STW technique in the future. The future full-scale experiment must answer completely the question stated above.

There should have more subjects (probably 200 people) attending the future experiment. The subjects must be realistic people such as managers, employees working in many different types of companies. All the subjects should take the test in that experiment at the same time, unlike the early pilot experiment where only two or three subjects take the test at a time. This can help to get the result as fair as possible.

Besides, the current research only focuses on one independent variable that is the types of text. However, the future research should also evaluate how computer knowledge, gender and English ability affect the experiment result. Thus, the future

research will have many independent variables, not just one like the early pilot experiment.

In the future experiment, a long STD consisting of all types of STW sentences needs to be developed as the experiment instrument. The concept reference list technique used in the early pilot experiment will be removed. The STD will be designed inside the STW software as mentioned above.

The instruction document will represent the examples of all the developed STW symbols. All the subjects will be trained in many days (probably 10 days, 2 hours a day) in order to deeply understand the STW technique. The subjects should be able to see the ability of STW in solving the language ambiguity and the inefficient concept manipulation problem. In this training session, all subjects will also be tested to see if they could understand completely the STW technique. The subjects also learn how to use fluently functions in the STW software so that they will know how to manipulate the concepts in STD. Only subjects who understand properly STW technique are allowed to attend the real experiment.

Unlike the early pilot experiment in which subjects did the reading test using pens and papers, all subjects will do the reading test on computers in the future full-scale experiment. The subjects will use the functions in STW software to manipulate concepts in the spatial text designed for the future experiment.

Each subject should be awarded well for attending the experiment. For example, each subject can be paid 30 dollars for each training session and 50 dollars for doing the

real reading test. The advices from the Statistical Consulting Service in designing the experiment and analysing the experiment result should also be taken into account and applied properly in the future full-scale experiment

Chapter 6: Conclusion

The main purpose of the research was to develop a new technical writing technique for solving the language ambiguity and inefficient concept manipulation problem which could not be solved properly by using the traditional narrative technical writing technique; and conduct an exploratory study to test how a typical student responses to that new technique and to identify key issues for further investigations in the future research.

As a result of this research, a new technical writing technique called spatial technical writing (STW) has been developed, and an exploratory study has been implemented to test how a typical student responses to STW.

The STW's syntax is similar to but simpler than the sentence diagramming technique's. STW forces writers to consistently show the clear relationships among concepts in a spatial text created by applying STW. A spatial text, thus, can help readers to efficiently manipulate the concepts like a concept map. In addition, STW also inherits good characters of the traditional narrative technical writing technique such as using short simple words and sentences. However, one important point to be kept in mind, the proposed STW is not a full-fledged method because STW was created from an iterative, reflective process, i.e., the technique was refined through feedback opinions. Hence, STW has not been able to represent all types of English grammar structure. Currently, STW can only represent basic English grammar

structures such as subjects, predicates, adjectives, adverbs, conditional sentences (IF), comparative sentences, etc.

The exploratory study used a small pilot experiment based on some basic quantitative and qualitative measure methods. The quantitative result showed that students achieved a little higher mark in narrative text than spatial text. However, the qualitative result explained that students have not understood properly the STW; and that is the main reason why students achieved higher marks in narrative text test. The research result required that there is a good reason to broaden the experiment because the experiment result was not significant.

Though there were some limitations expressed in the pilot experiment, this research made two contributions in the Information Systems area. They are the theoretical and practical contribution.

The theoretical contribution of the thesis is the development of a coherent novel technical writing technique and its justification in terms of existing literature. As mentioned in section 3.2.3, a variety of English sentences were represented in STW. The STW technique can help to remove structural language ambiguity and inefficient concept manipulation in the technical documents. Other researchers can thereby investigate critically STW and test the STW usefulness. Besides, as stated above, the STW technique has not developed fully; some English grammar structures have not yet represented in STW. Other researchers can discuss further this matter. In addition, a part of the research question, which stated whether or not STW technique can help to remove the language ambiguity and the inefficient concept manipulation problem

often existing in the narrative text, has not been answered properly because the pilot experimental result was not significant. Other researchers can implement a full-scale experiment to test the usefulness of STW. In that future full-scale experiment, the STW technique needs to be instructed properly to experiment participants so that they can thoroughly understand the STW technique before doing the experiment test. The future experiment also needs to check all types of STW symbols, not only a few limited symbols being used in the early pilot experiment.

The practical contribution, only partially substantiated, is that technical writers can apply this new technique to create well-structured spatial technical documents which do not have the language ambiguity and inefficient concept manipulation problems existing in narrative technical documents. Readers may then be able to more easily and efficiently understand the technical knowledge represented in spatial technical documents. This thesis implemented a pilot experiment to compare the reading performance between STW and traditional technical writing. Although the result of the quantitative experiment is not significant; the qualitative results stated that there is a potential for STW to replace the traditional technical writing technique in the future, because many student comments ranked ST is better than NT.

Moreover, a software that underlines the STW technique needs to be developed. This is because STW will not be practical if it is drawn by hand or on paper. STW only helps to limit the structural language ambiguity but not the lexical ambiguity. STW software with an integrated dictionary utility is the only solution that can solve the lexical ambiguity created by writers. In addition, the future STW software should help

readers to effectively manipulate the concepts or any nouns in the spatial technical documents as stated in the “Future Work” chapter.

The implication of STW software is that it can help people to gradually unify all the technical knowledge by utilizing the Internet. Let imagine an online network where all technical concepts are consistently linked together. This can be supported by the web-based STW software. All the technical knowledge concepts are controlled and tidy. If that spatial knowledge network comes to be true, then people can have a very powerful tool for speeding up their technical knowledge learning processes.

Finally, if there are a technique and software that can help people to accelerate the reading comprehension process of technical documents; then people can solve a big problem nowadays, that is, how to digest the technical knowledge in the shortest time and with the lowest effort?

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APPENDIX A: Research Participant Consent Form

University of Wollongong
Research Participant Consent Form

Consent Form

"Comparing the comprehension of readers on
a traditional narrative text with a novel spatial text."

by
Hung Ha

I have been given information about experimental project title and discussed the research project with Hung Ha who is conducting this experiment as part of a Master by Research supervised by Associate Professor and Doctor in the School of Economics and Information Systems at the University of Wollongong.

I understand that, if I consent to participate in this project I will be asked to do a reading test with giving the permission to the researcher to record my test result.

I have been advised of the nature and purpose of this study, and have had an opportunity to ask Hung Ha any questions I may have about the research and my involvement in it. On the basis of what I have been told, I am satisfied that my participation in this study will be harm or disadvantage me in any way.

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. If I have any inquiries about the research I can contact Hung Ha on , Associate Professor , and Doctor on . 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, Office of Research, University of Wollongong on 02 4221 4457.

By signing below I am indicating my consent to participate in the research entitled "Comparing the comprehension of readers on a traditional narrative text with a novel spatial text", conducted by Hung Ha as it has been described to me in the information sheet and in discussion with Hung Ha. I understand that the data collected from my participation will be used for thesis, and I consent for it to be used in that manner.

Signed Date

…… ……./……./……

Name (please print)

……

APPENDIX B: Instruction Paper for Narrative & Spatial Text

1-Spatial representation for Normal sentence pattern in English

A typical English sentence has this structure:

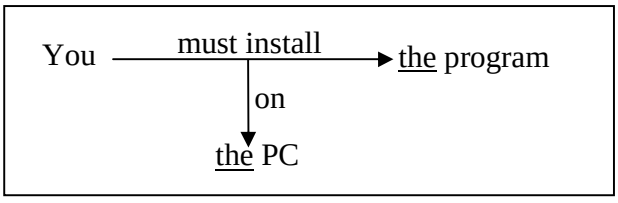
Subject	**Verb**	**Compliment**	**modifier**	**(Active voice)**
You	must install	the program	on the PC	

In the active voice sentence:
-Subject is often a person or thing that does the action.
-The action is the verb.
-The subject precedes the verb (in the case of commands, the subject [you] is understood, example "install the program on the PC").
-The compliment follows the verb. ***Note:*** *Every sentence does not require a complement (ex: "the hyperlink is blinking"), the verb "blink" in this case is intransitive verb which doesn't need a complement.*
-The compliment **CANNOT** begin with a preposition.
-The modifier tells the time, place, or manner of the action (it means the modifier modifies the verb). It is often a prepositional phrase which is a group of words that begins with a preposition and ends with a noun.
-Example of modifier "You must install quickly the program on the PC at 31/12/1999", "on the PC" is modifier of place, "at 31/12/1999" is modifier of time, & "quickly" is modifier of manner(adverb).

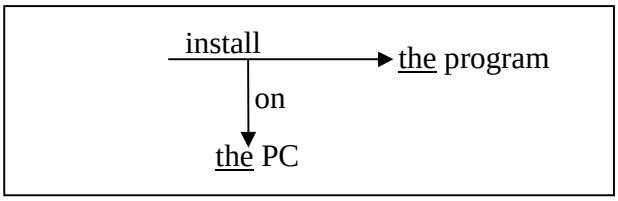
In the passive voice sentence, the compliment is put at the beginning of the sentence.
-Ex: "The program must be installed on the PC"

These are spatial representations for these normal English sentences.

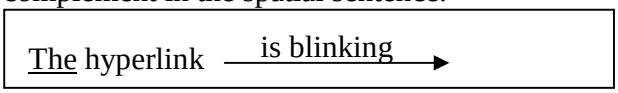
-In the sentence "You must install the program on the PC", the verb is represented by sitting on a single arrow. The arrow direction goes from subject to the complement in a sentence. Because the modifier modifies the verb, so there will be a link between the verb and the modifier. The preposition will sit on an arrow that links the verb with the noun of the modifier preposition phrase.



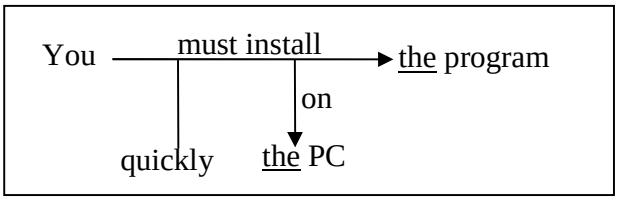
-In the sentence "install the program on the PC", we don't need to represent the subject in spatial sentence.



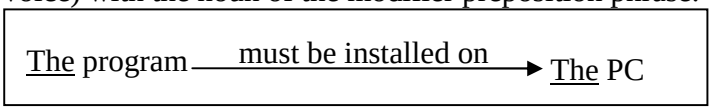
-In the sentence “the hyperlink is blinking”, we don’t need to represent the complement in the spatial sentence:



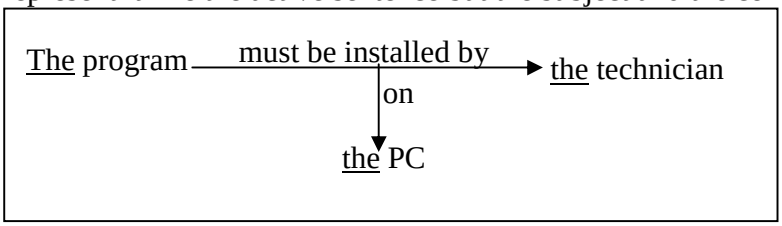
-In the sentence “You must install quickly the program on the PC”, the modifier of manner (adverb) “quickly” is represented by a *non-arrow* line that links it with the verb.



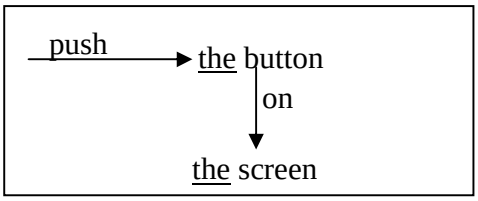
-In the passive voice sentence “The program must be installed on the PC”, the verb & the preposition will sit on an arrow that link the subject (the complement in active voice) with the noun of the modifier preposition phrase.



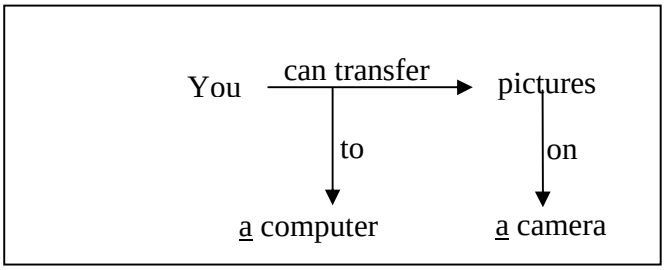
-But in the sentence “The program must be installed on the PC by the technician”, we represent it like the active sentence but the subject and the complement is reversed.



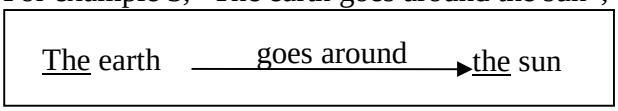
-For the prepositions such as “from”, “to”, “on”, “in”, “out”, “into”, “out of”, “around”, etc, the way of spatial representation is also depended on whether that the preposition *modifies the noun or verb*.
For example 1, “push the button on the screen”,
+“on the screen” *does not modify* the verb “push”, but it modifies the noun “the button”. In this case, the preposition “on” will sit on the arrow linking the 2 nouns- “the button” & “the screen”.



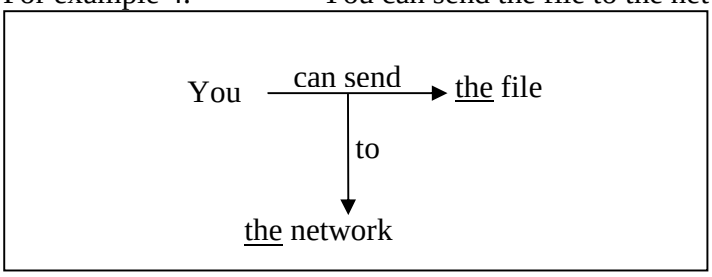
For example 2, "You can transfer pictures on a camera to a computer", *note that:* preposition "to" modifies the verb "transfer".



For example 3, "The earth goes around the sun",



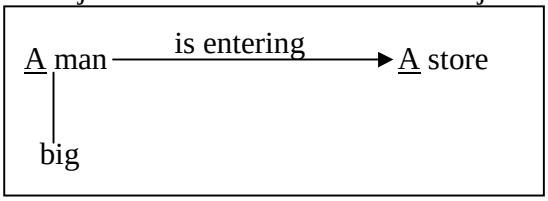
For example 4: "You can send the file to the network"



2-Spatial representation for Adjective pattern

-"A big man is entering a store"

In the narrative sentence, adjective often stands before a noun to modify that noun. In the spatial sentence, the adjective is represented by a *non-arrow line* that connects the adjective with the noun that the adjective modifies.

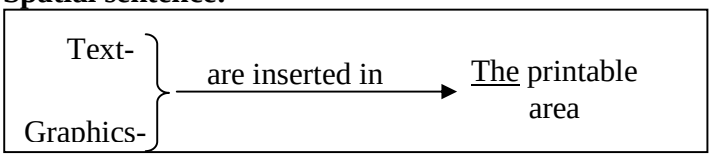


3-Spatial representation for COORDINATOR pattern-"AND" & "OR"

The coordinator "AND"
-The word AND is used as a function word to indicate connection or addition.
Narrative sentence: "The text and graphics are inserted in the printable area"

- In the spatial text, the symbol "{" is used to represent "AND"

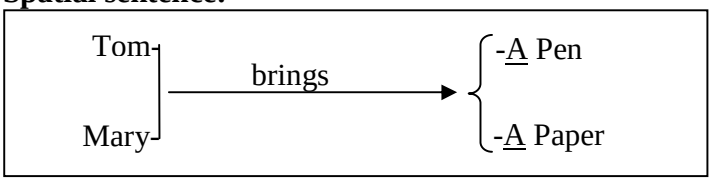
Spatial sentence:



The coordinator "OR"
- The word OR is used as a function word to indicate an alternative <coffee or tea> <sink or swim>
Narrative sentence: "Tom or Mary brings a pen and a paper"

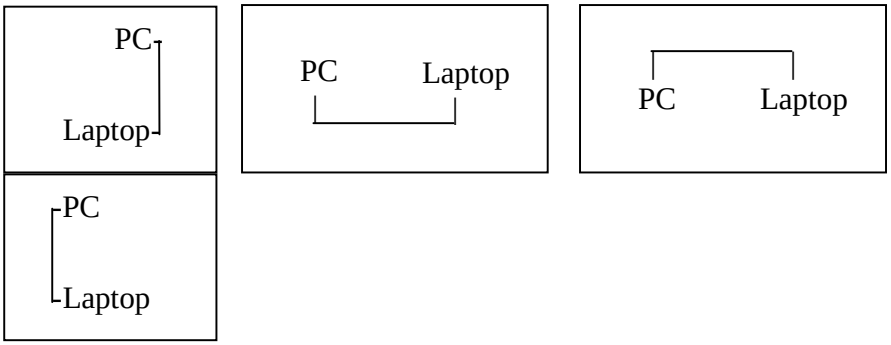
- In the spatial sentence, the symbol "[" is used to represent "OR"

Spatial sentence:



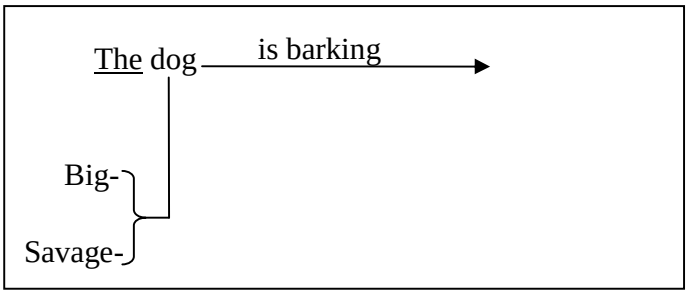
***Note:** The symbol "{" or "[" can be positioned in many different directions.*

For example, "PC or Laptop" can be positioned as:

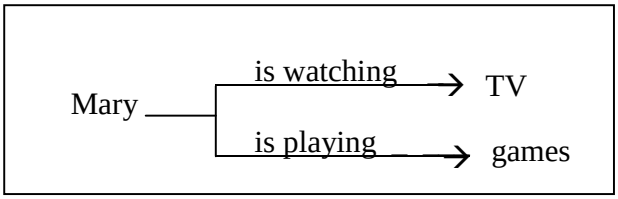


The symbol "{" or "[" can also be used for adjectives or verb.

For example: "The big and savage dog is barking"



Example: “Mary is either watching TV or playing games”



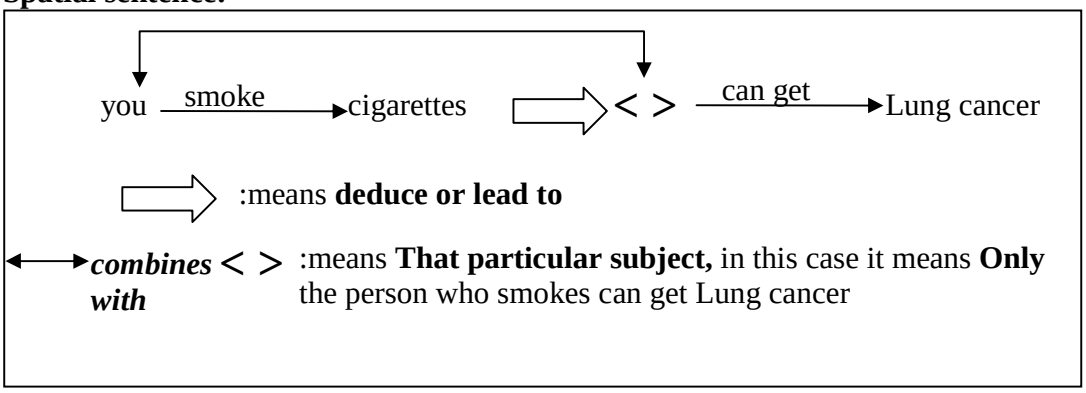
4-Spatial representation for the condition sentence

The condition sentence represents “the relation between a cause and its effect”

Narrative sentence: “If you smoke cigarettes, you can get lung cancer”

In the spatial text, the big arrow connects the “cause” sentence & the “effect” sentence. The double arrow line combined with the symbol <> specifies the particular subject in the “cause” sentence.

Spatial sentence:



5-Spatial representation for Comparison in English

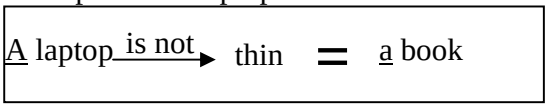
Comparison indicates the degrees of difference with adjective and adverb.

There are 2 levels of comparison:

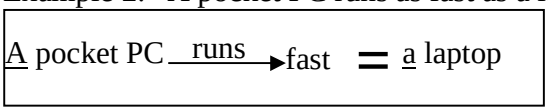
-Equal comparison

In the spatial sentence, we use “=” symbol for equal comparison.

Example 1: “A laptop is not as thin as a book”



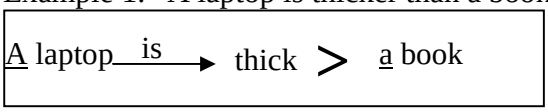
Example 2: “A pocket PC runs as fast as a laptop”



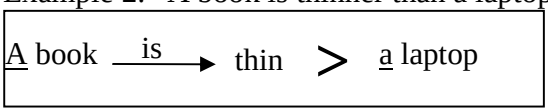
-Unequal comparison

In the spatial sentence, we use “>” & “<” symbol for greater & lesser degree comparison.

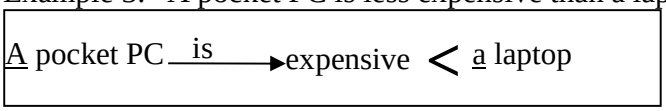
Example 1: “A laptop is thicker than a book”



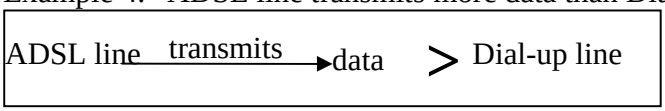
Example 2: “A book is thinner than a laptop”



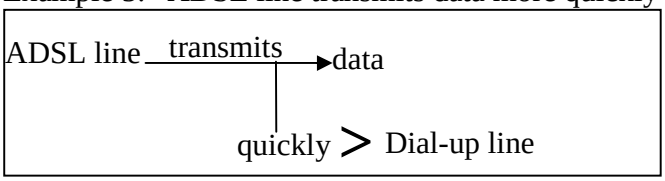
Example 3: “A pocket PC is less expensive than a laptop”



Example 4: “ADSL line transmits more data than Dial-up line”



Example 5: “ADSL line transmits data more quickly than Dial-up line”

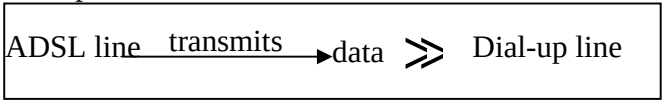


Note: The comparison symbol (“>”, “<”, “=”) should be put near the word that it modifies.

-Intensified Unequal comparison

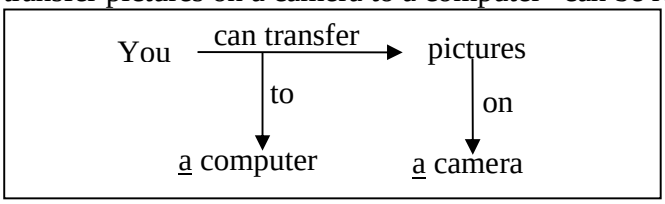
In the spatial sentence, we use “>>” & “<<” symbol for *intensified* greater & lesser degree comparison.

Example 1: “ADSL line transmits much more data than Dial-up line”

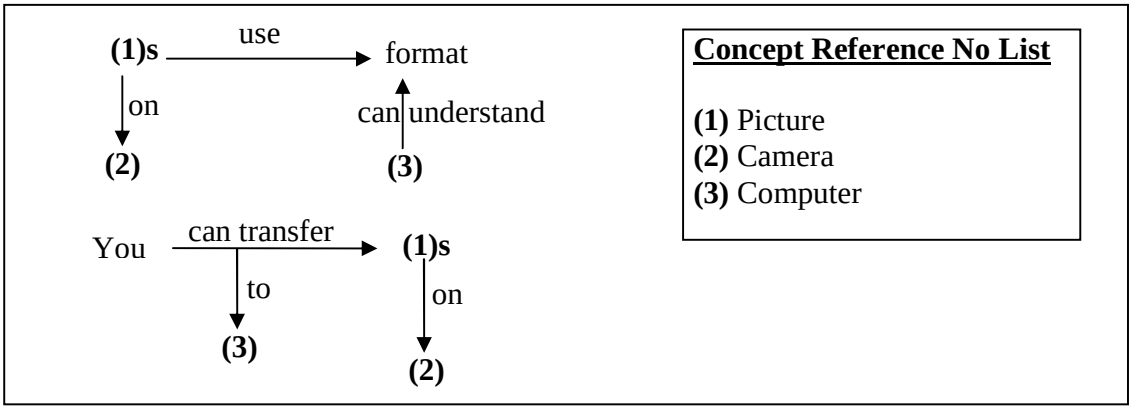


7-General & Specific Reference in Spatial Text

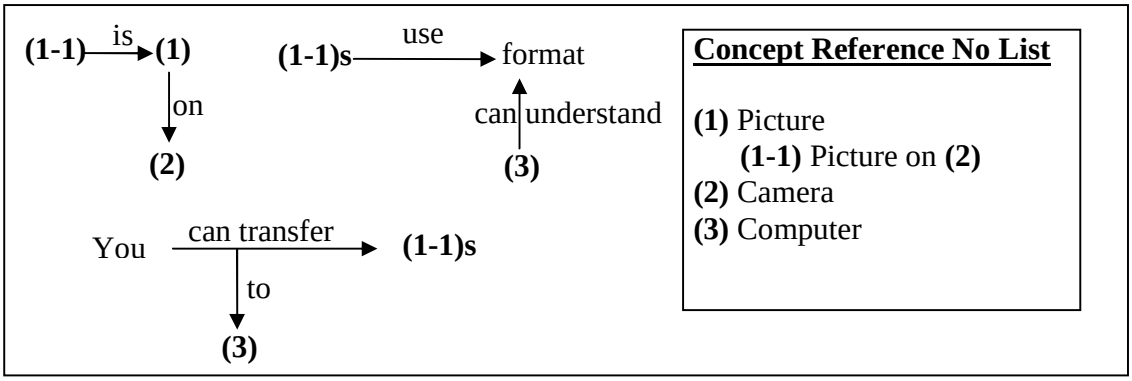
In the spatial text which contains many spatial sentences, all important NOUN words can be given a reference number. For example, a single spatial sentence "You can transfer pictures on a camera to a computer" can be represented like this:



However, let see the spatial text of this example 1: "Pictures on camera use format that a computer can understand. You can transfer pictures on a camera to a computer". All important nouns such as picture, camera, and computer are given a reference number 1, 2, and 3 respectively. The concept reference number refers to a general noun, for example **(1)** refers to "Picture". In the spatial text, if we want to represent the plural, using **s,** for example **(1)s** mean "Pictures". If we want to represent the singular noun, using "A or the" with underscore, for example "A **(1)**" means "A picture".



Spatial text example 2 "Pictures on camera use format that a computer can understand. You can transfer these pictures to a computer".

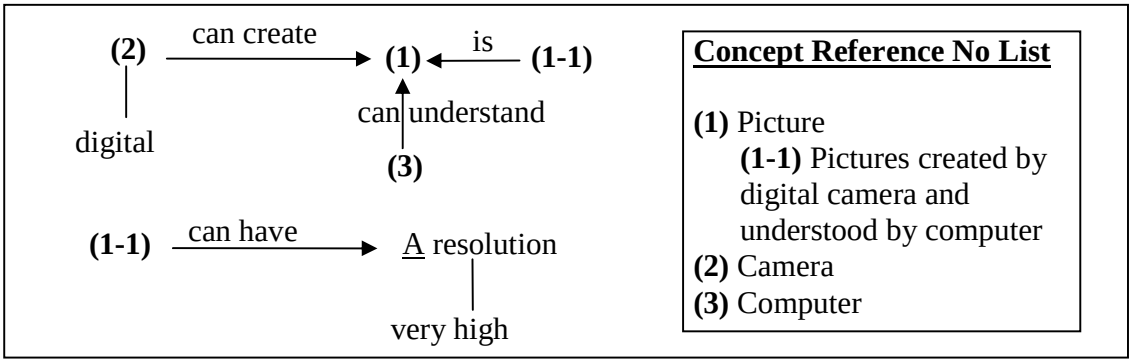


Note: Number 1, 2, 3 in the example 1 & 2 are called **general reference number** because it just mentions a general concept. For example, **(1)** refers to a general "Picture" of any types. Number (1-1) in the example 2 are called **specific reference number** because it points to a specific concept. Normally, "the, this, that, these, those, such" in narrative text play the same role as **specific reference number** in spatial text.

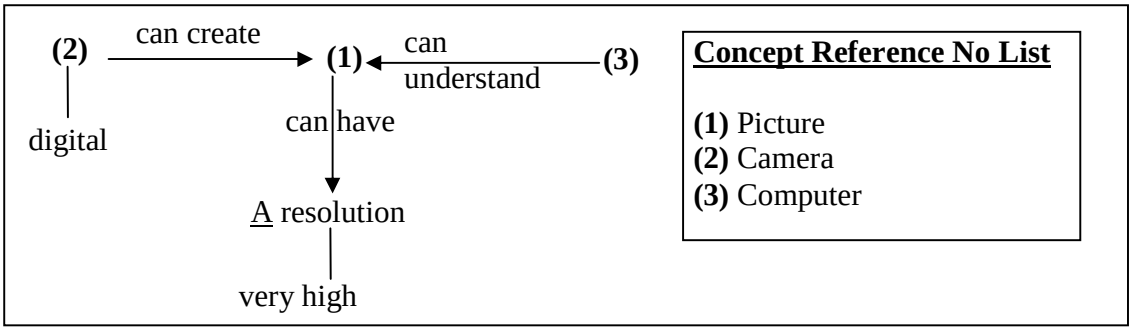
Specific concept reference without number

Let see this example "digital camera can create pictures that computer can understand. These pictures can have a very high resolution". There are two methods to represent spatially this sentence.

Method 1:

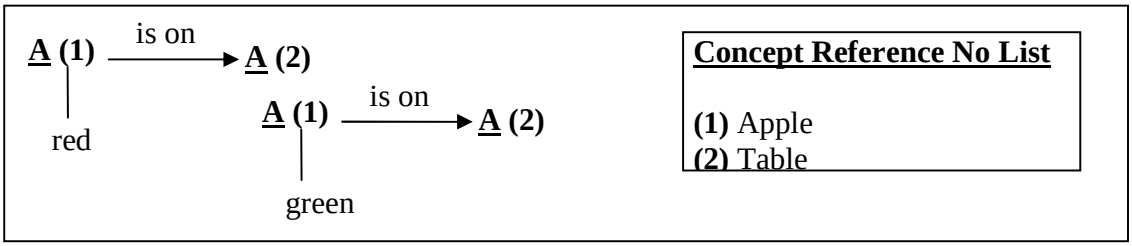


Method 2:

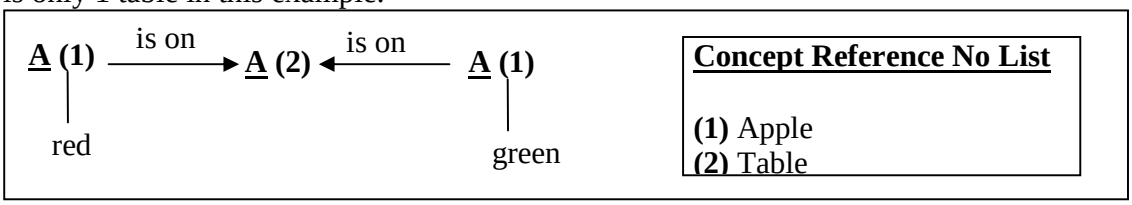


Spatial text represented in method 2 is called **Specific concept reference without number** because we can add the new meaning right to the current reference number without creating a new specific reference number.

Example 3, “A red apple is on a table. A green apple is on a table”. There are 2 tables in this example.



But, example 4, “A red apple is on a table. A green apple is on that (the) table”. There is only 1 table in this example.



This is **Specific reference without number** because the arrow points to the specific concept.

In conclusion, the general meaning of a concept in a single spatial sentence is modified by sum of meanings connected to it.

APPENDIX C: Narrative Technical Text 1

Volume has 2 types: basic volume & dynamic volume. Volume is formatted with FAT or FAT32 or NTFS.

Basic volume has 5 types:
-System partition
-Boot partition
-Primary non-system partition
-Extended partition
-logical drive

Basic volume can not be extended.

Dynamic volume has 5 types
-Simple volume
-Spanned volume
-Striped volume
-Mirrored volume
-RAID-5 volume
    *Simple volume has 3 types:
        +Simple system volume
        +Simple boot volume
        +Simple non-system volume

If Basic volume is upgraded to Dynamic volume, then:

System partition & Boot partition in basic volume will become Simple system volume & Simple boot volume in dynamic volume respectively. Both Primary Non-system Partition or Logical Drive in basic volume will become Simple non-system volume in dynamic volume. These simple system volume, simple boot volume & simple non-system volume can be installed W2K, but they can not be extended.

If dynamic volume is formatted with FAT or FAT32, that dynamic volume can not be extended.

Simple non-system volume, Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can be created in Dynamic volume.

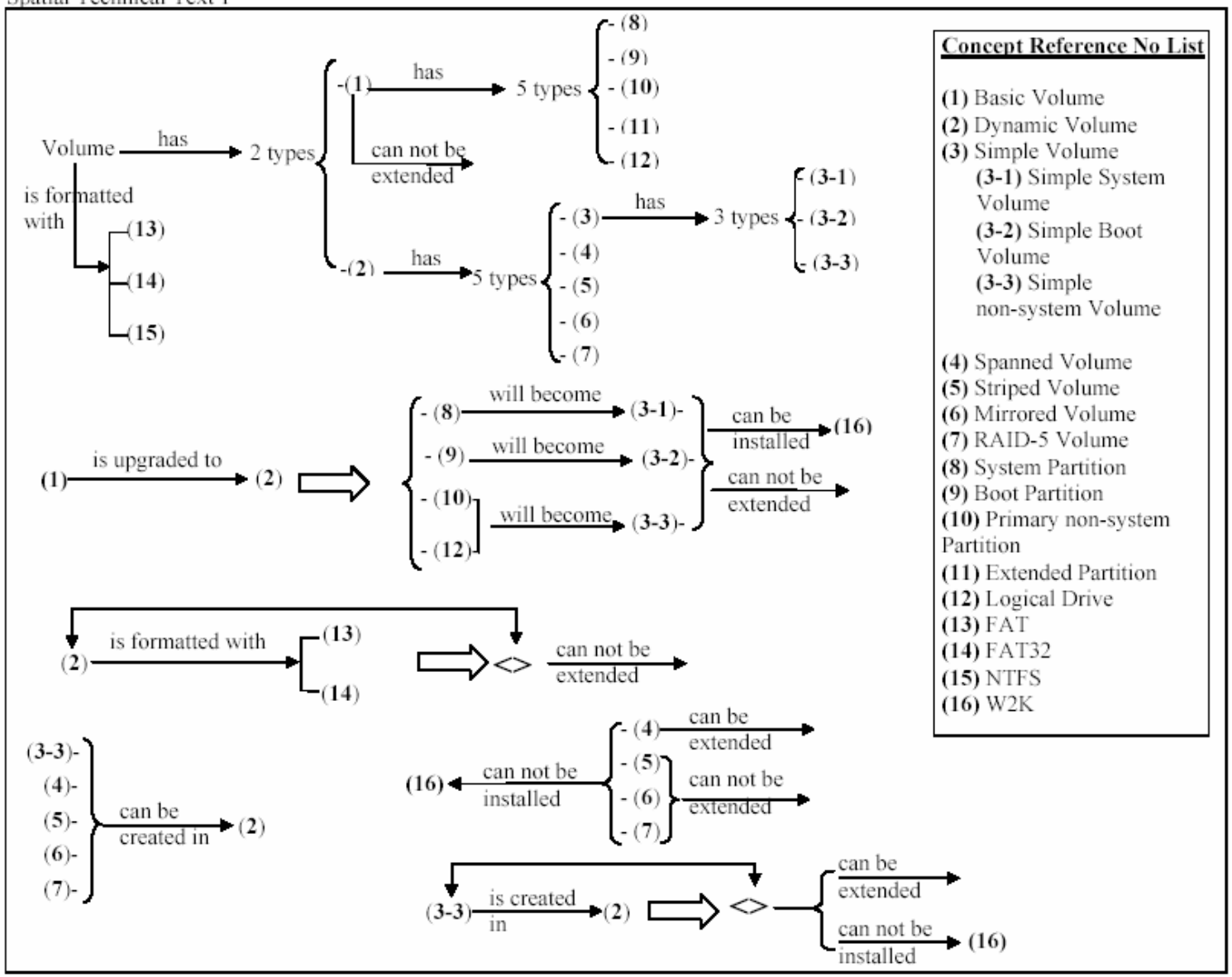
Spanned volume can be extended. Striped volume, Mirrored volume & RAID-5 volume can not be extended. Spanned volume, Striped volume, Mirrored volume, & RAID-5 volume can not be installed W2K.

If Simple non-system volume is created in Dynamic volume, then that Simple non-system volume can be extended but can not be installed W2K.

(revised Dynamic Disk in Windows 2000 Help)

APPENDIX D: Spatial Technical Text 1

Spatial Technical Text 1



APPENDIX E: Narrative Technical Text 2

If a volume is formatted by FAT or FAT32 or NTFS, then that volume can become FAT volume or FAT32 volume or NTFS volume respectively.

A volume contains files and folders. Only files and folders on NTFS volumes can be either compressed or encrypted.

If you copy a compressed file or folder to a FAT volume or FAT32 volume, that file or folder will be uncompressed.

If you copy a compressed or uncompressed file on a NTFS volume to a folder which is on that same NTFS volume or on a different NTFS volume, that file will inherit the attribute of that folder.

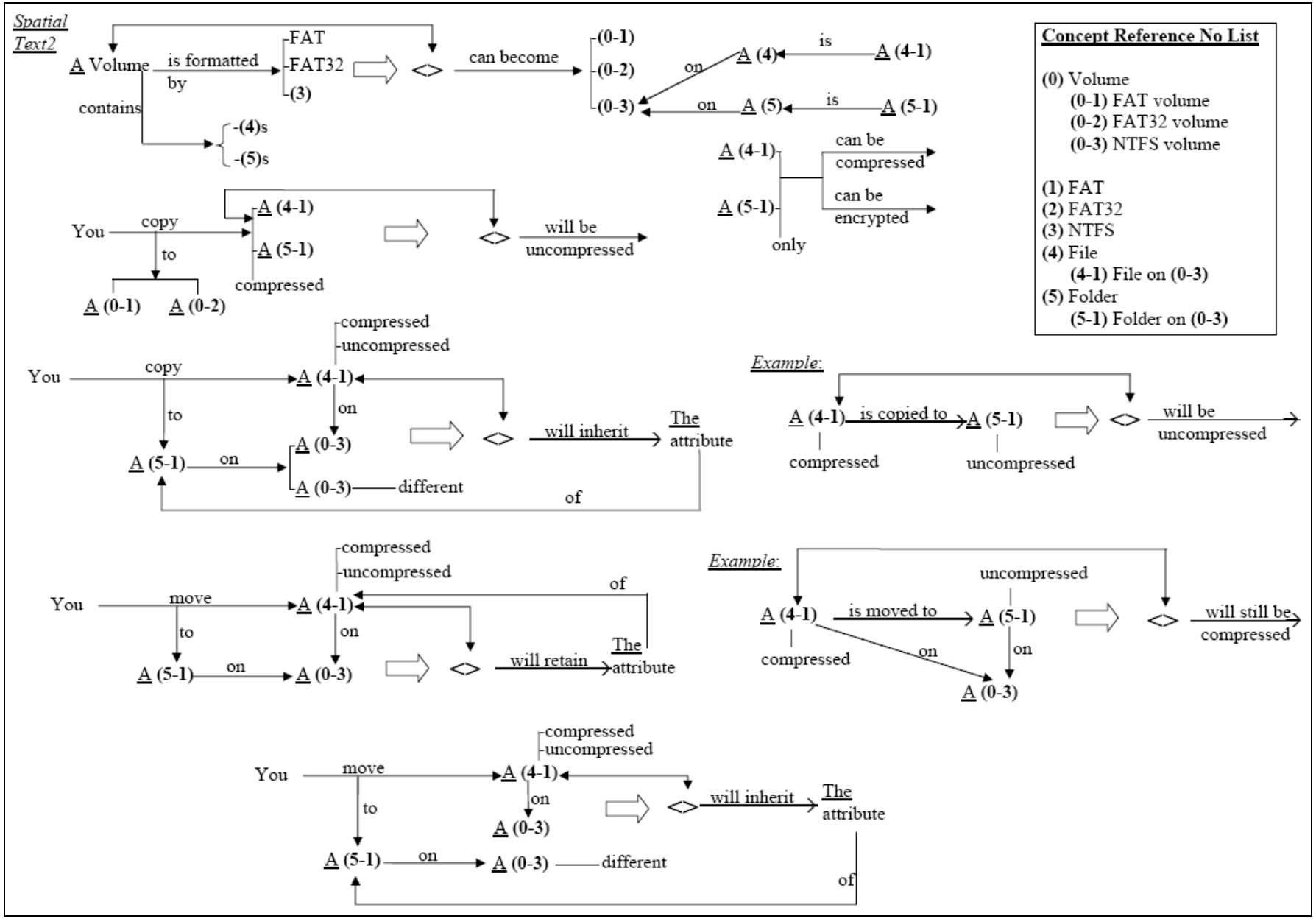
For example, if a compressed file is copied to an uncompressed folder, the file will be uncompressed.

If you move a compressed or uncompressed file on a NTFS volume to a folder on that same NTFS volume, the file will retain the attribute of itself.

For example, if a compressed file is moved to an uncompressed folder on the same NTFS volume, the file will still be compressed.

If you move a compressed or uncompressed file on a NTFS volume to a folder on a different NTFS volume, that file will inherit the attribute of that folder.

APPENDIX F: Spatial Technical Text 2


Spatial Text2
A Volume
is formatted by
FAT
FAT32
(3)
contains
(4)s
(5)s
can become
(0-1)
(0-2)
(0-3)
A (4)
is
A (4-1)
on
A (5)
is
A (5-1)
A (4-1)
A (5-1)
can be compressed
can be encrypted
only
You
copy
to
A (4-1)
A (5-1)
compressed
A (0-1)
A (0-2)
will be uncompressed
Concept Reference No List
(0) Volume
(0-1) FAT volume
(0-2) FAT32 volume
(0-3) NTFS volume
(1) FAT
(2) FAT32
(3) NTFS
(4) File
(4-1) File on (0-3)
(5) Folder
(5-1) Folder on (0-3)
compressed
uncompressed
You
copy
A (4-1)
on
to
A (5-1)
on
A (0-3)
A (0-3)
different
will inherit
The attribute
of
Example:
A (4-1)
is copied to
A (5-1)
compressed
uncompressed
will be uncompressed
compressed
uncompressed
You
move
A (4-1)
to
A (5-1)
on
A (0-3)
of
will retain
The attribute
Example:
uncompressed
A (4-1)
is moved to
A (5-1)
compressed
on
on
A (0-3)
will still be compressed
compressed
uncompressed
You
move
A (4-1)
to
on
A (0-3)
A (5-1)
on
A (0-3)
different
will inherit
The attribute
of

APPENDIX G: Question set 1 for Narrative & Spatial Technical Text 1

Please select only 1 choice (A or B or C) in each following question.

1- Which one is true:

A-Primary non-system Partition can be extended.
B- RAID-5 Volume can be extended.
C- Spanned Volume can be extended.

2- After upgrading basic volume to dynamic volume, the system partition in the basic volume will become:

A- Simple Boot Volume
B- Simple System Volume
C- Striped Volume

3- After upgrading basic volume to dynamic volume, Logical Drive will become Simple Non-System Volume. This Simple Non-System Volume can have one of these characters:

A-can be installed W2K
B- can be extended
C- can not be formatted with NFFS

4- The Simple Volume is formatted with FAT32, so it:

A-Can be extended
B-Can not be extended

5- A Mirrored Volume is created in Dynamic Volume. Which of the following is wrong?

A-That Mirrored Volume can not be extended
B-That Mirrored Volume can not be installed W2K
C-That Mirrored Volume can be installed W2K

6- Which is true?

A- Simple non-system volume, which is formed from Primary non-system partition by upgrading Basic volume to Dynamic Volume, can not be extended.
B- Simple non-system volume, which is created in Dynamic volume and is formatted with FAT, can be extended.
C- Simple non-system volume, which is created in Dynamic volume and is formatted with NTFS, can not be extended.

7- If A Spanned Volume is formatted with FAT, that Spanned Volume:

A- can be extended
B- can not be installed W2K
C- can span its size by upgrading

8- A Mirrored Volume is formatted with NTFS in a Dynamic volume, please select the wrong statement:

A- That Mirrored Volume can be extended
B- That Mirrored Volume can not be installed W2K
C- That Mirrored Volume can not be extended

9- Which one is wrong?

A- RAID-5 volume can be created in Dynamic Volume
B- Boot partition can be formatted with NTFS
C- Spanned Volume can be extended when we format it with Fat32

10- If a Simple non-system volume is created in Dynamic volume & is formatted with NTFS, Which of the following is wrong?

A-That Simple non-system volume can not be extended
B-That Simple non-system volume can not be installed W2K
C-That Simple non-system volume can be extended

APPENDIX H: Question set 2 for Narrative & Spatial Technical Text 2

Please select only 1 choice (A or B or C) in each following question.

1- Which one is true:

A- A file or folder on a FAT volume can be compressed
B- A file or folder on a FAT volume can be either encrypted or compressed
C- A file or folder on a FAT volume can not be encrypted

2- Which one is true:

A- A file or folder on a NTFS volume can be uncompressed
B- A file or folder on a NTFS volume can be either encrypted or compressed
C- A file or folder on a NTFS volume can not be encrypted

3-A compressed Folder on NTFS volume is copied to a FAT volume, that Folder:

A- will still be encrypted
B- will be uncompressed
C- will be compressed

4- You copy a compressed File B on a NTFS volume to a compressed Folder A on a different NTFS volume.

A-File B will inherit the attribute of the Folder A.
B-File B will be uncompressed.
C-File B will retain the attribute of itself.

5- You move a compressed File B on a NTFS volume to a compressed Folder A on a different NTFS volume.

A-File B will retain its attribute.
B-File B will be uncompressed.
C-File B will inherit the attribute of the Folder A

6- You move an uncompressed File A on a NTFS volume A to a compressed Folder A on that same NTFS volume A.

A-File A will still be uncompressed
B-File A will be compressed
C-Folder A will be compressed

7-You copy a compressed File C on a FAT32 Volume C to a Folder C on that FAT32 Volume C.

A-File B will be compressed
B-File B will be uncompressed
C-This sentence is wrong because only files on NTFS volumes can be compressed

8-You move an uncompressed File A on a NTFS volume to a compressed Folder B on a different NTFS volume. After moving:

A-File A will be compressed
B-File A will be uncompressed
C-Folder A will be compressed

9- You move a compressed File B on a NTFS Volume B to a certain folder on that same Volume B

A-File B will be decrypted
B-File B will be uncompressed
C-File B will still be compressed

10- You copy an uncompressed File A to a compressed Folder A. The File A & The Folder A are on the same NTFS Volume A.

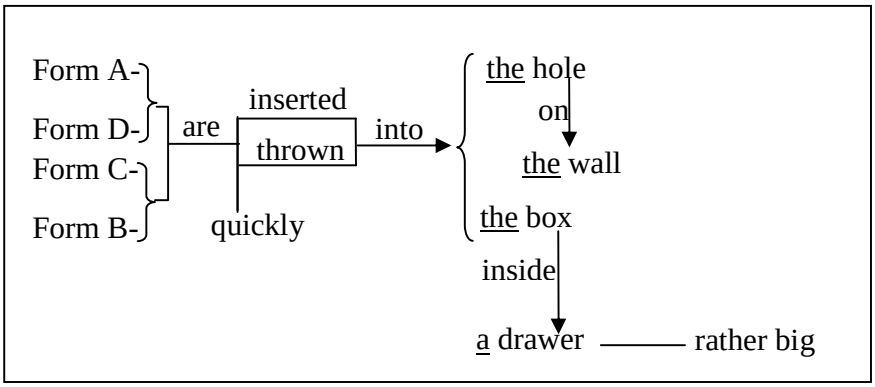
A-File A will be uncompressed
B-File A will be compressed
C-Volume A will be compressed

APPENDIX I: Opinion Question

Opinion Question about narrative text and spatial text

Given you **this narrative text**:
"Form A and Form D or Form C and Form B are inserted or thrown quickly into the hole on the wall and the box inside a rather big drawer".

And **the equivalent spatial text**:



Based on this example, please answer these 2 questions:

1-Please rank the type of text by choosing one of these

A. The narrative text is **very much easier to understand** than the spatial text

B. The narrative text is **rather easier to understand** than the spatial text

C. The narrative text is **a little easier to understand** than the spatial text

D. The narrative text is **a little harder to understand than** the spatial text

E. The narrative text is **rather harder to understand than** the spatial text

F. The narrative text is **very much harder to understand than** the spatial text

2-Please give your comment about spatial text and narrative text

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APPENDIX J: The multiple-choice answers and total mark of each student doing NT1/ST1, or NT2/ST2 test

Appendix

The multiple-choice answers and total mark of each student doing NT1/ST1 test:

The correct choice for each question in NT1/ST1 test	**1-C**	**2-B**	**3-A**	**4-B**	**5-C**	**6-A**	**7-B**	**8-A**	**9-C**	**10-A**	**Total mark**
Student1-ST1	1-A	2-A	3-A	4-B	5-B	6-A	7-B	8-B	9-A	10-B	4
Student2-NT1	1-C	2-A	3-B	4-B	5-B	6-B	7-A	8-C	9-B	10-B	2
Student3-NT1	1-C	2-B	3-B	4-B	5-B	6-B	7-B	8-A	9-C	10-A	7
Student4-ST1	1-C	2-B	3-A	4-B	5-A	6-C	7-A	8-A	9-C	10-B	6
Student5-NT1	1-C	2-B	3-A	4-B	5-C	6-A	7-B	8-A	9-C	10-C	9
Student6-ST1	1-C	2-C	3-A	4-B	5-B	6-C	7-B	8-A	9-C	10-A	7
Student7-ST1	1-C	2-B	3-A	4-B	5-A	6-C	7-C	8-C	9-C	10-C	5
Student8-NT1	1-C	2-B	3-A	4-B	5-B	6-A	7-A	8-A	9-C	10-A	8
Student9-NT1	1-C	2-B	3-B	4-B	5-B	6-C	7-B	8-A	9-C	10-A	7
Student10-ST1	1-A	2-B	3-A	4-B	5-C	6-A	7-A	8-C	9-C	10-B	6
Student11-ST1	1-C	2-B	3-A	4-B	5-C	6-B	7-B	8-A	9-C	10-B	8
Student12-NT1	1-B	2-B	3-A	4-B	5-C	6-A	7-B	8-A	9-C	10-A	9
Student13-ST1	1-C	2-B	3-A	4-B	5-C	6-B	7-B	8-B	9-C	10-A	8
Student14-NT1	1-C	2-B	3-A	4-B	5-A	6-C	7-A	8-A	9-A	10-C	5

The multiple-choice answers and total mark of each student doing NT2/ST2 test:

The correct choice for each question in NT2/ST2 test	**1-C**	**2-B**	**3-B**	**4-A**	**5-C**	**6-A**	**7-C**	**8-A**	**9-C**	**10-B**	**Total mark**
Student1-NT2	1-B	2-B	3-B	4-A	5-A	6-A	7-B	8-B	9-B	10-A	4
Student2-ST2	1-B	2-B	3-B	4-B	5-A	6-B	7-C	8-B	9-C	10-B	5
Student3-ST2	1-B	2-C	3-B	4-C	5-A	6-C	7-A	8-B	9-B	10-C	1
Student4-NT2	1-C	2-B	3-B	4-A	5-A	6-A	7-C	8-B	9-C	10-B	8
Student5-ST2	1-B	2-A	3-B	4-C	5-C	6-B	7-C	8-A	9-B	10-B	5
Student6-NT2	1-B	2-B	3-B	4-C	5-C	6-A	7-C	8-B	9-A	10-A	5
Student7-NT2	1-C	2-B	3-B	4-A	5-A	6-B	7-C	8-A	9-C	10-B	8
Student8-ST2	1-B	2-B	3-B	4-C	5-C	6-B	7-A	8-A			4
Student9-ST2	1-C	2-B		4-B	5-C	6-A	7-C	8-B	9-C	10-A	6
Student10-NT2	1-A	2-B	3-B	4-A	5-A	6-B	7-B	8-C	9-C	10-B	5
Student11-NT2	1-A	2-B	3-C	4-A	5-C	6-A	7-B	8-B	9-C	10-A	5
Student12-ST2	1-B	2-A	3-B	4-A	5-C	6-A	7-B	8-C	9-A	10-B	5
Student13-NT2	1-C	2-B	3-B	4-A	5-C	6-A	7-C	8-A	9-C	10-B	10
Student14-ST2	1-B	2-B	3-A	4-A	5-A	6-B	7-A	8-A	9-C	10-A	4

Explanation: The two above tables show the multiple-choice answers and total mark of each student doing NT1/ST1, or NT2/ST2 test. The top lines in the tables show the correct choice of each question in NT1/ST1, or NT2/ST2 test. The following lines represent the real multiple-choice answer of each student. The '**total mark**' columns show the number of correct answers of each student for his/her text type in the test.