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Using Situated Learning and Multimedia to Investigate Higher-Order Thinking

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This paper describes a qualitative study into students' use of higher-order thinking as they use an interactive multimedia program based on a situated learning framework. The analysis of types of talk used by students as they worked with the program clearly shows that the majority of their thinking was higher order, as defined by Resnick (1987) and other theorists. Social, procedural and lower-order talk was less evident but present in their talk in reduced proportions. These findings suggest that a multimedia program based on a situated learning approach can provide a learning environment capable of supporting and maintaining substantial levels of higher-order thinking.

Many educators and researchers discuss the importance of engaging students in activities which require more than the simple application of rules and procedures. Collins, Brown, and Newman (1989) contend that few educational resources (including interactive multimedia) are devoted to higher-order problem solving activities, and few activities require students to use cognitive and metacognitive strategies and processes.

While higher-order thinking might most simply be described as "all intellectual tasks that call for more than information retrieval" (Baker, 1990), Lewis and Smith (1993) give a more comprehensive definition: "Higher-order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations" (p. 136).

There is an abundance of literature on the nature of thinking, problem solving and reasoning. Many studies have produced methods and procedures to classify and define higher-order learning. However, as Newmann (1990) points out, each approach has its own persuasive rationale. He contends that it is not productive to try to choose the best, but more sensible "to search for a common conception that embraces diverse emphases but which attracts professional consensus" (p. 42).

SITUATED LEARNING

Situated learning as a model of instruction has grown out of a general theoretical shift within the educational community from "behavioral to cognitive to constructivist" learning perspectives (Ertmer & Newby, 1993, p. 50; von Glasersfeld, 1995; Jonassen, 1991; Lebow, 1993). In the mid-to-late nineteen eighties, teachers and researchers in education began to investigate the notion of apprenticeships and to try to distinguish those characteristics which were critical to its success. Their aim was to begin the process of developing a theoretical perspective for learning based on the apprenticeship model, the success of which cognitive science had, to date, not been able to explain. Brown, Collins and Duguid (1989) were among the first to use the ideas to produce a proposal for a model of instruction that has implications for classroom practice. The proponents of situated learning argue that meaningful learning will only take place if it is embedded in the social and physical context within which it will be used (Brown, et al., 1989; McLellan, 1996; Lave & Wenger, 1991).

Collins, et al., (1989) suggest that higher order learning—"cognitive and metacognitive strategies and processes"—can "best be taught" through methods that employ a situated learning approach (p. 455). However, to date, there appears to have been scant research into whether higher order thinking is enhanced and promoted by learning environments based on a situated learning framework. The majority of studies that have been conducted to investigate students' use of higher order thinking as they use multimedia packages report little evidence of it in mainstream student activity (e.g., Frampton, 1994). While the proponents of situated learning continue to claim that higher-order learning is a consequence of learning within a situated learning environment, very little research has been done to evaluate the impact of situated learning elements on students' thinking, particularly with regard to the use of interactive multimedia programs.

This paper describes a study which investigated students' thinking as they used an interactive multimedia program based on the situated learning

approach. The learning environment incorporated nine characteristics of a situated learning framework, namely: (a) an *authentic context*; (b) complex *authentic activities*; (c) *multiple perspectives*; (d) *expert performances*; (e) *coaching and scaffolding*; (f) opportunities for *collaboration*, *reflection*, and *articulation*; and (g) *authentic assessment* (Herrington, Herrington, Sparrow, & Oliver, 1998; Herrington & Oliver, 1995; Herrington, Sparrow, Herrington, & Oliver, 1997).

The learning environment was designed for preservice teachers of mathematics. The multimedia program focused on the issue of assessment and presented a number of resources for preservice teachers to investigate from a variety of perspectives, such as (a) short video clips of assessment strategies being used in classrooms, (b) interviews with teachers and students on the strategies, and (c) a variety of text documents, such as a description of each strategy, sample resources and mathematics experts' views. The program is a substantial one, with over 60 video clips, and over 100 text documents for students to examine. The main interface is presented in Figure 1, together with annotations on the resource which sits behind each visual metaphor.

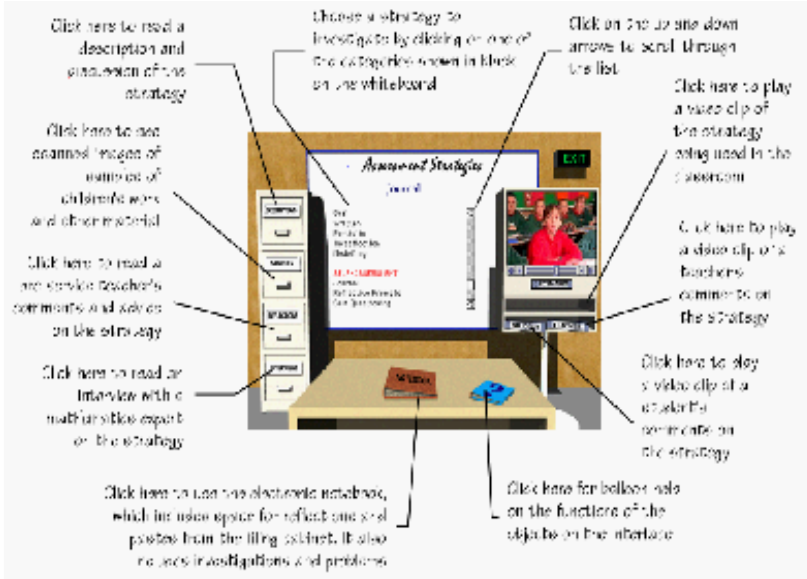

Figure 1. The main interface of the assessment program

As they used the program, the preservice teachers were given a complex and sustained authentic task to investigate, presented to them simply in the form of two letters. One letter was from a parent complaining to the school about the number of tests her child is required to take, and how the anxiety is causing great difficulties in their home environment. In response to this letter, the Mathematics Coordinator of the school sends a memo to the new teachers at the school (the preservice teachers) asking them to prepare a new assessment plan for mathematics in the school. The task is not broken down into more simplified steps, but presented to students in all its complexity, as frequently happens in real life. Essentially, the question for the students is: "A parent has complained about our assessment methods in mathematics. What can we as teachers in this school do to improve it?" The students then use the multimedia program, in effect, to observe assessment strategies in classrooms, interview teachers, students and experts, look at children's work and other resources, and finally, to prepare a report on an improved assessment plan for the school.

Four groups of two students were videotaped using the resource over two semester weeks, and their discussion was transcribed for analysis with *NUD•IST* qualitative analysis software (Qualitative Solutions & Research, 1993).

Framework for Analysis

While there is little option in this type of study other than to count talk as the outward representation of thought (and this is accepted in many of the studies described in this chapter, such as Marland, Patching, & Putt, 1992; Alexander & Frampton, 1994; Nastasi & Clements, 1992; Henri, 1992), doubt has been expressed about the usefulness of this method. For example, Halliday (1985) has pointed out that academic discourse, in particular, can be disjointed and unlike everyday talk:

> When philosophers of language began recording speech they started with academic seminars, because they were easiest to get at...But this is just the kind of discourse that is most disjointed, because those taking part are having to think about what they are saying, and work out the arguments as they go along. The ordinary, everyday exchanges in the family, the gossip among neighbours, the dialogue with narrative that people typically bandy around when sitting together over a meal or at the bar...these tend to be much more fluent and articulated, because the speakers are not having to think all the time about what they are saying (p. 90).

This view is supported by Young (1995) who also points out that 'think-aloud' protocols used with students often fail to enlighten researchers about problem-solving methods because at the point when the students are most engaged in problem solving, they become quiet, 'possibly due to cognitive workload and the invasiveness of having to say what one is doing and at the same time doing it' (p. 92). Nevertheless, the social context of a situated learning environment to some extent vindicates the position that the students articulate their thoughts as they communicate with one another in a meaningful way. Rather than *thinking aloud* and articulating unnaturally and individually to a researcher, a social context means that the sharing of thoughts is critical to communication. As von Wright (1992) points out: "The advantage of social contexts for learning is that they elevate thinking to an observable status" (p. 66), and it is the acceptance of this assumption that is the foundation of analysis of the higher-order thinking used by students in the study.

As noted by Henri (1992), there is no lack of analytical methods for the study of communication patterns. However, many of the methods developed for use in the disciplines of psychology and linguistics, for example, are complex, highly-specific research tools which may have little relevance for the nonspecialist, or enable little useful meaning to be drawn about the messages students convey as they use interactive multimedia.

To be helpful, the framework chosen for the present study needed to encompass a view of higher-order thinking which is in keeping with research into both educational contexts and the use of new technologies, and be compatible with interpretive research methods. Several frameworks have been developed for analysis of student cognition within learning environments which serve as a useful starting point for the current study, although Frampton (1994) cautions that such frameworks inevitably have different features which may lead to different interpretations of meaning.

Marland, Patching, and Putt (1992) analysed students' thought processes while studying distance education texts using stimulated recall video techniques. They classified mediating thought processes into one of 19 data-generated categories, such as, (a) analysis, (b) anticipation, (c) comparing, (d) confirming linking, (e) metacognition, (f) recalling, (g) strategy planning, and (h) transformation. Similarly, Alexander and Frampton (1994) used a nonhierarchical scheme which used an unspecified number of categories such as; (a) read**,** (b) infer, (c) generate, (d) plan, (e) evaluate, and (f) conclude, to categorise students' cognitions as they worked on an interactive multimedia program. Nastasi and Clements (1992) analysed social processes and higher-order thinking in group problem-solving in two different computer

environments, using a behavioral coding scheme. The scheme used indicators of social-cognitive behaviour such as; (a) collaborative, (b) noncollaborative, (c) peer as resource, (d) teacher as resource, (e) social conflict, and (f) cognitive conflict. Clearly, the categorisation of spoken messages within learning environments is a practised format for analysis of student talk.

However, the work of Henri (1992) has been most useful in providing a model for analysis of the data in the study. Henri developed her framework for analysis of student talk in a computer-mediated conferencing environment. Student exchanges during lessons were monitored and analysed using content analysis. Henri and Parer (1993) claim that content analysis, "when conducted with an aim to understanding the learning process, provides information on the participants as learners, and on their way of dealing with a given topic" (p. 451).

Content analysis, as used by Henri (1992), was characterised by a cognitive view of learning and used a framework of five related categories to analyse the social, psychological, and cognitive dimensions of the exchanges: (a) participative, (b) social, (c) interactive, (d) cognitive, and (e) metacognitive. The emphasis content analysis places on the type of exchange observed between the student participants, together with its qualitative approach and its compatibility with the categories suggested by Resnick's (1987) definition of higher-order thinking, meant that it was a useful organising framework for the classification scheme to be used in the study.

In order to classify students' talk as they used the interactive multimedia program on assessment, a table of indicators was prepared based on Resnick's (1987) characterisation of higher-order thinking which include nine characteristics. Higher-order thinking is; (a) nonalgorithmic, (b) complex, (c) often yields multiple solutions, (d) involves nuanced judgement and interpretation, (e) involves the application of multiple criteria, (f) often involves uncertainty, (g) involves self-regulation of the thinking process, (h) involves imposing meaning and finding structure in apparent disorder, and (i) is effortful (p. 3). To simplify the classification for the purpose of the research, several of Resnick's characterisations were combined to enable more distinct categories to be drawn.

Table 1 presents each of the revised characterisations together with corroborating definitions from other theorists and researchers in the area. The final column of the table gives precise indicators of each of the characterisations to be used in the study to enable classification of the students' talk.

Table 1
Corroboration of Characteristics of Higher-Order Thinking and Indicators for Classification

Revised characterisation of higher-order	**Corroborating definitions of higher-order thinking thinking from other theorists**	**Indicators for the purpose of classification**
Uncertainty	Asking clarifying questions. (Ennis, 1993)	Any question or statement seeking clarification of requirements, or uncertainty.
Deciding on a path of action	Deciding what to do (Lewis & Smith, 1993) Browsing and searching (Duchastel, 1990)	Any statement referring to a suggested course of action. Any question asking opinion on a course of action.
Judgement and interpretation	Identifying conclusions, reasons and assumptions. (Ennis, 1993) Developing and defending a position on an issue. (Ennis, 1993) Defining terms in a way appropriate for the context. (Ennis, 1993) Making contributions which are relevant and connected to prior discussion (Newmann, 1990)	Any statement which seeks to defend a position taken on an issue. Any statement which connects to, and furthers, the discussion. Any statement which defines terms in a way appropriate for the context.
Multiple perspectives	Angling (establishing different perspective) (Duchastel, 1990) Assuming the role of questioner and critic (Newmann, 1990)	Any statement which suggests an alternative approach. Any statement which challenges a conclusion or previously made point by providing an alternative perspective. Any statement which challenges a perspective given in the interactive multimedia program.

Table 1 (continued)

Imposing meaning, effortful thinking and multiple solutions	Drawing conclusions when warranted, but with caution. (Ennis, 1993) Offering explanations for conclusions (Newmann, 1990) Deciding what to believe (Lewis & Smith, 1993) Integrating (interrelating conceptual elements) (Duchastel, 1990) Generating original and unconventional ideas, explanations, hypotheses or solutions to problems (Newmann, 1990) Creating a new idea, a new object, or an artistic expression (Lewis & Smith, 1993) Making a prediction (Lewis & Smith, 1993)	Any statement which states a conclusion. Any statement which offers a summary of the point of view adopted. Any statement which states a belief or original perspective on the subject matter. Any statement which proposes alternative solutions to problems. Any statement which recognises that alternative approaches have different costs and benefits.
Self-regulation of thinking	Applying metacognitive skills (Vockell & van Deusen, 1989)	Any statement which expresses an awareness of thinking processes or understanding. Any statement or question which acts on awareness of thinking to affect a change.

This classification scheme provided a workable tool for analysis of *Higher-order* student talk. It was also necessary, however, to draw up similar criteria for the classification of talk which could not be considered higher order. While this type of thinking was not a primary focus of the study, three subcategories were used: *Social, Procedural* and *Lower order,* rather than have a simple category of *Nonhigher order thinking*.

All student talk was classified according to the scheme which is represented diagrammatically in Figure 2:

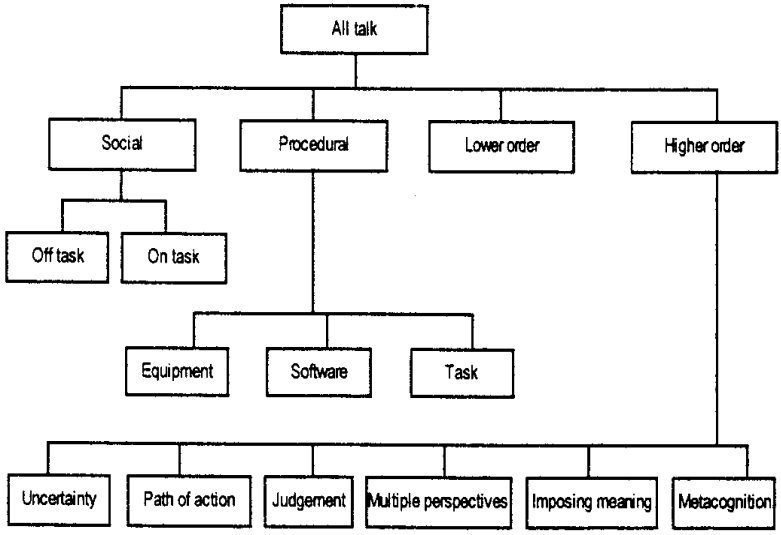

Figure 2. Flow chart of classification scheme of student talk

The Unit of Analysis

In order to assign student talk to a category, it was necessary to define the grain size of the unit of speech to be classified. Analysis by individual words, while used in some research using discourse analysis, was not considered to be necessary or useful in the present study which was to focus much more generally on themes discussed rather than the individual words used. Several options remained. Talk could be divided into passages of dialogue, single utterances (each one's turn at talk), or units of meaning.

Each of these units of analysis has limitations. Categorisation by passage was unsuitable because of difficulties of determining where one passage began and another ended. Such division inevitably became arbitrary. Another problem with this approach was that at times, each student in the pair would talk in parallel in different categories for a short time. For example, one student might have begun by using *Judgement*, the partner may have responded with *Uncertainty* or *Multiple perspectives* before they both used anecdotes or arguments to *Impose meaning*. Such difficulties associated with this method precluded the use of the approach in the study.

Each student utterance, (that is, a comment by a student before the other student speaks, or a turn at talk) was also considered as a unit for classification and this was used for the first analysis of the data. This approach worked quite well, as generally each student remained within a single category in a single utterance. However, there were a considerable number of times when a student might have used more than one type within a turn at talk. If instances of types of talk were to be counted, simple counting of the category detected most predominantly in the comment could have given a wrong impression of the relative frequency of each type.

The third method considered was to count each unit of meaning, that is, each instance of a type of talk as it occurred, (Henri, 1992). This method enabled the detection of types of talk which may have been neglected by the other methods.

Using the unit of analysis of each unit of meaning as described above, each instance of a type of talk from the transcript of the videotapes was assigned to a category. The comments were assembled by category using the qualitative analysis package (*NUD•IST*) for analysis, but they were also kept in chronological order to enable the context of the comment to be investigated further if necessary.

Summary of Classification of Talk

All types of talk were evident in the students' talk as they used the interactive multimedia program on assessment, although not necessarily in each group. Each category of talk, together with a definition, has a short summary and example of type in Table 2.

Table 2
Summary Chart of classification of student talk

Category	Sub-category	Definition	Example of type
Social	Off-task	Any statement not related to the subject matter.	G: We got caught in a traffic jam...We didn't see it happen but we saw a van, the side of it was all smashed in.
	On-task	Any social statements which relate in some way to the task.	C: Hey I know this guy ... He was my teacher. What a spin. I wonder what he is doing. I can't remember his name.

Table 2 (continued)

Procedura	Equipment	Any exchange of information related to the equipment (such as the operation of the computer, monitor, keyboard, CD-ROM drive etc.).	R: No you won't have a volume on this ... it'd be on the Apple menu. You have to go into systems folder then control panel.
	Software	Any exchange of information related to the software (any functional aspect of the assessment program itself).	C: That didn't work. R: Did you push copy first? C: I'm rushing it. Here we go. Wiped it.
	Task	Any exchange of information related to the task (the formal requirements of the oral or written report).	G: Are we actually supposed to prepare this as a report to staff? D: No, I don't think so. I think we prepare our notes and then just say it.
Lower order		Any student talk which is routine, requiring little thought, or the mechanical application of well known rules.	C: You are missing an r in strategies. R: They are playing dominoes. It is a little primary school class.
Higher order	Uncertainty	Any student talk which involved deciding on an approach to adopt, suggesting a course of action, or any expression of dilemma or uncertainty.	L: So really we want to look at all of them don't we? E: OK do you want to start putting anything into our notebooks? L: Like what?
	Path of action	Any talk which involved decisions about which elements of the program to access, decisions about what to save in the notebook and negotiations on how to proceed.	R: We should go right through the whole lot again. We need to make more notes on it.
	Judgement	Any statement or question which referred to students' attempts to interpret and defend their understanding of the issues presented in the assessment program.	G: If you're going to do anecdotal records on all the kids ... D: You wouldn't carry them around. You'd make notes and put them in later.

Table 2 (continued)

			G: That's the whole point of having them combined.
	Multiple perspectives	A statement or question was classified in this category if it suggested an alternative approach or challenged a conclusion, or previously made point, by providing an alternative perspective.	R: OK investigations, factual ... Ah, factual, factual recall, rote learning. C: No, it's not saying you learn everything by rote, it's just saying that sometimes you want students to respond automatically.
	Imposing meaning	Talk was classified into this category if it referred to a possible solution to a problem or suggested alternative solution, if it expressed a decision about what to believe, or the creation of a new idea, or if it drew cautious conclusions.	G: Obviously we can introduce all of the strategies but not to start with. I think in the lower primary you probably can't expect them to do a mathematical investiga tion, so if they start out with oral work in the lower school and work towards doing the written ones in the upper school.
	Metacognition	Any comments which showed that students were aware of their own thinking and performance, and comments related to the use of this awareness to improve performance.	G: What was that? I didn't get any of that. E: I don't know what to do. Where is that piece of paper I had before? [The activity].

Findings, and the trends they suggest, are given below together with examples of the students' dialogue as they used the assessment program. In some cases, more than one instance or utterance is provided to enable the reader to grasp the context of the comment rather than view it as an isolated statement (Cobb & Whitenack, 1996). However, in the majority of cases all the dialogue provided is of the type under discussion.

DISCUSSION

The analysis of the transcripts showed that higher-order thinking was a substantial component in all the students' talk. In each of the four groups observed, the proportion of higher-order thinking to the other major categories observed was quite consistent and was measured at around 70% of the total talk. Figure 3 shows the proportion of categories for Group 1. The two students in this group used a substantial proportion of higher-order thinking in their talk as they used the interactive multimedia program on assessment. Lower order comments, together with social talk, were kept to a minimum and procedural matters occupied only a moderate amount of their time.

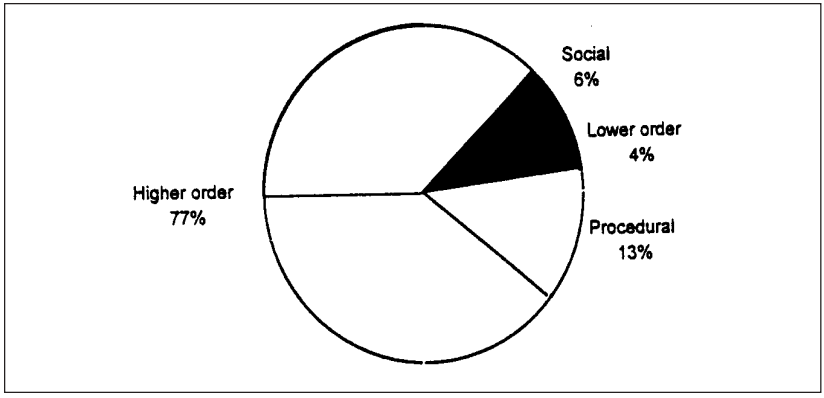

Figure 3. Proportion of categories of talk: Group 1

Like Group 1, the students in Group 2 used a substantial proportion of higher-order talk (70%), a moderate amount of procedural and minimal lower order talk. Of all the groups, this group had the most social talk, largely centered around discussion of their mutual friends, computers, and work from other units of study.

The students in Group 3 were least typical in their pattern of talk as they used the interactive multimedia program on assessment. There was a complete absence of social talk which appeared to be the result of the fact that they did not know each other prior to commencing work on the program. The amount of higher-order talk was 71%. A relatively high amount of procedural talk was observed in Group 3 and this was largely related to recurring computer equipment problems which were not satisfactorily rectified until the second week of the study. Like the other groups, however, they had a high proportion of higher-order talk, and minimal use of lower order talk. Group 4

was similar to the other groups in their use of a substantial amount of higher-order talk (68%). The remaining categories of talk were also comparable with other groups.

Proportions of Higher-Order Thinking

The high level of higher-order thinking amongst all the groups meant that there was a substantial number of units of meaning in students' talk which could be classified according to the classification scheme described earlier. Each unit of meaning was categorised as; (a) Uncertainty, (b) Path of action, (c) Judgement, (d) Multiple perspectives, and (e) Imposing meaning or Metacognition. While the amount of higher order talk was quite consistent between the groups, there were many differences in the extent and levels of the various forms of higher-order thinking evident in the talk. The proportion of each of these types to the whole of higher-order talk for Group 1 is shown in Figure 4.

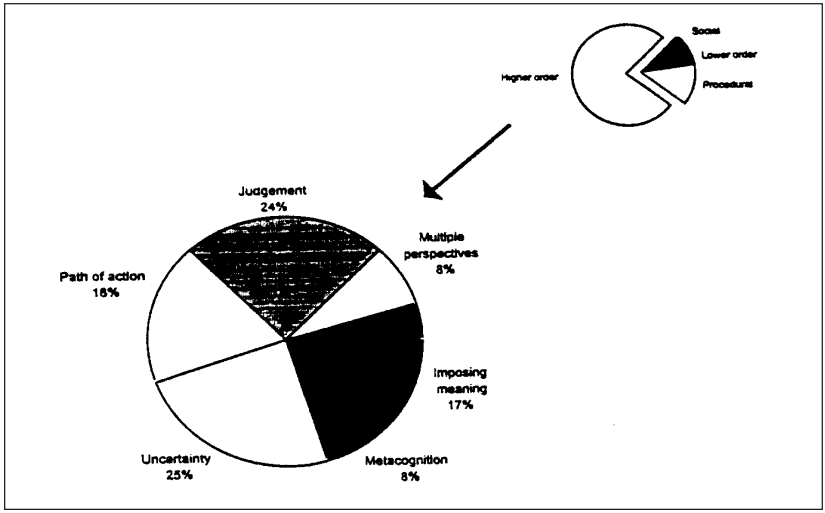

Figure 4. Proportion of categories of higher-order thinking: Group 1

The students in Group 1 used a substantial amount of all types of higher talk identified in the classification scheme. As with most of the groups, *Uncertainty, Path of action* and *Judgement* comprised the major part of their talk, with the other classifications making up the remainder. One would expect that comments related to *Uncertainty* and *Path of action* would take up

a reasonable portion of students' time in collaborative groups as they would use this type of talk to decide where they would go within the program and how they would approach the task. It might be expected that students who did not know each other well would have a larger amount of this type of talk as they negotiated the group dynamics and established a working relationship. Clearly, these students were relatively comfortable working together, with the total of these two types less than half their talk.

The moderate proportion of *Multiple perspectives* appeared to indicate that these students were not excessively argumentative or critical, but were not afraid to challenge each other or the program when they saw the need. These students were also capable of spending a good proportion of their time *Imposing meaning* on their learning and coming to conclusions about the task and the recommendations to include in their reports. As with all the groups, these students' expression of metacognitive awareness was minimal, and it is possible that this is a type of thinking which does not manifest in the spoken word as well as the other categories of talk.

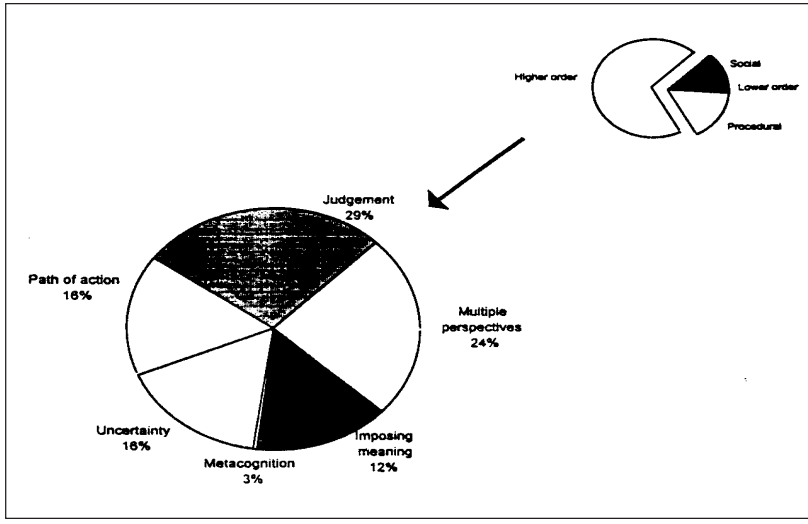

Figure 5. Proportion of categories of higher-order thinking: Group 2

The interesting aspect of the analysis of talk in Group 2 (Figure 5) is the relatively low proportion of *Uncertainty* and *Path of action* compared to *Judgement* and *Multiple perspectives*. This division indicates that these students were forthright and confident in working out their path through the

interactive multimedia program, and that they appeared to very comfortable working together. The high proportion of *Multiple perspectives* indicates that they adopted a very critical approach to the information they were obtaining from the program and from each other. The high proportion of *Imposing meaning* also seems to indicate that they were then readily able to consolidate the information into a meaningful form. As with Group 1, these students showed little *Metacognition* as they worked together on the interactive multimedia program.

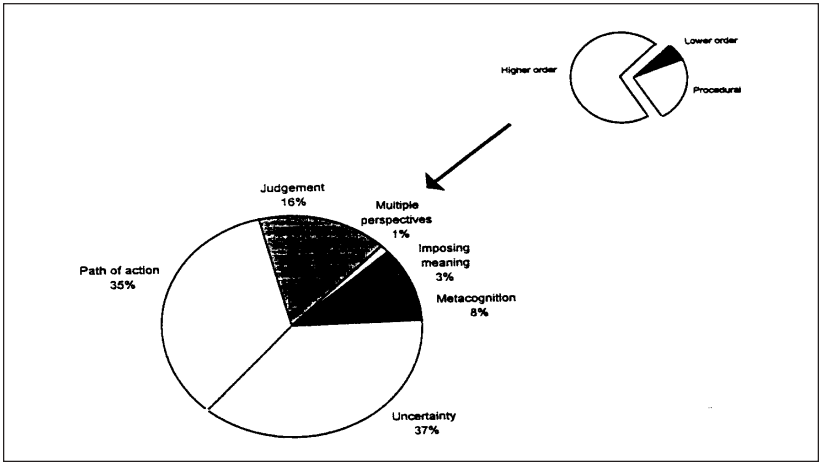

Figure 6. Proportion of categories of higher-order thinking: Group 3

While it is difficult to nominate an optimum spread of talk to categories within higher-order thinking, clearly Group 3 had difficulties which became apparent with closer scrutiny of their types of talk. The high percentage of time spent in both *Path of action* and *Uncertainty* reflects the tentative nature of their collaboration (Figure 6). Almost three quarters of the total talk fell into one or other of these categories. As they were unaccustomed to working together, the students appeared to spend a relatively large proportion of their time consulting with each other about the nature of their collaboration—how they were to proceed, how to interact, and the responsibility each was to take in the process. The remaining groups were not hampered by these concerns, possibly because they had all worked with their partner on several previous occasions.

Another interesting finding in the proportion of talk for this group was the almost complete absence of *Multiple perspectives* talk between the two students. Their collaboration was characterised by a reluctance to challenge

each other's ideas or to challenge the perspectives that were presented in the multimedia program. The very low proportion of *Imposing meaning* was also indicative of a failure to confidently adopt a position to present in their final report.

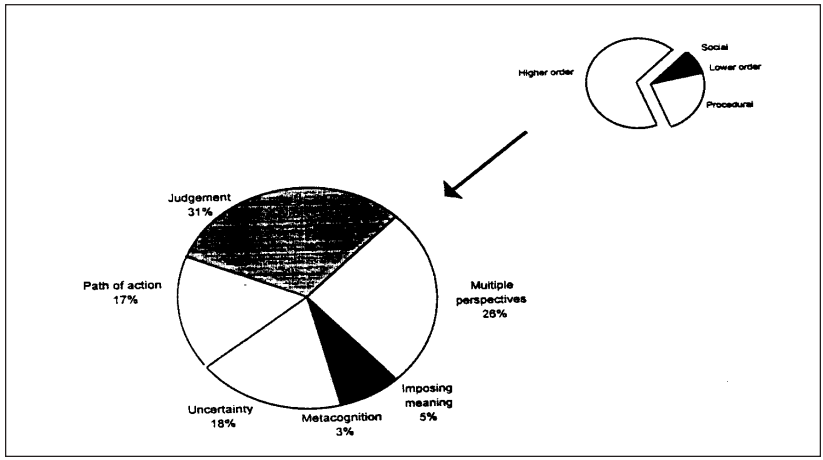

Figure 7. Proportion of categories of higher-order thinking: Group 4

The students in Group 4 used relatively little talk which was classified as *Uncertainty* and *Path of action* indicating that they needed minimal talk to establish a working relationship and a proposed plan of action (Figure 7). Like others, they demonstrated a high proportion of *Multiple perspectives* as they used the multimedia program. However, a large proportion of this talk was an argumentative style of interaction they used as they worked together, rather than a thoughtful disagreement with ideas presented in the program. This is possibly evident in the fact that there was a minimal proportion of talk which was classified in the category of *Imposing meaning*. These students, unlike Group 2, did not use the multiple perspectives they offered each other to inform the meaning of the task.

DISCUSSION

It is interesting to note the wide disparity between types of higher-order thinking used by the students as they used the interactive multimedia program on assessment. The findings show that all the students used a substantial proportion of higher-order thinking in the situated learning environment, where other studies (e.g. Frampton, 1994; Oliver & McLoughlin, 1996)

have shown little. The possibility exists that the classification scheme developed to analyse students' talk was not a precise enough instrument to truly reflect the cognition of students as they used the program. This issue has been raised by Frampton (1994) who suggests that many of the classification schemes he reviewed were unsuitable for the analysis of technology-supported cognitions (p. 90). He stated that: "It is not clear, in our view, that current means of identifying cognitive events can adequately cater for responses to the organisation of media in a multimedia program" (p. 90).

While the current classification scheme was specifically developed for use with multimedia, its interpretation of higher-order thinking may be too liberal. For example, many of the comments and statements classified as *Uncertainty* and *Path of action* may actually be better defined as *Lower-order* thinking, simply because such comments may require little mental effort. For example, comments such as "What do you want to do now?" may be closer to a cliché or automatic response than a thoughtful reflection of the best course of action. While many of the theorists and researchers would possibly argue with this view (e.g., Ennis, 1993; Duchastel, 1990; Lewis & Smith, 1993), it is interesting to reclassify the data accordingly. For example, Figure 8 shows the proportion of higher-order thinking in Group 4, when all the incidences of *Uncertainty* and *Path of action* for one of the groups of students have been reclassified as *Lower-order*.

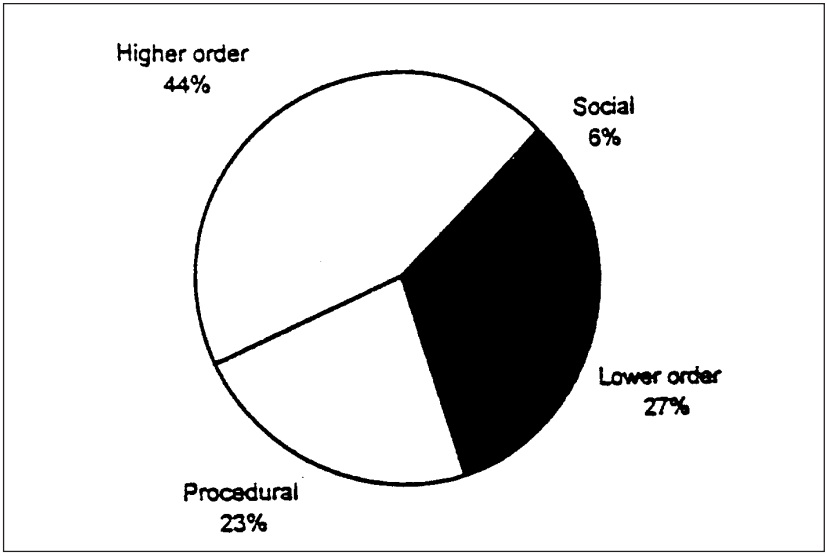

Figure 8. Proportion of categories of thinking when all Uncertainty and Path of action are classified as Lower-order: Group 4

The pie chart shows that, even with this recount, *Higher-order thinking* remains a high proportion of the type of talk used by this group, and this was so for all the groups. Perhaps a more plausible explanation for the high level of this type of talk is that the constructivist nature of the learning environment provided greater opportunities for students to engage in higher-order thinking, a finding also confirmed by Maor and Taylor (1995).

Another interesting finding was the nonsequential nature of the types of thinking used by the students, confirming Resnick's (1987) and Newmann's (1990) contentions that higher-order thinking is relative and nonhierarchical, and counter to behavioural theorists such as Bloom (1956) and to some extent, Gagné (1985), where progression to each level of the hierarchy is dependent upon mastery of the previous level.

If one accepted a hierarchical approach to classification of thinking, it might be expected that students would begin with a little social talk to establish their working relationship; then procedural talk as they worked out the computer equipment, the software and the task. They might then be expected to move to lower order talk before using higher-order talk later in the session. Interestingly, there was no sequence or pattern to their use of talk. From the beginning, the students moved freely and without notice to any type of talk.

CONCLUSION

The analysis of types of talk used by students as they worked with the interactive multimedia program clearly shows that the majority of their thinking was higher-order, as defined by Resnick (1987) and other theorists. Social, procedural and lower-order talk was present but less evident in their talk in reduced proportions. These findings confirmed our expectations that a multimedia program based on a situated learning approach could provide a learning environment capable of supporting and maintaining substantial levels of higher-order thinking .

The study also revealed some outcomes which are particularly interesting in their implications for further research. One group, whose students who did not know each other before their collaborative use of the assessment program, appeared to use different types and proportions of thinking to the groups who had worked together before. The finding suggests that social ease and experience at collaboration facilitates higher-order thinking. Further research is needed to establish the relevant determinants for this finding and the implications for classroom practice.

The second interesting finding was the high proportion of argument and challenge found in two of the groups observed. As described earlier, one group appeared to use this process to enlighten the meaning they constructed, the other group did not. Again, further research is needed to ascertain whether a pattern can be deduced in this regard, and to determine the factors which lead to the construction of meaning from multiple perspectives (Vockell & van Deusen, 1989).

Our findings contrast with many previous studies exploring students' cognition and thinking in multimedia use. The findings suggest that the instructional design embraced in the situated learning program, and its implementation in this study, successfully combined a number of enabling elements and components frequently lacking in contemporary learning settings.

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