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M. Morgan
Monash University

G. Brickell
University of Wollongong, gbrickel@uow.edu.au

Barry Harper
University of Wollongong, bharper@uow.edu.au

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Michael Morgan, Monash University, Melbourne, Australia, michael.morgan@infotech.monash.edu.au
Gwyn Brickell and Barry Harper, University of Wollongong, Wollongong, Australia,
gbrickel@uow.edu.au, bharper@uow.edu.au

Abstract: This research analyses video data to examine changes between levels of process of text-based content of learners using two versions of the 'Copy and Paste' function, an unmodified control version and an experimental version with an embedded interaction strategy designed to prompt learners to process more content effectively. Observed learner activity types were categorized as involving Low, Medium or High levels of cognitive processing and the pattern of learner switching between these levels is examined. The conclusions drawn from this analysis indicate that learners not only need mediating artifacts that prompt them to use appropriate processing strategies but that they also need to be made aware of; i) the level of cognitive processing in which they are engaged and ii) more importantly to be prompted to switch activities to those involving higher levels of cognitive processing when they have been conducting low level processing for extended periods.

Background

In 2004 and 2005 a study was conducted into a mediating artefact, the 'Copy and Paste' function, as reported in Morgan, Brickell, & Harper, 2006a, 2006 b, and 2008. The 'Copy and Paste' function was of interest because it is integrated into many computer-mediated learning environments. This study arose out of concerns that the fundamental affordances of the 'Copy and Paste' function were undermining the Constructivist learning principles that underpinned the design of many interactive learning environments, such as the multimedia package *Exploring the Nardoo* (1996), a product aimed at secondary schools and focusing on issues of water quality and use. The study involved university students processing text-based resources for an essay task, which emphasized the need to synthesize information from several sources. It was theorized that effective processing techniques require extensive interaction with content at the time of reading and collection rather than at a later time when context and meaning of the text segments may be forgotten. The study focused on the use of a modified 'copy and paste' tool incorporating and embedded interactive strategies support tool with three main sources of data, video observations of learner activity, pre and post treatment surveys of learner familiarity with note taking techniques, and finally an examination of the text notes produced by learners. With regard to the video observation of learner activity, Morgan, et. al., (2008) reported an interesting contrast between the data tracks of those students in the Experimental Group (modified 'copy and paste' tool) and those students in the Control Group (unmodified 'copy and paste' tool). Students in the experimental group tended to move backwards and forwards between different levels of processing while those in the control group often became stuck in low level processing activities.

A number of interesting question arise from this observation. Is making an appropriate interaction strategy available sufficient for effective learner processing of content? Do the learners need to be made aware of their current level of processing? Finally, do learners need to be prompted to change levels of cognitive processing when they have been processing content at a low level for an extended period? This paper extends the analysis of the original data and examines the relationships between three factors; i) the relative distribution of high level processing as opposed to low level processing of content, ii) the frequency of changes in processing levels, and iii) student outcomes as identified by the relationship between essay score and overall unit grade. It is hypothesized that; a) higher levels of cognitive processing will correlate strongly with higher performance, b) a high frequency of changes in the level of processing will correlate with higher performance, and c) a regular distribution of changes in the level of processing will correlate with higher performance. This paper will attempt to address these hypotheses in order to suggest ways in which learners can be made aware of the level of cognitive processing in which they are engaged and to be prompted to change processing levels when appropriate.

The 'Copy and Paste' Function

The aim of the initial study in redesigning the 'Copy and Paste' function used in notepad tools was to change the order and manner in which the learners carry out the learning activity. Three issues were identified; i) it was too easy to appropriate content 'as is', ii) the processes of exploring and responding to information tended to be separated, and iii) the difference between original and copied work was not made explicit, (Morgan, et. al., 2006a). For the study reported here, the form of the 'Copy and Paste' learning activity was reorganised to integrate a deeper information processing strategy into the interaction. The interaction was also modified to assist the learner to preserve contextual information regarding the original content in order to facilitate the generation of understanding and the appropriate use of copied content. It was also intended that the constraints of the tool would be focused on discouraging ineffective interaction strategies such as plagiarism. In this context the ownership of content was clarified through the constraints of the tool, clearly formatting copied text in blue italics, so that both the learner and the teacher could assess more accurately the level of the performance of the learner through their output in the form of a project or presentation. The order in which processes are carried out during the learner's interaction with content was also rearranged in order to allow the learner to process the content for understanding at the time it is moved out of its original context. This was intended to alleviate delays between the collection of content and the use of that information in order to construct a response. Another issue that was addressed was the implementation of strategies to assist the learner in organising their notes so that they become a useful resource for knowledge construction, review and project construction. The figure 1 shows the compilation of all these strategies into the interface of the redesigned 'Copy and Paste' function used in the initial study in the form of a pop up dialogue box, which consists of five components: assigning a label or keyword, noting of the source of the content or a reference, differentiating quoted material through formatting of the text block, relating the material to a question or concept, and finally creating a summary.
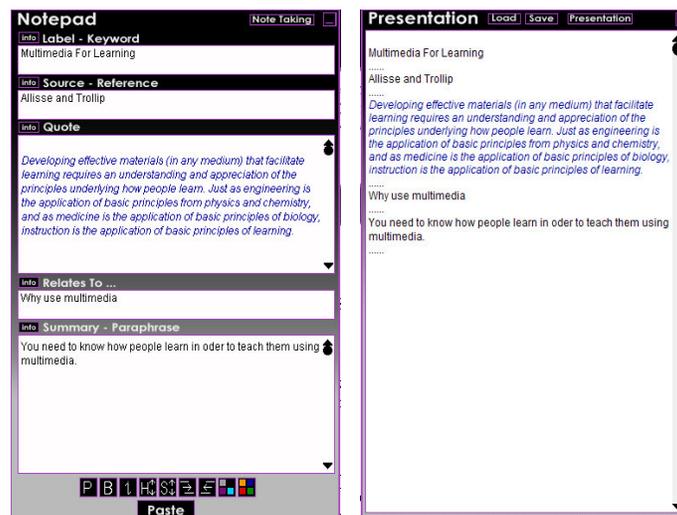

Fig 1 : The Modified Version of the 'Copy and Paste' Function, Dialogue Box and Notepad Window.

In order to assess the impact of the modified version of the 'Copy and Paste' function a method was devised to characterise the observed onscreen activity of participants as involving either, high, medium or low levels of cognitive processing as described in Morgan, et. al, (2008). Three basic types of learner activity were identified for the video data; i) Creating/Composing text generally requiring High Levels of cognitive activity - defined as the act of writing texts without direct reference to external resources, ii) Manipulating/Restructuring generally requiring Medium Levels of cognitive activity- the process of altering, re-sequencing, combining, refining or elaborating one or more existing texts, and iii) Consuming/Browsing generally requiring Low Levels of cognitive activity - experiencing existing content through reading, navigating or copying with little or no attempt to manipulate or alter the resource. Each of these three basic types of activity was then aligned with specific observable actions such as Creating/Composing being aligned with activities writing, labelling and summarisation, Manipulating/Restructuring being aligned with paraphrasing and reorganisation of text, and finally

Consuming/Browsing being aligned with browsing text, navigation, and the 'Copy and Paste' action.

The effectiveness of the experimental treatment in promoting high levels of learner processing of content has been reported in Morgan, et. al, (2008). To summarise these results of learners using the modified version of the 'Copy and Paste' function in terms of ; changes to interaction strategies employed by learners, changes in learner familiarity with note taking and summarisation interaction strategies, and changes to the features of the text produced by learners; significant differences were observed in each area between the Experimental and Control Groups. For the purposes of this paper the results of video observations of learner activity are summarised. After approximately 13 hours and 43 minutes of video taped observations were analysed, significant differences were detected in the nature and duration of participants' onscreen activity between the Experimental and Control Groups. The most significant finding was that on average the Experimental Group spent 27.65 % (High, such as writing) of their time engaged in activities that indicated a high level of cognitive processing, 5.11% (Medium, such as referencing), and 67.25% (Low, such as browsing) which was a much higher percentage than the Control Group, 6.67% (High), 1.63% (Medium), and 91.70% (Low). Statistical analysis indicated a significant t Test, 4.75, n=59, $p < 0.001$, for a difference between the Experimental and the Control groups in the percentage of time spent in activities indicative of high levels of cognitive processing, differences of medium levels of cognitive processing were not significant, and differences in the percentage of time spent in activities indicative of low levels of cognitive processing were significant, t Test 3.47, n=59, $p < 0.01$. The Experimental Group tended to display a greater range of activities, and also a willingness to switch between activities, requiring differing levels of cognitive processing, such from browsing and copying to labelling, writing and summarisation activities. It was an important finding of the study that the Control Group spent much less time engaged in activities that indicated a high level of processing. This pattern of low levels of engagement with the content was widespread and persistent in the Control Group who used the unmodified version of the 'Copy and Paste' function and tended to confirm that there was a major problem with the affordances of this tool. The Control Group tended to pursue low level processing strategies such as browsing for extended periods and rarely interrupted the browsing activity to process the content further in order to consolidate their learning by using other forms of activity that required higher levels of processing.

While the initial study into the 'Copy and Paste' function described above produced some significant results, several features of the data collected warranted further investigation. One particular aspect of the data that was of interest was the frequency and distribution of changes in processing level displayed by the participants. Participant activity in the Control Group tended to follow a pattern of browsing the resource for extended periods, using the 'Copy and Paste' function for three or four seconds, checking the copied material in the notes and then a return to browsing activity. This interaction cycle generally featured extended periods of browsing but very short periods of text manipulation, and in general all activities indicated a fairly low level of cognitive processing of the content. In contrast the Experimental Group tended to have a markedly different interaction cycle with a greater variety of activities evident. This group frequently moved from Low Level processing tasks such as browsing to High Level processing tasks such as labelling and summarisation. The remaining sections of this paper seek to examine these issues by first discussing the role of mediating artefacts in facilitating appropriate learner interaction strategies. The paper will then go on to systematically describe differences in the interaction patterns observed between the Control and Experimental groups and to relate these differences to student outcomes. Finally the implications of these results will be discussed.

Theory

Vygotsky (1980) has argued that the cognitive processes of humans are to a large extent enabled and shaped by artefacts from the cultural context. This concept differentiates distributed cognition and activity theory (Cole & Engeström, 1993; Engeström, 1999; Hutchins, 1995; Hollan, Hutchins & Kirsch, 2000; Nardi, 1996; Pea, 1993; Perkins, 1993; Salomon, 1993; and Wertsch, 1985) from other theories of cognition such as information processing theory, (Atkinson & Shiffrin, 1971). Information processing theory is generally concerned with the means by which stimulus is processed internally by the individual. The significant events in the cognitive process are seen to be internal to the individual and therefore, the outcomes of cognitive activities are determined primarily by the internal resources of the individual. The goal of the information processing view of cognition is the efficient and accurate internalisation of

information or strategies. This results in the view that information is only useful and accessible once it has been internalised. In contrast, distributed cognition theory sees the mind as a node embedded in a mesh of social and cultural relationships.

> Minds are not passive representational engines, whose primary function is to create internal models of the external world. The relations between internal processes and external ones are far more complex, involving coordination at many different time scales between internal resources—memory, attention, executive function—and external resources—the objects, artifacts, and at-hand materials constantly surrounding us. (Hollan, et al., 2000, p. 177)

A valid outcome of cognition in terms of distributed cognition theory may involve the successful utilisation of resources in the environment, or the adaptation of a mediating artefact to a new context or purpose, or even the fixing of a successful pattern of cognition or activity into a new mediating artefact.

> … *effects with* technology, how the use of a technology often enhances intellectual performance; *effects of* technology, how using a technology may leave cognitive residues that enhance performance even without the technology, and *effects through* technology, how technology sometimes does not just enhance performance but fundamentally reorganizes it. (Salomon & Perkins, 2005, p72.)

The arena for examining issues of cognition is therefore changed from the concept of the mind in isolation, planning actions and evaluating experiences, to the mind situated and enmeshed in a context.

Distributed cognition and activity theory (Jonassen & Land, 2000; Kaptelin &Nardi, 2006, and Sternberg & Preiss, 2005), extend and clarify the nature of mediating artefacts in important ways from Vygotsky's initial concept. Distributed cognition focuses on outlining the nature of mediating artefacts, especially those mediating artefacts that take advantage of the physical characteristics of designed tools. It also seeks to describe how mediating artefacts can restructure cognitive activities in important ways, such as maintaining representations of information, offloading tasks in order to reduce internal cognitive load, automation of processes, distribution of computations across time and space, removing redundant computations, and constraining actions. Distributed cognition also examines how mediating artefacts represent reified or fixed patterns of reasoning. Activity theory takes a slightly different approach by outlining how mediating artefacts influence individuals working in concert to achieve group activities. In particular goals and plans, roles and division of labour are seen as important mediating artefacts that control actions and result from activities. Mediating artefacts are interesting from this perspective because they persist beyond individual instances of action and can only be understood fully by tracing the historical development of the artefact.

The 'Resources Model', proposed by Wright, Fields and Harrison (2000) provides an important insight for a discussion of learning activities.

> The resources model takes seriously the idea introduced to HCI by Suchman (1987), that various kinds of external artefact can serve as resources for action and it defines a set of abstract information structures which can be distributed between people and technological artefacts. These information structures can be combined to inform action, and in taking an action new resources are configured. (Wright, et al., 2000, p. 5)

Action, and how internal and external resources shape it, is one way to examine the activity of learners in computer mediated learning environments. To a large extent the teacher, or the learning environment designers, often set the goals of the learning interaction. In this sense the teacher or designer assumes an executive function of setting goals. Often the learner is not in a good position to examine what resources are available to achieve the specified goals or to develop a plan for action. Often the goals in learning environments are only generally outlined or are implicit. What are sometimes needed are an explicit representation of the goals and an explicit representation of effective plans for action based on the available resources. According to Wright, Fields, et al. "The resources model also introduces the concept of interaction strategy and describes the way in which different interaction strategies exploit different information structures as resources for action." (Wright, et al., 2000, p. 5). One aspect of activity in learning environments is linking broad educational goals to specific activities that allow these goals to be realized. In some cases learners may not make formal plans and as the difficulty of the cognitive task increases they will sometimes fall back in to ineffective interaction strategies such as the indiscriminate use of the 'Copy and Paste' function, often resulting in plagiarism.

Figure 2 depicts an inclusive model of a cognitive system based on distributed cognition theory that emphasizes flows between internal and external elements of the system. It emphasises the idea that interaction strategies can be supplied from various sources in the system, both internal and external. Interaction strategies provide a good example of the fact that the resources that shape and enable cognitive processes are not limited to internal cognitive resources and may be derived from a variety of sources. Wright, et. al. (2000), point out that all activities require a range of 'resources for action'. These resources not only influence the nature of the activity but also the nature of the cognitions that occur during that activity. Interaction strategies, structures that control action, are probably the most important category of the 'resources for action' discussed by Wright, et. al. but they are only one example of the resources for cognition that may be distributed between the internal and external components of the system.
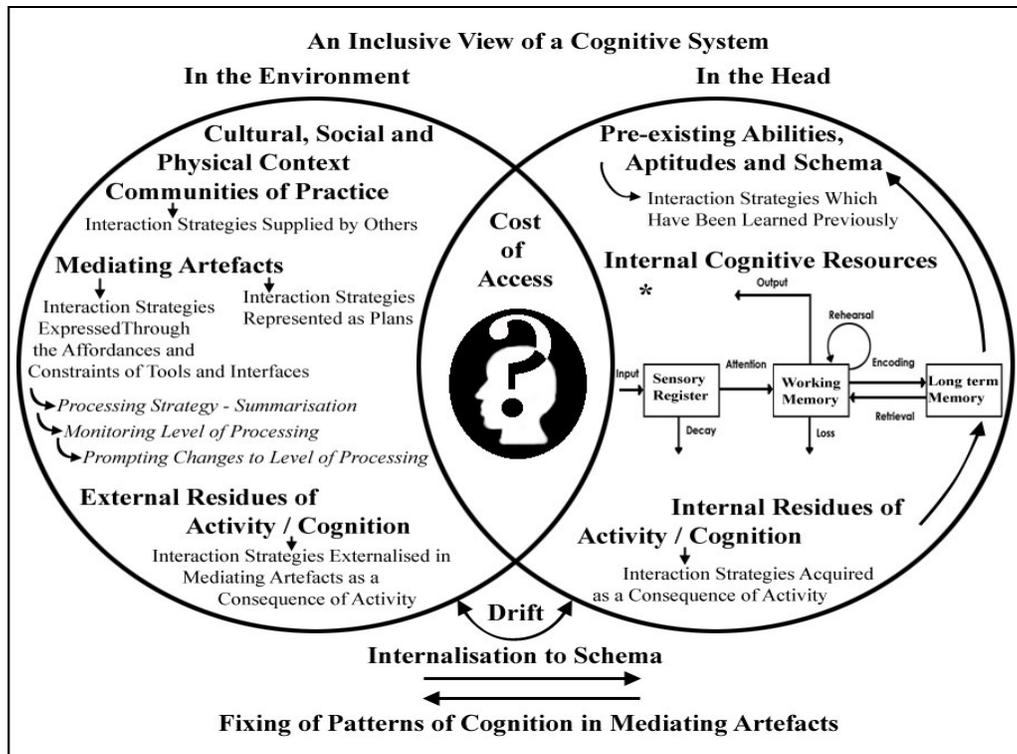

Fig 2 : Distributed Cognition Systems – Sources of Interaction Strategies.
*(Adapted from Morgan, et. al., 2008 and * adapted from Atkinson & Shiffrin, 1971)*

In terms of distributed cognition theory the actual source of the interaction strategy, whether internal or external, not as important as its access characteristics. Access characteristics, or the cost of access, may be assessed from a variety of perspectives. These include the reliability of access, the ease with which it is employed, and the cost in internal cognitive resources of accessing and using the resource. All internal and external resources will have a variety of costs and benefits. Results of the initial study of the 'Copy and Paste' function seem to indicate that embedding an interaction strategy into the interface of a tool may be more effective than resources represented in the environment in the form of a plan for action or relying on internal resources to remember and implement the appropriate interaction strategy. In addition inappropriate strategies that have unintentionally been embedded in the interface due to the historical development may work to subvert more effective interaction strategies that are represented in the environment as a plan, that are supplied by others, or that have been learned. In the context of this paper three aspects of a 'Copy and Paste' interaction strategy embedded in the interface are identified as being of interest. Firstly, it has been demonstrated that a summarisation information processing strategy can be embedded into the interface. Secondly, it is proposed that learners may need to be assisted to monitor the level of processing of content at which they are engaged. Finally, learners may need to be prompted change levels of processing when they have been engaged in low level processing for extended periods.

Figure 2 also indicates that cognition and activity produces residues both internally, in the form of schema, and externally in the environment, in the form of mediating artefacts. In learning activities there is a two way process of internalisation of resources and externalisation of resources. Both these process can represent learning gains for the system and can in turn have a significant impact on future cognitive activity. The cognitive activity engendered by the process of externalising/fixing a pattern of cognition in the affordances and constraints of mediating artefacts may also result in a very strong learning effect in terms of schema development. Finally represented in Figure 2 under the heading of 'Internal Cognitive Resources' is an adaptation of the Atkinson and Shiffrin (1971) model of human cognitive architecture. These cognitive resources are a vital part of a cognitive system but do not adequately describe the entire system from a distributed cognition perspective. It is the interaction between these elements and the environment that defines the nature of the cognitive activity that occurs.

To summarise these issues, 'interaction strategies' can be embedded in the interface in order to assist the user complete specific tasks in computer mediated learning environments. The consequence of embedded interaction strategies into interfaces is to free the learner's cognitive resources to focus on interacting with and processing the content for understanding. This approach may also be useful in modelling a variety of interaction strategies for learners. This contrasts with the practice of relying on the learner's familiarity with appropriate interaction strategies or showing the learner a strategy and then expecting the learner to implement the strategy using their internal cognitive resources. The approach proposed takes into account the role of mediating artefacts and activity that influence the total cognitive system.

Methodology

In 2004 and 2005, over three one hour sessions, video observations of learner onscreen activity were conducted with students interacting with text-based resources in order to prepare notes for an essay task using modified and unmodified versions of the 'Copy and Paste' function. Video observations of 59 sessions were recorded, with some students being observed more than once over the three-week period, and these observations were analysed to identify the nature and sequence of learner activity resulting in 59 data tracks, Experimental 30 and Control 29. In addition, data was available for 33 essay marks for the task and the matching final subject grades that these students, Experimental 17 and Control 16. This data was examined to identify any correlations between the frequency, sequence and distribution of changes in the learner's level of processing and learner outcomes.

The initially the methodology required the data to be prepared for analysis. First all time observations were converted from minutes and seconds to seconds in order to facilitate data handling. Secondly, all sequential activities that were categorised as having the same level of processing were combined, thereby indicating only when the participant actually changed their level of processing rather than when they changed activity. The number of changes to levels of processing was then counted for each data track. The video observations varied somewhat in duration, for example in the 2005 data the longest observation lasted 17 minutes and 34 seconds while the shortest lasted 5 minutes and 34 seconds, Experimental average 893 seconds, Control average 767 seconds, overall average 832 seconds. Therefore all time tracks were scaled to a Standardised Time Factor (STF) of 10 minutes (600 seconds). This data was graphed on a timeline to indicate the frequency and sequence of changes in processing levels for the two groups, in order to show the pattern and distribution of changes to the level of processing, as shown in Figure 3.

Variations to the length of observations presented an issue when examining the frequency of changes to the level of processing, as it would be expected that longer observations would yield a greater number of changes. A Scaling Factor (SF), derived by dividing the original time by the standardised time, was calculated and applied to the raw data for the number of changes in processing levels. This resulted in a corrected number of changes to levels of processing standardised to the 600-second time period, as shown in Figure 4. Finally, data on student performance needed to be prepared. Due to the fact that some participants were observed more than once over the three-week observation period, changes to the level of processing for these subjects were averaged. For each participant an essay mark and an overall grade for the unit were available. In order to attempt to correct for variations in participant ability a Student Success Factor (SSF) was calculated by dividing the essay score by the overall subject grade.

Analysis and Results

Figure 3 represents an average of the data tracks of Experimental and Control groups scaled to a standard 600-second time factor. The level of processing is represented on the *y*-axis, 3 representing a High level of processing, 2 a Medium level and 1 a Low level. It proved to be impractical to represent all 59 data tracks on a single graph therefore an average for the Experimental and Control groups has been given. In order to generate these average tracks the total number of data points at a level for each group were counted and scaled to a standard 600-second time segment, (exp 1-121, 2-48, 3-96, con 1-92, 2-20, 3-34). This yielded the proportion of scores at each level, which was then combined with the average number of changes in processing levels (exp=8.04 and con=4.52), resulting in an average of the scores at each level (exp 1-4, 2-2, 3-3, con 1-3, 2-1, 3-1 with rounding applied). In order to calculate the time spent at each level the average percentage of time, (exp High-27.65%, Medium-71, Low-67.25%, con High-6.67%, Medium-1.63, Low-91.7%,), was applied to the 600-second time range and the result divided by the count at each level. Finally a logical arrangement for the patterns of changes in processing levels was plotted as shown in Figure 3. The average plot indicates a 3 to 1 proportion of incidences of High level processing events for the Experimental group and a 2 to 1 proportion of incidences of Medium level events.
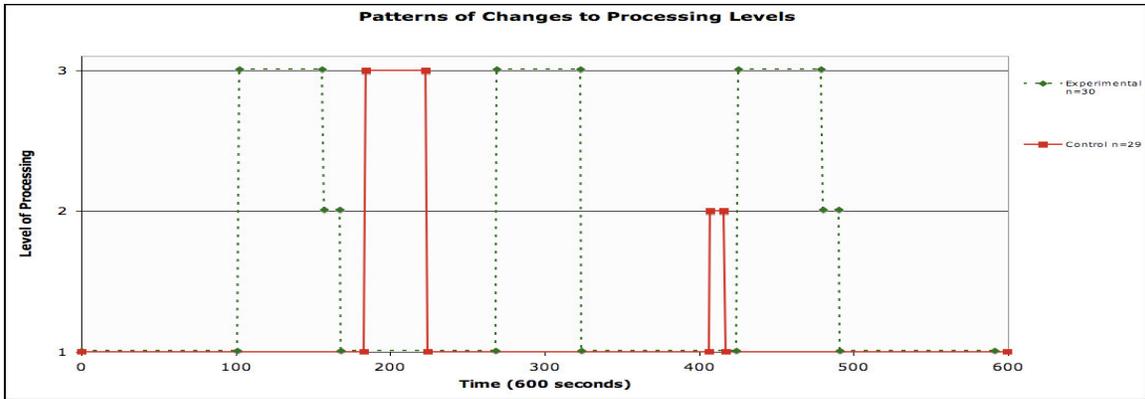

Fig 3 : Average Patterns of Processing for Experimental and Control Groups.

In Figure 4 the frequency of changes in processing level of the Experimental and Control groups is shown. These results have been scaled to take into account variations in the length of observations with the number of changes recorded over 600 seconds. The Experimental group averaged 8.04 changes while the Control group averaged 4.52. Observations are ranked in ascending order of frequency of changes and this reveals a greater tail of readings under the level of 5 changes in processing level per 600 seconds, or under 1 change per 2 minutes of activity, in the Control group (22) than in the Experimental group (8).
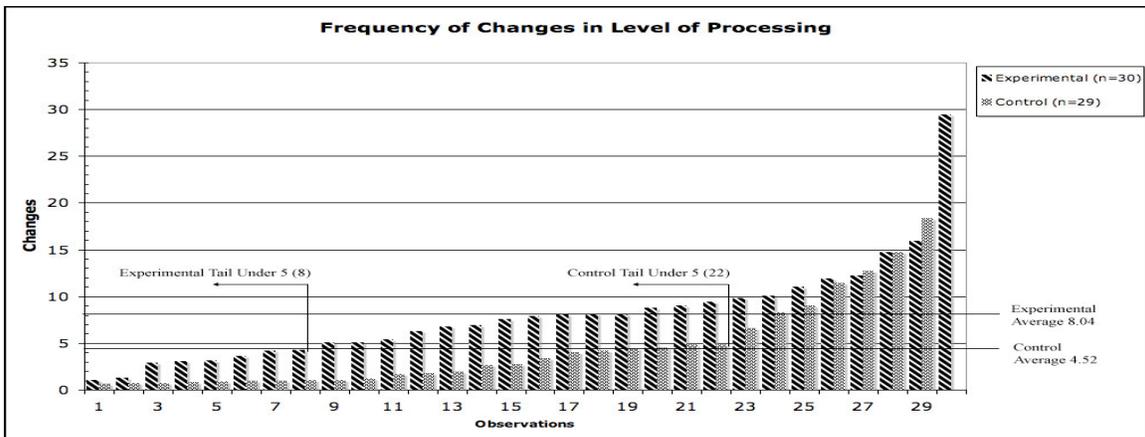

Fig 4 : Frequency of Changes in Levels of Processing.

With regard to the relationship between frequency of changes and student success Table 1 outlines the data. A high frequency of changes is associated with the Experimental group, as is a higher average essay mark and subject grade. When the data is sorted into those having a higher frequency of changes in both the Experimental and the Control groups, over 5 per 600 seconds, the relationship between a high frequency of changes in processing level, high essay marks and high unit grades is demonstrated more clearly. A high frequency of changes is associated with better student outcomes.

Raw Data	Experimental (n=17):	Control (n=16):
Frequency of change	7.90 *	5.90 *

Essay mark	69.71	63.25
Grade	68.71	61.94
Changes per 600 seconds	Above 5 (n=20, Exp = 14, Con =6)	Below 5 (n=13, Exp=3, Con=10)

Frequency of change	9.90	2.33
Essay mark	69.15	62.62
Grade	69.45	59.23

Table 1 : Frequency of Changes and Student Success.
(*Multiple observations of subjects averaged)

Conclusions and Further Research

The initial study, reported in Morgan, et. al., (2008), demonstrated the effectiveness of embedding an interaction strategy into the interface of the 'Copy and Paste' function. The data analysis in this paper has highlighted the importance of changes in levels of processing, the pattern of changes observed, and the relationship between the frequency of changes in levels of processing and student performance. In summary on average the Experimental Group exhibited a 3 to 1 incidence of High level processing and 2 to

incidence of High level processing and 2 to 1 incidence of Medium level processing. This translated to a higher average essay score and grade for the unit for this group. Those students from both groups who changed processing level more than 5 times also achieved a higher average essay score and unit grade. The results indicate that students not only need to have an appropriate interaction strategy provided to them to enable them to process information but more importantly they need to be regularly prompted to activate such strategies. In the case of the 'Copy and Paste' function students need to be made aware of the level of processing they are engaged in and to be prompted to exit extended periods of low level processing, such as browsing, in order to consolidate the information they have gathered through high level processing activities, such as writing and summarisation.

With regard to further research, Figure 5 presents a proposed feedback mechanism that might in the future be integrated into a notepad tool in order to track the student's level of processing and provide feedback to students on percentage of time spent in specific processing levels. In addition an alert might be used to indicate if a student was engaged in low level processing for an extended period. A system of green, amber and red highlights could be used to indicate the current state of processing and to warn of a lack of high level processing.
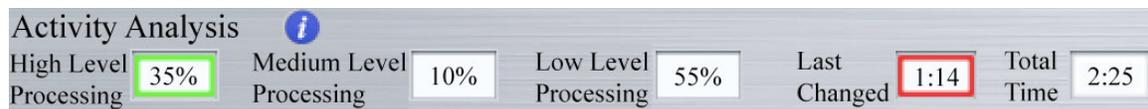

Fig 5 : A Proposed Solution for Monitoring Processing Level and Prompting Level Changes.

Further research will involve designing and constructing a prototype of the feedback system described in Figure 5 for a notepad tool. This tool will then be evaluated to determine its impact on the nature and sequence of levels of processing of content.

Acknowledgements

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