The Impact of Three Navigation Models on Students' Learning Performance: A Case Study of a Hypermedia-Based Course at a Vocational High School in Taiwan

Mei-Sheng Chao

National Taiwan Normal University

Jin Tan Yang

National Koahsiung Normal University

Nan Hui Chiang

National Koahsiung Normal University

Abstract

Hypermedia are widely being used for the presentation of information, and by virtue of the ease of accessing and retrieving information they provide, they have gained increasingly wide popularity in the e-learning environment during the past few decades. The very flexibility of the hypermedia, however, has also created problems as concerns learning disorientation and cognitive-overload. In the past, instructional designers have tried to overcome these problems by providing learners with various navigation tools, such as those in the form of a conceptual framework or an index. This study examines the effects of three different navigation models on high school students' learning performance in a hypermedia-based course. The hypermedia-based content of the course was developed with a focus on the "semi-conductor", and the three navigation models, namely regular hyperlinks, a hierarchical structure and a menu-driven design, were employed to evaluate their respective influence on students' performance. Seventy-six 11th graders at a vocational high school participated in this study, and their searching performance and the extent of their learning disorientation were examined. The results demonstrate that for these high school students, the navigation model with a hierarchical structure was superior to the other two models in terms of both the efficiency and effectiveness of browsing. The results of this study point out significant differences in the use and effects of the three navigation models. Finally, the implications for designing effective hypermedia-based content are discussed.

Keywords: e-learning, hypermedia course design, learning disorientation, navigation model, SCORM

Introduction

As technology plays an increasingly prominent role in our society, it is critical that the academic community continue to investigate and make great strides in building the effectiveness of the computer as an instructional tool. While instructional technology has

allowed educators to re-evaluate and re-design teaching methods, one question long considered centers on what makes for the most effective design in computer-based learning environments. With the advent of more sophisticated Internet technologies, the Web, in light of its ability to produce complex, richly-interconnected and cross-referenced bodies of multimedia information, is unquestionably a widely-distributed hypermedia environment (Utting & Yankelovich, 1989). Although the hypermedia enable greater control over larger amounts of information, users frequently experience disorientation or cognitive-overload when browsing the Web. Thus, in pursuit of maximizing the successfulness of hypermedia-based instruction, it is important to understand and apply sound theoretical background knowledge that is most likely to thoroughly enhance the design and use of hypermedia systems. In the following section, the theoretical background and applications of the hypermedia are reviewed from the perspectives of (1) teaching applications; (2) navigation models; and (3) learning disorientation.

Review of the literature

Hypermedia and teaching applications

As information technology progresses, the hypermedia, partially as a product of hypertexts, have become a major platform for the presentation and retrieval of information. Hypertexts, having been used since the introduction of Apple's HyperCard system in 1987 are, in essence, defined as digital texts with hyperlinked nodes which replace pages, while offering multiple paths through a wide range of texts. The hypermedia, on the other hand, share the same rationale in the way in which information is displayed but have the additional advantage of doing so via a non-linear organization of information, such as with pictures, videos and sounds to enhance reception with a variety of media (Jonassesn, 1988; Gupta & Gramopadhye, 1995).

Hypermedia systems have, of course, been extensively used in both scholarly and vocational contexts with a variety of applications, ranging from browsing to training (Konradt, 2004). Jonassen and Gabringer (1990) listed a multitude of uses of the hypermedia in instructional tools, for example in language learning, science teaching and browsing in encyclopedias. Taking a different direction, Christensen, Giamo, and Jones (1993) developed a hypermedia-based instructional tool for facilitating the teaching of the design of hypermedia systems, while other researchers developed a hypermedia-based vision of a maintenance manual for diagnostic training (Gupta & Gramopadhye, 1995). Thus, hypermedia systems, with their tremendous potential to enhance learning, additionally offer invaluable opportunities for their application to various learning and training programs. Owing to the hypermedia's non-sequential nature of presenting and accessing information, learners can freely move through information based on their own, specific needs and at their own pace (Marchionini, 1988); on the other hand, the very flexibility of the hypermedia also creates problems pertaining to user disorientation and cognitive-overload. It is well recognized that the strengths of the hypermedia stem from their flexibility vis-'a-vis storing and retrieving knowledge in a non-linear fashion (Conklin, 1987; Gupta & Gramopadhye, 1995), where pieces of information are linked to one another, thereby providing unlimited possibilities for users to collect overwhelmingly vast amounts of information. Such features, along with a notable increase in computer access and Internet connectivity, make the hypermedia even more and more powerful in the e-learning environment. Meanwhile, it is true and very well documented that hypermedia systems empower users with extensive control to select paths and to navigate

freely, but nevertheless, they do not exist without problems; on the contrary, what results is that the very flexibility of the hypermedia may indeed create problems pertaining to user disorientation and cognitive-overload. This is discussed next.

Hypermedia and learning disorientation

Disorientation has been defined by Gupta and Gramopadhye (1995) as, "…the tendency to lose a sense of location and direction in a hypertext document." They go on to explain that this, "… can become a problem since users must know where they are in the network or how to get to some other place that they know exists in the network." (Gupta & Gramopadhye, 1995, p.438). Other research has indicated that one of the main problems in using hypertexts is the user's risk of "loosing himself" (Roselli, 1991). This, in fact, echoed the same viewpoint as that of Woods (1984) who first proposed the phenomenon of "getting lost", when "the user does not have a clear conception of relationships within the system, does not know his present location in the system relative to the display structure, and finds it difficult to decide where to look next within the system" (pp. 229-230). Along the same line, Smith (1996) reported that when users experienced "cognitive problems of finding their way in the information space" (p. 365), the "lost in hyperspace phenomenon" appeared. As indicated by Foss (1989), problems of disorientation in the hypermedia environment fall into one of two categories: the Art Museum Phenomena and the Embedded Digression Problems. Whereas the former refers to problems concerning an open information-seeking situation, the latter involves the multiplicity of path choices provided by hypermedia systems. No matter which type it is, disorientation may very well impose severe perceptions of difficulty, not to mention feelings of frustration on the part of learners in the hypermedia environment. Previous studies have shown a causal linkage between disorientation and learning difficulties in terms of finding a page known to exist, finding a page already visited, visualizing paths that have already been taken and alternative paths that could have been taken (Pitkow & Kehoe, 1996; Jarvenpaa & Todd, 1997; Ahuja & Webster, 2001). Simply put, disorientation represents one of the most common problems faced by e-learners. As long as disorientation leads to feelings of frustration and the desire to abandon the task at hand, designers of hypermedia systems must do their utmost to overcome this problem by providing users with the most effective navigation tools, such as indexes, maps, menus, and so on. These are discussed in the next section.

Hypermedia and navigation models

Designers of hypermedia systems have proposed several navigation tools to reduce disorientation, and among these are indexes, maps, and overview diagrams (Nielsen, 1990). Several earlier studies found that using maps coupled with menus as one integrated navigation tool was, perhaps unsurprisingly, far more likely to enhance searching-efficiency than was the use of indexes alone (Billingsley, 1982; Hitch, et al, 1986). According to Conklin (1987), a hypertext system can be designed based on two typical approaches – one on organization and the other on references. The organizational-type approach consists of a hierarchical structure, unlike the referential-type which displays the menu-driven topology. Much more recently, some studies have pointed out the differences in disorientation within a hypermedia environment when these two navigation models were used, and it is now widely accepted that the referential-type is more likely to result in disorientation than is the hierarchical structure (McDonald and Stevenson, 1996, 1998). Beasley and Waugh (1996) recently studied the influences on learning disorientation from three types of navigation maps, i.e., spider maps, hierarchical maps and hot words. Their results showed that in

reducing disorientation, hierarchical maps were superior to hot words, while the differences between spider maps and hot words were not at all significant. Although it is well recognized that reducing disorientation is essential for hypermedia system designers, it is, at best, hard to develop a "standard" model for designers to follow. In short, this is attributed to the fact that as e-learning becomes more pervasive, hypermedia systems find an even broader stage and more participants for their presentation. It is evident, therefore, that the standard specifications developed by the Advanced Distributed Learning Initiative (ADL), could be used as a spring board to build such a protocol (ADL, 2004). In the latest model of the Shareable Content Object Reference Model (SCORM) 2004, regular hyperlinks and a hierarchical structure are employed as the two major formats in e-learning, and both learning paths are determined by the system. In Taiwan, however, the hierarchical structures and menu-driven design have been developed by National Sun Yat-sen University, Kaohsiung, and they have been applied to the e-learning platform established by that university (http://ds.k12.edu.tw).

To summarize the types of navigation tools used since the 1980's, they could be categorized as being: hierarchical structures (including maps and/or text formats), menu-driven structures, and index/regular hyperlinks. Accordingly, this study employs these three navigation models, namely the hierarchical structure, menu-driven structure, and regular hyperlinks, as the treatment variables to examine their respective impact on students' learning.

It is difficult to maintain a sense of where things are in a relatively unstructured network of information, and as a result, unless some navigation tools are provided, learning disorientation and cognitive-overload commonly result (Valdez, et al. 1988). Hence, the present study examines the effects of the three different navigation models on high school students' performance in a hypermedia-based course. This hypermedia-based course unit was developed in Chinese with a focus on the topic of "semi-conductors". The three navigation models i.e., regular hyperlinks, a hierarchical structure, and a menu-driven structure, were employed to investigate their individual influences on students' performance. Given the rationale previously discussed, it was hypothesized here that a hierarchical structure should make students better oriented, which in turn, should result in their completion of a greater number of tasks and in a shorter length of search time.

Method

Subjects

The student population in Taiwan at the vocational senior high school level is relatively homogeneous since virtually all students can only enter senior high schools directly from junior high schools. Beyond this, all Taiwanese students must succeed in the same entrance exams before entering a senior high school. Contrast this with a typical senior high school class in the U.S. or Europe which may be made up of a much broader spectrum of students, for example in terms of ethnic, linguistic, and educational background. Thus, from the outset of this study, it was assumed that the student population is of a fairly uniform level of knowledge. Seventy-six male and female 11th graders at a Kaohsiung city vocational high school participated in the experiment. The subjects possessed some basic Internet skills and had succeeded in a one-year Introduction to Computer course.

Design

The experiment used a single factor design with each type of the three navigation models representing one independent variable. Three treatment levels were optionally defined for each navigation model -- that is, regular hyperlinks, a hierarchical structure, and a menu-driven design. Figures 1, 2, and 3 show an example of a screen for each of the three different navigation models. Each subject was randomly assigned to one of the three groups, with each group performing their tasks either with regular hyperlinks, the hierarchical structure or the menu-driven design.

In the regular hyperlinks model, the organizational-type consisted of a one-layer hierarchical structure, and it was more loosely designed with the key terms in the frame on the left-hand side. It only displayed the referential titles of each section. In regard to the second model, the design of the hierarchical structure was based on a strict hierarchy, with the domain knowledge serving as the scaffolding for students. As for the menu-driven model, it was designed on the basis of a domain hierarchy, where the titles of the content structure appeared as students clicked the menu at the top of the screen. Although all three models offered a topology of the hierarchical structure, each of them used a different form of presentation, and it is this that affected the way in which the depth of the content structure was handled by the students.

The subjects' individual performance in the hypermedia-based course was measured in terms of the number of items completed and the time spent searching. In addition, learners' perceived learning disorientation was measured using the Non-linear Media Disorientation Assessment, as developed in 1996 by Beasley and Waugh.

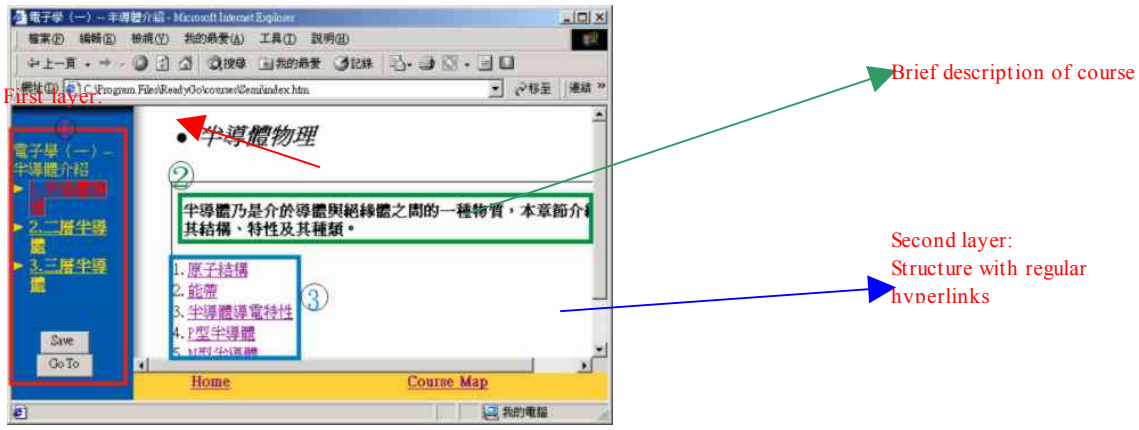

Figure 1: Navigation Model: An instance of the regular hyperlinks model

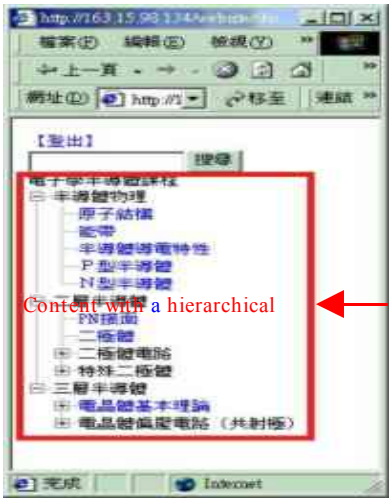

Figure 2: Navigation Model: An instance of the hierarchical structure model

Figure 3: Navigation Model: An instance of the menu-driven model

Material/Hypermedia system

The experiment material, as stated previously, was a hypermedia-based course unit related to "semi-conductors", with three different navigation models, namely regular hyperlinks, a hierarchical structure and a menu-driven design. Thirty-four web-pages for each model were developed, and each contained a built-in tracking mechanism to trace learners' browsing processes, and furthermore, to understand their level of disorientation. All three versions shared the same contents but differed with respect to organizational structure.

On the level of operations, the Active Server Page (ASP), a web-based programming language created by Microsoft Company, was employed to develop the tracking mechanism, and each learner's log-in time, total time spent browsing material, time and frequency spent on a single web-page and the answers to the tasks were all recorded in the My Structured Query Language (MySQL) database, which was used for statistical analyses after the experiment. Learners were required to complete ten tasks in the experiment, with each task containing 10 questions. The number of correct items indicated the extent to which learners were able to follow the tracking paths, while the time spent searching was indicative of their disorientation level. An ASP web-page was designed to determine whether the subjects' answers were correct (Figure 4). The Non-linear Media Disorientation Assessment was used to assess the learners' perceived disorientation (Beasley & Waugh, 1996).

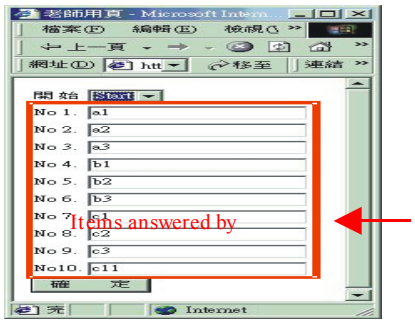

Figure 4: Built-in tracking mechanism to trace learners' browsing processes by the ASP

Procedures

First, all participants received instruction on the correct usage of each of the hypermedia systems, and they were briefly introduced to the goals of the experiment. Each participant was then randomly assigned to one of the three groups: one with regular hyperlinks (25 subjects), one with the hierarchical structure (26 subjects) and one with the menu-driven design (25 subjects). After a 30-minute learning session, learners were asked to fill in the Non-linear Media Disorientation Assessment form and were then instructed to begin the searching tasks.

Results

The analysis of variance (ANOVA) was used for data analyses in this study. To obtain conceiving generalizations, this study employed the Levene Statistic Technique to test if the samples had equal variances. Equal variances across samples in a study are collectively referred to as the homogeneity of variances. Some statistical tests, for example the analysis of variances, assume that variances are equal across groups or samples. The Levene test was used here to verify this assumption. The results, presented in Table 1, show that all three dependent variables met the requirements of equal variances ($p>.05$), strongly suggesting that the results of the ANOVA met the requirements of "Equal variances across the three navigation models". In other words, the ANOVA could successfully be applied in this study.

Table 1: Test results of the dependent variables of homogeneous variances

Dependent Variable	Levene Statistic	DF 1	DF 2	Significance p
Item searching	**0.599**	**2**	**73**	**0.552**
Searching time	**0.112**	**2**	**73**	**0.895**
Disorientation	**1.590**	**2**	**73**	**0.211**

score

N=76

Legend: DF = degree of freedom

Table 2: Means and SDs across the three treatments

Independent Variables	**Regular hyperlinks (N= 25)**		Hierarchical **Structure (N= 26)**		**Menu-driven (N= 25)**	
Dependent Variables	Mean	SD	**Mean**	**SD**	**Mean**	**SD**
Completed item searching	**44.40**	**17.37**	**54.92**	**14.43**	**49.58**	**17.31**
Searching time	**68.42**	**14.98**	**80.01**	**13.69**	**76.02**	**13.17**
Disorientation score	**25.48**	**5.83**	**23.92**	**6.20**	**24.32**	**4.38**

Legend: SD = standard deviation

Completed item searching

Table 2 presents the means and standard of deviations (SDs) of each of the three dependent variables. The first row in Table 2 shows the mean numbers of correct items answered and their standard deviations. In the case of the hierarchical structure group, the subjects have more correct items when compared with their counterparts in the other two groups (54.92 vs. 49.58 vs. 44.40), though the results are not statistically significant ($F_{(2,73)}$=2.619, p>.05), as shown in Table 3. The value of probability (PROB), however, is in fact very close to .05, which indicates that the differences between the groups are fairly significant.

Table 3：ANOVA of completed item searching

Source of Variation	SS	DF	Mean Square	F-ratio	PROB
Between-groups	1410.6	2	705.3	2.619	.080

Within-groups	19655.9	73	269.2
Total	21066.5	75	

Legend: SS = sum of square

DF = degree of freedom

PROB = probability

Searching time

To obtain the mean time spent on searching individual items, the mean of time searching was divided by the mean of item searching shown in the second and first rows of Table 2. The results show that the hierarchical structure group demonstrates greater efficiency in searching (80.01/54.92 = 1.45 min.) than does the menu-driven group (76.02/49.58 = 1.53 min.) and the hyperlink group (68.42/44.40 = 1.54 min.). In addition to this, the ANOVA was applied to examine statistical significance, and the results do reach the level of statistical significance ($F(2,73)=4.509$, $p<.05$), as shown in Table 4. At this stage, the Scheffe *post-hoc* multiple comparisons approach was applied to further examine the differences in the levels of significance.

Table 4： ANOVA of searching time

Source of Variation	SS	DF	Mean Square	F-Ratio	PROB
Between-groups	1759.58	2	879.795	4.509*	.014
Within-groups	14244.30	73	195.127		
Total	16003.88	75			

Legend: SS = sum of squares

Df = degree of freedom

PROB = probability

* = $p<.05$

Table 5：Scheffe *post-hoc* multiple comparisons of searching time

Group I	Group J	Mean Difference (I-J)	SD Error	Significance	95% Confidence Interval	
					Lower bound	Upper bound

Regular hyperlinks	Hierarchical structure	-11.58*	3.91	.016*	-21.36	-1.81
	Menu-driven design	-7.60	3.95	.164	-17.47	2.26
Hierarchical structure	Regular hyperlinks	11.58*	3.91	.016*	1.81	21.36
	Menu-driven design	3.98	3.91	.598	-5.79	13.76
Menu-driven design	Regular hyperlinks	7.60	3.95	.164	-2.26	17.47
	Hierarchical structure	-3.98	3.91	.598	-13.76	5.79

Legend: * = p< .05

Table 5 presents the results of the Scheffe *post-hoc* multiple comparisons. No significant differences are found between the regular hyperlink and menu-driven groups, and neither are there any between the hierarchical structure and menu-driven groups. However, significant differences are found between the hierarchical structure and the regular hyperlink groups. Compared with other pairs, the upper and lower bound values for these two groups lay within 1.81~21.36 based on the 95% confidence interval; hence, it is obvious that the differences between the hierarchical structure and regular hyperlink groups are statistically significant.

Perceived learning disorientation

The bottom row of Table 2 shows the mean scores of the Non-linear Media Disorientation Assessment forms filled in by each subject, and no statistically significant differences are found, as shown in Table 6.

Table 6： ANOVA of learning disorientation

Source of Variation	Sum of Squares	DF	Mean Square	F-VALUE	PROB
Between-groups	33.1	2	16.5	.540	.585
Within-groups	2239.5	73	30.6		
Total	2272.6	75			

Legend: SS = sum of squares

DF = degree of freedom

PROB = probability

Discussion

For the most part, this study shows that the hierarchical structure model does facilitate learners' browsing efficiency. As described previously, browsing is an information-seeking activity that involves scanning text ideas from one node to another in a non-specific manner. With this in mind, of the three navigation structures studied here, the one that enables learners to access more content information and, at the same time, revisit the smallest number of links is the hierarchical structure model. The results here strongly imply that this type of structure probably facilitates broader perusal and provides a stronger sense of whereabouts. To sum up, it appears that the hierarchical structure allows for more effective searching in terms of both the number of tasks completed and the time spent browsing.

Regarding the number of searching tasks completed, in this study, the students were told before the experiment that their searching performance would be counted as part of their semester GPA, which may very well have motivated them to try their best no matter which group they were part of. This could have been the main reason that some of the results do not reach the level of statistical significance. Nevertheless, as mentioned earlier, the value of PROB is very close to .05, and this may imply that the probability of obtaining significant differences would have actually been higher if, before the experiment, students had not been told that their performance would be evaluated.

Based on the mean scores presented in Table 2, the hierarchical structure group has more correct items compared with the other two groups (54.92 compared with. 49.58 and. 44.40). This is highly consistent with the findings obtained by Webb and Kramer (1987) and Zellweger (1989) which indicated that subjects who received structured navigation models outperformed subjects who did not (Gupta et al, 1995). With respect to the time spent searching, it is noteworthy that the hierarchical structure group shows a significantly better performance than does the regular hyperlink group. This result closely agrees with that of McDonald and Stevenson (1996, 1998) whose subjects with the hierarchical treatment were at least as fast as those who searched for the answers using regular hyperlinks. While the hierarchical structure both displays the major topics and records the time spent as well as the frequency of visiting each node, it is evident that it also reduces learning disorientation, and thus, makes searching more efficient.

To be sure, the organization type of the hypermedia system employed can contribute to superior navigation performance by helping learners to develop better searching skills. Wickens (1992) suggested that human navigation memory consists of three types of spatial knowledge: landmark knowledge, route knowledge, and survey knowledge. Navigation in a hierarchical condition demands quite rigid, yet simple, movements among a limited number of nodes, thereby allowing those nodes to function as prominent landmarks which are essential in easing a user's passage into accurate route knowledge. Though route knowledge is more ego-centered, survey knowledge is globally defined, which is crucial in directing the learner back to the appropriate route after digressing onto an inappropriate one. It should be expected, therefore, that the hierarchical structure not only relieves learners' from cognitive-overload in regard to spatial orientation but also makes it easier for them to develop a more accurate mental map when browsing the Web. What's more, the significant differences we find in the searching time spent may be attributed to the superiority of the hierarchical structure. More specifically, in a hierarchical hypermedia environment, movements from one topic to another are directed in accordance with the limited number of path alternatives, as defined by certain types of relations; as a result, it obviously offers the shortest route to the desired destination, meaning that the time wasted digressing is substantially reduced.

The measurement of the searching tasks and searching time aside, the third measure of this study concerns learners' perceived learning disorientation. The results, however, do not fully mirror those of Beasley and Waugh (1996) which give support to the notion that different types of navigation maps do have varying effects on learners' perceived learning disorientation. One factor that may account for the discrepancy between these two studies is that the subjects in the present study were asked to fill in the measurement questionnaire by themselves, and this might have resulted in more homogeneous statistics; that is, the students may well have shown a tendency to underestimate their learning disorientation on the grounds that they believed it might serve as a self-evaluation process, thus affecting their GPA. However, this study does provide the same results as those of Wong (1998), whose measurement for the reliability coefficient was 0.728; both of these coefficients are quite comparable to the coefficient of 0.803 reported by Beasley and Waugh (1995). Numerous researchers have determined and pointed out differences in terms of perceived disorientation which are related to differing Web designs or navigation systems (Ahuja & Webster, 2001). This may also explain the inconsistency between the present study and that of Beasley and Waugh (1996).

Conclusions

Internet technologies have unambiguously had a profound effect on the way teachers instruct. While the government of Taiwan has initiated a national project on e-learning so as to enhance its efficacy in and application to our daily lives, the advent of e-learning has provided new opportunities for teachers to consider the various roles that different instructional strategies can play. This, in turn, should help students better learn in cyberspace. As mentioned earlier, the hypermedia have become major platforms for the presentation of information, and thus, it follows that to determine the best ways to design effective hypermedia navigation tools has become a fundamental issue in this era of digital technology.

In this study, an investigation into the influence of three different navigation models on high school students' learning achievement was conducted, and the results clearly suggest that in terms of searching efficiency and the completion of tasks, the hypermedia-based course with a hierarchical structure is superior to one which is menu-driven or one which has regular hyperlinks. Future studies are, nonetheless, required to extend this research to other types of users. Unquestionably, this will allow us to quantify potentially different effects on subjects of different age groups. Besides this, designers of hypermedia systems may consider alternative approaches when developing navigation support. Most recently, such approaches as adaptive hypermedia (AH) systems with their focus on adaptation to the user's needs have gained considerable attention (Brusilovsky, 2003). To put it briefly, more research specifically aimed at exploring adaptive navigation support techniques and analyzing learning issues in various pedagogic scenarios as well as in a vocational context is strongly recommended.

References

ADL (2004). Advanced Distributed Learning. http://www.adlnet.org

Ahuja, J. S. & Webster, J. (2001). Perceived disorientation: an examination of a new measure to assess web design effectiveness. *Interacting with Computers*, 14, pp. 15-19.

Beasley, R. E., & Waugh, M. L.(1996). The effects of content-structure focusing on learner structural and disorientation in a hypermedia environment. *Journal of Research on Computing in Education*, 28(3), 271-281.

Billingsley, P. (1982). Navigation through hierarchical menu structures: Does it help to have a map? *Proceedings of the Human Factors Society, 26th Annual Meeting*, pp.103-107. Santa Monica, CA: Human Factors Society.

Brusilovsky, P. (2003). Adaptive navigation support in educational hypermedia: the role of student knowledge level and the case for meta-adaptation. *British Journal of Educational Technology,* Vol 34, No. 4, 487–497.

Chen, S. (2002). A cognitive model for non-linear learning in hypermedia programmes. *British Journal of Educational Technology*, 33(4), 449-460.

Christensen, M., Giamo, M. and Jones, T. (1993). Support for teaching the design and implementation of multimedia systems. *SIGSE Bulletin*, 25(1), 242-246.

Conklin, J. (1987). Hypertext : an introduction and surveys. *IEEE Computer*, 20(9), 17-41.

Foss, C. I. (1989). Tools for reading and browsing hypertext. *Information Processing and Management*, 25, 407-418.

Gupta, M. & Gramopadhye, K. (1995). An evaluation of different navigational tools in using hypertext. *Computers and Industrial Engineering*, 29, 437-41.

Hitch, G. J., Sutcliffe, A. G., Bowers, J. M. & Eccles, L. M. (1986). Empirical evaluation of map interfaces: A preliminary study. In M. Harrison & A. Monk (Eds.), *People and computers: Designing for usability* (pp.565-585). Cambridge: Cambridge University Press.

Jarvenpaa, S. L. & Todd, P. A. (1997). Consumer reactions to electronic shopping on the World Wide Web. *International Journal of Electronic Commerce* 1 (2), 59-88.

Jonassen, D. H. (1988). Designing structured hypertext and structuring access to hypertext. *Educational Technology*, 28(11), 13-16.

Jonassen, D. H. and Gabringer, R. S. (1990). Problems and Issues in Designing Hypertext/ Hypermedia for Learning. In Jonassen, D. H. and Mandl, H. (Eds.) *Designing Hypermedia for Learning.* NATO ASI Series. Springer-Verlag. Berlin Heidelberg.

Konradt, U. (2004). Hypermedia in vocational learning: A hypermedia learning environment for training management skills. *International Journal of Instructional Media,* Vol. 31(2), 175-184.

MacGregor , S. K.(1999). Hypermedia navigation profiles: cognitive characteristics and information processing strategies. Journal of educational computing research, 20(2) 189-206.

Marchionini, G. (1988). Hypermedia and learning: Freedom and chaos. Educational Technology, 8-12.

McDonald, S. and Stevenson, R. J. (1996). Disorientation in hypertext: the effects of three text structures on navigation performance. *Applied Ergonomics*, 27, 61-68.

McDonald, S. and Stevenson, R. J. (1998). Effects of text structure and prior knowledge of the learner on navigation in hypertext/?s. *Human Factors*, 40, 18-27.

Nielsen, J. (1990). The art of navigating through hypertext. *Communications of the ACM*, 33(3), 298-310.

Paolucci , R.(1998). The effects of cognitive styles and knowledge structure on performance using a hypermedia learning system. Journal of Educational Multimedia and Hypermedia, 7(2/3), 123-150.

Pitkow, J. & Kehoe, C. (1996). Emerging trends in the WWW user population. *Communications of the ACM* 39 (6), 106-108.

Relan, A.(1995). Promoting better choices: effects of strategy training on achievement and choice behavior in learner-controlled CBI. Journal of Educational Computing Research, 13(2), 129-149.

Roselli, T. (1991). Control of user disorientation in hypertext systems. *Educational Technology*, 42-46.

Smith, P. A. (1996). Towards a practical measure of hypertext usability. *Interacting with Computers* 4, 365-381.

Valdez, F.; Chignell, M. and Glenn, B. (1988). Browsing models for hypermedia databases. *In Proceedings of the Human Factors Society – 32nd Annual Meeting*, Ahaheim, CA. 318-322.

Utting, K. & Yankelovich, N. (1989). Content and orientation in hypermedia networks. *ACM Transactions on Information Systems* 7 (1), 58-84.

Webb, J. M. and Kramer, F. A. (1987). Learning hierarchical menu systems: A comparative investigation of analogical and pictoral format. *Proceedings of the Human Factors Society 31st Annual Meeting*.

Wickens, C. D. (1992). *Engineering psychology and human performance*. New York: Harper Collins.

Wong,F. M. (1998) . *The influence of the navigation map field on the disorientation of elementary students in a web- based hypermedia course.* Master's Thesis, Tainan city: National Tainan Teachers College.

Woods, D. D. (1984). Visual momentum: A concept to improve the cognitive coupling of person and computer. *International Journal of Man-Machine Studies*, 21, 229-244

Zellweger, P. T. (1989). Scripted documents: A hypermedia path mechanism. *In Proceedings of Hypertext*.