Journal of Information Systems Education
Volume 5, Number 2

NONLINEAR INSTRUCTION OF MIS: WHY AND WHEN?

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ABSTRACT: With the latest developments in information technology, nonlinear organization and management of information has become easier and more cost-effective. This has facilitated the development of nonlinear instruction environments. The potential of such environments is increasingly recognized by many researchers. In this research, we examine the potential of a particular nonlinear environment: hypercourseware. More specifically, this article describes the development of a hypercourseware for an introductory MIS course and discusses the results of an empirical study designed to examine why and when the usage of such a system can enhance student performance. Both observed and perceived effects of the system are examined. The hypercourseware improves significantly student learning as measured by the performance of students in exams. Its effect is more significant when it is used in the initial stages of learning to enhance concept formation and understanding. These results are also supported by student perceptions. The hypercourseware is perceived by the students as more efficient and more enjoyable than a strictly linear environment. Furthermore, most students used the system in the initial stages of learning to understand and form new concepts, then relied on lecture notes to review already learned concepts.

KEYWORDS: Information Systems Courseware Design, Hypertext-Based Training.

INTRODUCTION

The use of hypertext/hypermedia systems in training and education is advocated by several researchers (e.g., Carr [1]; Conklin [2]; Kearsley [3]; Marchionini [4]; Morariu[5]; Nielsen [6]; Shneiderman et al. [7]; Spiro et al. [8]; Siviter et al. [9]). A hypertext system is a nonlinear electronic organization and text management system. As defined by Shneiderman and Kearsley [7], hypertext is a database with active cross-references allowing non-sequential reading/writing. It could be conceptualized as a network of nodes and links where documents are the nodes and the links are the cross-references. If the documents being linked are not restricted to text only and include graphics, photographs, audio or video, the term hypermedia is used.

Hypertext systems overcome human limitations by providing mechanisms for compact storage and rapid retrieval of enormous volumes of textual, numeric and visual data [10]. The tremendous potential of hypertext systems in training and education is increasingly recognized by many researchers, academicians and courseware developers. Spiro et al. [8] claim that hypertext systems can address several of the deficiencies associated with traditional learning environments. They argue that there is a common basis for the failure of many training systems. This common basis consists of the representation of the instructional domain in an unrealistically simplified and well-structured manner. To address the deficiencies associated with the traditional training environment, Spiro et al. propose a constructivist theory of learning and instruction that emphasizes the complexity of the real world and ill-structuredness of many knowledge domains. They argue that hypertext systems are ideally suited for conveying the ill-structured aspects of knowledge domains and for supporting cognitive flexibility.

In this research, we investigate the potential of one particular application of hypertext to training and education: hypercourseware. Hypercourseware can be defined as a collection of hypertext/hypermedia-based learning material. The main advantages of hypercourseware over regular courseware stem from the benefits of nonlinear organization of text. Nonlinear text is more suited for human cognitive processes. It is believed that humans learn on several fronts and develop concepts along multiple lines simultaneously [2]. Hypercourseware support the multi-front cognitive processes by allowing the student to instantaneously switch between topic areas. Hypertext is more appropriate than linear text for open learning applications where the student is allowed freedom of action and encouraged to take the initiative [6]. Furthermore, the associations provided by links between nodes representing related concepts facilitate the processes of remembering, concept formation, and understanding [3].

Hypercourseware are not, however, without disadvantages. One of the principal drawbacks is that users could be "lost-in-space", but this problem can be alleviated by the design of appropriate navigation aids. Another disadvantage associated with any courseware is that reading from computer screens is difficult. Empirical studies have demonstrated that many display screens take 30% longer to read than typewritten text [7]. This difficulty, however, can be reduced by using graphics instead of text whenever possible and by designing concise screens.

Fascinated by the advantages of hypertext, more and more teachers are using hypercourseware. This has been facilitated by the availability of easy to use hypercourseware management systems (see [9] for a description of the implementation of a hypercourseware management system). It is only natural that MIS teachers join their colleagues in the field of education technology and apply information technology to the enhancement of student learning. To investigate the potential of hypercourseware in teaching MIS courses, we developed a prototype system for an MIS introductory course taught to MBA students. In a previous study[1], we tested the impact of the system on student performance. We found that students who had access to the hypercourseware showed a significantly better performance than their counterparts who were restricted to a linear environment. Encouraged by the results of the first study, we decided to conduct another empirical study in order to gain a better understanding of how the students use hypercourseware and to determine when such systems are most effective. In this article, we describe the MIS hypercourseware and discuss the empirical results. These results indicate that the students used the system in the initial stages of learning to understand and form new concepts, then relied on lecture notes to review already learned concepts. This nonlinear instruction environment is perceived by the students as more efficient and more enjoyable than a strictly linear environment. There is also suggestive evidence that the hypercourseware has a more significant effect on student performance when used in the initial stages of learning to enhance understanding.

> ***Hypertext is more appropriate than linear text for open learning applications where the student is allowed freedom of action and encouraged to take the initiative [6].***

DEVELOPMENT OF THE MIS HYPERCOURSEWARE

Human factors such as ease of learning and ease of use are critical factors for the success of a hypercourseware. The advantages of hypertext could be undermined by a poorly designed user interface. Human-Computer Interaction (HCI) literature proposed several principles and guidelines for designing user interfaces (see [11] for a discussion of interface design principles and guidelines). Smith and Mosier [12] by themselves have presented 679 guidelines. However, interface designers must be very careful in choosing the appropriate principles and guidelines because some of them are either incorrect, contradictory or vague. Furthermore, most of them are not at the appropriate level of specificity [13], cannot be applied to real design problems or may lead to conflicts when one tries to apply them to real design problems. After careful consideration of hundreds of principles and guidelines, we selected the ones that we believe are the most pertinent to the design of hypertext systems:

- Reduce memorization-this principle refers to reducing the memory load of the user by, from among other things, displaying the navigation path so that the user does not have to remember the sequence of visited nodes and by allowing the selection of items rather than entry of data.

- Reduce cognitive effort-in addition to avoiding memorization, one way of reducing cognitive effort is to minimize text and use graphics whenever possible ("a picture is worth a thousand words").

Minimize the likelihood of errors-this principle refers to preventing errors by using the direct manipulation interaction style. It eliminates the risk of incorrect command syntax and allows actions to be reversible.

- Avoid discomfort-discomfort may be caused by an exhaustion of the perceptual system (e.g., illegible display due to the use of small fonts, insufficient spacing or the wrong foreground/background colours).

- Avoid boredom-boredom and sometimes panic could be the result of long delays (e.g., long system response times).

- Avoid confusion-confusion could be a consequence of insufficient information or overwhelming details.

[1] The results of the first study are the subject of another article that has been submitted for publication.

The MIS hypercourseware consists of three modules. The first module is an introduction to MIS that includes a discussion of different types of computer-based information systems. The second module addresses the topic of information systems and organizations, while the third module discusses the topic of database management. The architecture of every module consists of a sequence of screens and a web of pop-up windows. Screens are used to describe the main concepts in a given topic (one screen per concept) and windows are used to explain additional concepts needed to understand the concept addressed in a given screen.

Screens can be sequentially or directly accessed from the first screen which contains the module's table of contents. Windows are triggered by highlighted words embedded in the screens (see Figure 1). The system has a WALK-THRU facility that allows novice users to visit each and every screen sequentially in order to review the total module content at their own pace.

The table of contents, on the other hand, allows more knowledgeable students to have direct access to the concepts of interest without having to browse through screens that address unrelated concepts. We tried to make screens and windows self-contained (minimize number of links or highlighted words), while trying to minimize the amount of information displayed. Every screen or window addresses one single concept. Whenever additional concepts were needed to fully explain the concept discussed in a given screen or window, additional nodes (windows) were created and linked to the original screen/window. Hence, everything required to fully understand a given concept is accessible from the same screen or window. To alleviate the "lost-in-space" problem, we made the following design decisions:

- The full path of visited nodes (screens and windows) is always displayed on the screen. This has been achieved by cascading (superimposing downwards) the visited screens or windows, so that their titles are always visible (see Figure 1).
- From any node (screen/window), it is possible to go back to the previously visited nodes or to the table of contents. It is also possible to exit the system from any node.
- To avoid any possible confusion, the title of any given window is the same as the highlighted word that leads to that window (see Figure 1). Similarly, the title of any screen is the same as the item in the table of contents that leads to that screen.

WHY AND WHEN SHOULD HYPERCOURSEWARE BE USED?

Researchers who are advocating the use of hypertext systems in training and education claim that these systems enhance learning. However, they provide little empirical evidence to support their claims. One of the main objectives of this study is to verify empirically whether hypercourseware improve significantly student learning, as measured by student performance in exams. Other important objectives of this research are to investigate how the students perceive and use hypercourseware and to determine when such systems are most effective.

One very important advantage of a hypercourseware over a linear instruction environment is its ability to provide a nonlinear representation of information. The links between the different nodes of the system make the relationships between the concepts represented in these nodes more explicit. This explicit representation of relationships facilitates concept formation and enhances understanding. Furthermore, these links represent associations that facilitate remembering. All of these advantages lead us to believe that a hypercourseware is very effective in the initial stages of learning, when the learner is trying to understand and form new concepts.

Another important advantage of a hypercourseware is its ability to provide faster access to larger volumes of data. This benefit is important for all stages of learning as well as for reviewing after understanding. Its effect is, however, undermined by the difficulty of reading from display screens. For this reason, we believe that the most beneficial usage of a hypercourseware is to establish relationships between concepts and gain a better understanding of the topic rather than to simply review the material. Hence, we expect the MIS hypercourseware to be more effective when used in the initial stages of learning to enhance concept formation than when used simply as a tool to review already learned concepts. To verify these claims, an empirical study was conducted. The study represents an investigation of the usage and the effect of the hypercourseware both as observed and as perceived by the students. More specifically, the purpose of the study is to verify the following hypotheses:

H1: The usage of the hypercourseware will have a significant positive effect on student learning, as measured by student performance in exams, and the students will perceive it as more effective, faster and more enjoyable than a linear environment.

H2: The hypercourseware is more effective when used early in the learning process to enhance concept formation and understanding than when used for reviewing and the students will perceive it as such.

EMPIRICAL STUDY

In the empirical study, the effect of the hypercourseware on student performance was measured, depending on when the system was used (early or late in the learning process). The subjects were also asked to describe the usage of the system, to rate its ease of learning and ease of use, to evaluate its effects, and to indicate when it is the most effective.

Subjects

The subjects of the empirical study consisted of 74 MBA students taking an introductory course in MIS, which is a core course that the students must take in their second semester in the program. One of the prerequisites of this course is a computer literacy course that introduces the students

Figure 1: EXAMPLES OFSCREENS/WINDOWS OF THE MIS HYPERCOURSEWARE

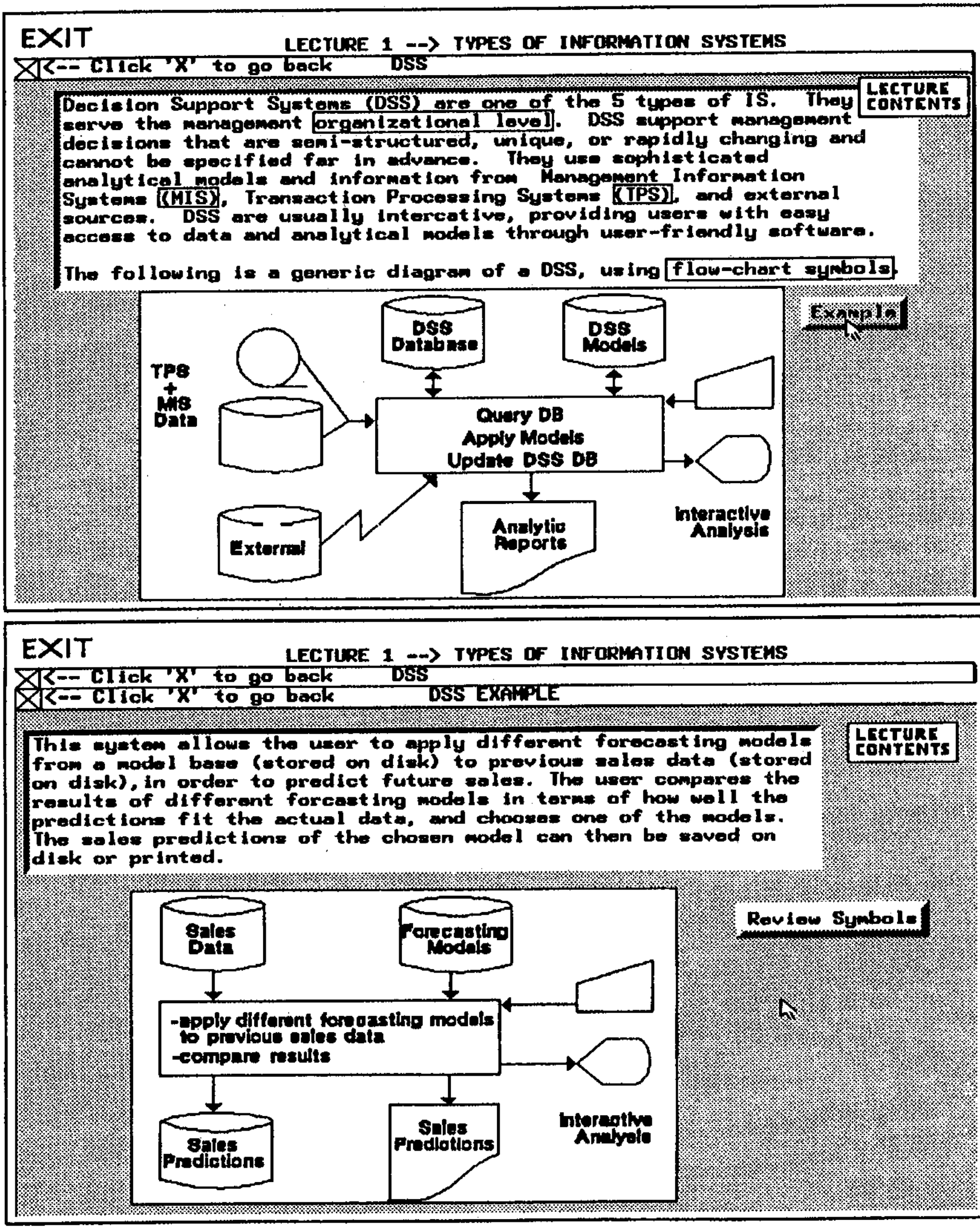

Table 1: EXPERIMENTAL DESIGN

	Exam 1	Exam 2	Exam3	Exam 4	Exam 5
Group 1	Module 1 + Notes	Module 2 + Notes	Module 2 + Notes	Notes	Module 3
Group 2	Module 1 + Notes	Notes	Module 2 + Notes	Module 3 + Notes	Module 3 + Notes

Table 2: STUDENT PERCEPTIONS

	Questions	Mean	Significance
1.	The hypercourseware is easy to learn.	1.86	*
2.	The hypercourseware is easy and enjoyable to use.	2.14	
3.	The hypercourseware provides faster access to information.	2.28	*
4.	The hypercourseware helped me learn more and better.	2.78	**
5.	The hypercourseware helped me learn faster.	2.66	**
6.	The hypercourseware helped me understand better.	2.58	**
7.	The hypercourseware helped me remember better.	2.18	*
8.	The hypercourseware helped me perform better in exams.	2.35	*
9.	The hypercourseware is more useful for understanding than for reviewing.	2.56	**
10.	I used the hypercourseware to understand then relied on the lecture notes to review.	2.14	*
11.	I used the lecture notes to understand then relied on the hypercourseware to review.	-2.82	**
12.	I relied on the hypercourseware only.	-2.94	**
13.	I relied on the lecture notes only.	-2.94	**

Scale: Strongly disagree -3 -2 -1 0 1 2 3 Strongly agree

* $p < 0.05$ ** $p < 0.01$

to hardware and PC software such as Lotus 123 and dBASE III plus. Hence, all students had some computer knowledge. However, some of them were not familiar with direct manipulation interfaces and had to go through a training session prior to participating in the experiment.

Experimental Procedure

The MIS hypercourseware was installed in a PC lab that was dedicated to the experiment. The students could go to the lab and access the system at any time. Every student was given a different password that was used by the system to create a protocol file keeping track of the screens explored and the time spent on every screen. The passwords were also used by the system to identify the students that were permitted to access the system for a given lecture. After a given module was completely covered, the students were provided with lecture notes and were given one week to use the lecture notes and the hypercourseware to prepare for an exam on that module. A student's mark in a given exam was used as a measure of the student's learning of the material of the corresponding module.

The students were randomly divided into two groups of 37 students each. To familiarize the students with the hypercourseware and with the testing method, both groups had access to the first module of the hypercourseware and were tested on this module (Exam 1). In addition to the first exam, the students had to write four other exams. Exams 2 and 3 tested the students on Module 2, while Exams 4 and 5 tested them on Module 3. Group 1 had access to Module 2 of the hypercourseware right after the content of that module was covered in class. Hence, the students assigned to the first group were able to use the hypercourseware to prepare for both exams (2 & 3).

Group 2, on the other hand, had access to Module 2 of the hypercourseware only after Exam 2. Hence, the students assigned to the second group relied uniquely on the lecture notes to prepare for Exam 2 and were able to use the hypercourseware to prepare for Exam 3. For the third module, on the other hand, Group 2 had access to the hypercourseware to prepare for both Exams (4 & 5), while Group 1 could use the system only after the first exam on that module. The experimental design is summarized in Table 1.

We chose this design to measure the usage and the effect of the hypercourseware when used during the initial stages of learning (to prepare for the first exam on each module) and when used to review already learned concepts (to prepare for the second exam on each module). We alternated between the groups in order to be able to perform within-group as well as between-group comparisons. With within-group comparisons, we can control for individual differences, but not for lecture content. Between-group comparisons, on the other hand, are useful for contrasting the performance of the two groups for the same lecture (control for lecture content, but no control for individual differences other than the random assignment of individuals to groups). At the end of the experiment (after Exam 5), the students were asked to answer a questionnaire where they described the usage of the system, its ease of learning and ease of use, its perceived effects on their performance. The questions as well as a summary of the student response are presented in Table 2. To avoid biasing the students' answers, the results of the exams were not given to the students until the end of the experiment.

RESULTS AND DISCUSSION

Before testing the hypotheses, it is important to examine the students' perception of the ease of learning and use of the hypercourseware. These human factors may affect student performance significantly and could explain whatever effects the hypercourseware has on the students. As illustrated in Table 2 (Questions 1-3), the students perceive the system as easy to learn, easy and enjoyable to use and providing faster access to information. The results of the empirical study also confirm all hypotheses.

Hypothesis 1

As illustrated in Table 3, the average mark of the group that had access to the hypercourseware is always higher than the average mark of the group that did not use the system. As verified by t-tests at the 0.05 confidence level, the average mark of Group 1 in Exam 2 is significantly higher than the average mark of Group 2 and the average mark of Group 2 in Exam 4 is significantly higher than the average mark of Group 1.

Furthermore, within group comparisons also indicate that the average performance of the students improved significantly in the exams in which they had access to the hypercourseware. Indeed, as confirmed by paired t-tests at the 0.05 confidence level, the average mark ofGroup 2 in Exam 3 is significantly higher than their average mark in Exam 2 and the average mark of Group 1 in Exam 5 is significantly higher than their average mark in Exam 4. These results confirm Hypothesis 1, which postulates that the hypercourseware has a significant positive effect on student learning. This hypothesis is also supported by the student perceptions (see Questions 4-8 in Table 2).

Hypothesis 2

The performance of the students who used the hypercourseware earlier in the learning process is better than the performance of the other students. The average marks of Group 1 are higher for both exams that covered Module 2 (see Table 3). Even when the students of Group 2 had access to the hypercourseware (second exam on Module 2), they could not reach the same performance level as the students of Group 1. As verified by a t-test at the 0.05 confidence level, the average mark of Group 1 in Exam 3 is significantly higher than the average mark of Group 2. Similar results are observed for Module 3; the students who were allowed to use the hypercourseware earlier in the learning process (Group 2) outperformed the other students in both exams of that module ($p < 0.05$). These results can be interpreted as an indication that the hypercourseware is more effective when used in the initial stages of learning to enhance concept formation and understanding rather than when used to just review already learned concepts. The difference in performance can also be explained by the longer usage of the hypercourseware - the group that started earlier used the system for two weeks, while the other group used it for only one week. The students' descriptions of the way they used the hypercourseware, however, favours the first explanation. Most of the students indicated that they used the hypercourseware to understand and then relied on the lecture notes to review (Questions 10-13 in Table 2). Most of the students also believe that the system is more useful when used to gain an initial understanding of the material rather than to review (Question 9 in Table 2).

CONCLUSION

Several researchers advocated the use of hypercourseware to enhance student learning. There is, however, very little empirical evidence showing that such systems improve learning. There is also very little discussion of how these systems should be designed. Furthermore, it is not well understood how and when hypercourseware should be used. In this study, we attempted to clarify some of these matters. More specifically, we discussed the design of a hypercourseware for an MIS introductory course and tested the effect of this system on student performance in exams to have some empirical evidence of the way hypercourseware affect learning. The results of the empirical study showed that the MIS hypercourseware improved student performance significantly. We also looked at the way the students perceived this nonlinear instruction environment and how they used the hypercourseware.

The students found the nonlinear environment more efficient and more enjoyable than a strictly linear environment. The students also preferred to use the hypercourseware to understand and form new concepts rather than to review already learned concepts. This finding is further supported by the fact that the

Table 3: AVERAGES MARKS (OUTOF 10)

	Exam 1	Exam 2	Exam3	Exam 4	Exam 5
Group 1	7.9	8.3	8.6	7.5	8.2
Group 2	7.8	7.1	7.9	8.3	8.8

hypercourseware had a more significant effect on student performance when used in the initial stages of learning to enhance understanding. The results of this study help to gain a better understanding of how and when hypercourseware should be used.

We still, however, need to study why and how these systems affect student learning. It is believed that the associations provided by links between nodes representing related concepts facilitate concept formation, and understanding [3]. Hence, hypercourseware encourages the students to form more general concepts by establishing relationships between specific concepts rather than to simply memorize definitions. This hypothesis, however, should be investigated further, using techniques such as concept mapping.

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ISSN 1055-3096