Navigation in Hypermedia Learning Systems: Experts vs. Novices

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Abstract

With the advancement of Web technology, hypermedia learning systems are becoming more widespread in educational settings. Hypermedia learning systems present course content with non-sequential formats, so students are required to develop learning paths by themselves. Yet, empirical evidence indicates that not all students can benefit from hypermedia learning. Research into individual differences suggests that prior knowledge has significant effects on student learning in hypermedia systems, with experts and novices showing different preferences to the use of hypermedia learning systems and requiring different levels of navigation support. It is therefore essential to develop a mechanism to help designers understand the needs of experts and novices. To address this issue, this paper presents a framework to illustrate the needs of students with different levels of prior knowledge by analyzing the findings of previous research. The overall aim of this framework is to integrate students' prior knowledge into the design of hypermedia learning systems. Finally, implications for the design of hypermedia learning systems are discussed.

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1. Introduction

Hypermedia learning systems are becoming widespread in educational settings owing to the growth of the use of web-based applications in higher education. Hypermedia is characterized by presenting information in a non-linear format. The non-linearity allows learners to have greater navigational control and freedom, and gives learners the opportunity to access and sequence information according to their information needs (Lawless and Brown, 1997). However, empirical evidence indicates that not all learners can decide the navigation strategies by themselves (Lawless and Kulikowich, 1998; Shapiro, 1999; Lazonder *et al*., 2000; Last *et al*., 2001). In particular, many studies have found that learners with different levels of prior knowledge benefit differently in hypermedia learning systems, with experts and novices showing different preferences to the use of hypermedia learning systems and requiring different levels of navigational support (Shin *et al.*, 1994; McDonald and Stevenson, 1998a, 1998b; Calisir and Gurel, 2003).

It is, therefore, essential to develop a mechanism to help designers to understand the needs of users with various levels of prior knowledge. In this paper, a framework is presented to illustrate their diverse requirements by analyzing the findings of previous research. The overall aim of this framework is to integrate prior knowledge into the design of hypermedia learning systems. The framework includes four elements drawn from the analysis of existing research - disorientation problems; content structure; navigation tools; and additional support - as literature suggests that these elements are of importance for the effective design of hypermedia learning systems. In addition, a number of recommendations for the design of hypermedia systems are proposed based on the framework, with a particular emphasis placed on navigation support and user interface issues since the analysis suggests that they are of prime importance.

2. Experts and Novices

Expertise in a domain cannot easily be defined by quantifiable variables, but it is possible to define certain qualities that an expert may possess (Tennyson, 2001). According to Simmons and Lunetta (1993), an expert can be simply defined as an individual with formal training and experience in the area under investigation, whereas a novice can be defined as having little or no formal training/experience in the area examined. Spires and Donley (1998) argue that the contrast between experts and novices lies in the differences in the organization of their conceptual structures. Experts possess a mental representation (i.e. a hierarchical structure) of the concepts in the domain. Conversely, a novice's structure is more chaotic and disorganized. Jenkins *et al.* (2003) conducted a study that examined the different information seeking strategies used by experts and novices. The participants were asked to look for medical information with search engines. Their findings indicated that experts focused on locating detailed information by using depth-*first strategies,* beginning at the first link on the initial site, then following links provided by the site and from one site to another, until they found a suitable site. In contrast, novices tended to get an overview by using *breadth-first strategies*, following the first link of the initial site, then going back to the initial site and following the second link without exploring any links offered in depth. In addition, Shertz and Weiser (1981) argue that experts and novices use different ways to represent problems. The former place emphasis on the deep features, such as the solution method, while the latter tend to be surface features, such as application areas. The aforementioned issues indicate that experts and novices possess different learning characteristics. Table 1 summarizes the key differences between experts and novices.

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As Table 1 suggests, experts and novices possess different learning characteristics, which raises the importance of prior knowledge in student learning, and, we would argue, makes it necessary to explore how to integrate prior knowledge into the design of hypermedia learning systems. The next section will look at the interaction effects between prior knowledge and student learning to help inform the design of hypermedia systems that are beneficial to both experts and novices.

3. Hypermedia Learning and Prior Knowledge

In the past decade, a growing body of research has examined the influence of prior knowledge in hypermedia learning systems. Such research has suggested that different levels of prior knowledge suited to different types of content structure (Calisir and Gurel, 2003) and different navigation tools (McDonald and Stevenson, 1998b). It demonstrates that prior knowledge can determine how well learners acquire information from hypermedia and can influence their learning patterns in a hypermedia system (Alexander *et al*., 1994, Last *et al*, 2001). We will illustrate the interaction of prior knowledge with hypermedia learning by presenting a review of relevant research covering 26 quantitative and qualitative studies from 1990 to 2003. In particular, the review will focus on four themes - (1) disorientation problems; (2) content structure; (3) navigation tools; and (4) additional support - as they are considered to be important issues pertaining to hypermedia learning in the literature.

3.1 Disorientation Problems

Hypermedia differs from traditional forms of computer-based instruction in that it allows non-linear access to large amounts of information and provides learners with great navigation control to sequence the information. However, not all learners can manage the high level of control offered by hypermedia systems. Some learners may get lost or become disorientated in such systems (Nielsen, 2000), and a number of studies indicate that learners' prior knowledge is an essential factor that influences the degree of disorientation that learners experience in hypermedia systems.

In an early study by Gray (1990), a hypermedia system was used by 10 readers who were given the goal of answering questions. The results indicated that readers experienced a variety of disorientation problems, including uncertainty over what they had and had not read, that they lacked organizational cues, and that they were not sure where to find the information they needed. In particular, novice hypermedia users met more disorientation problems and needed analogies with conventional structures if they were to learn successfully. Last *et al.* (2001) conducted a study, which showed similar results. 12 undergraduates participated in the study and the level of students' prior knowledge was determined by identifying whether they had had prior exposure to the material. They

found that students with high prior knowledge of the content were better able to navigate easily, remember where they had been, and decide how to get to where they wanted to go. These students reported more positive feelings about using the system than did the low prior knowledge students and seemed to suffer much less from frustration while performing their tasks. The students with low prior knowledge often suffered from disorientation, not knowing where they had been, or where they could go to find the information that they needed.

Another study by McDonald and Stevenson (1998a) examined the effects of prior knowledge on hypermedia navigation and showed that subjects who lacked sufficient prior knowledge of the topic covered demonstrated more disorientation problems than subjects with high prior knowledge. Non-knowledgeable learners tended to open more additional notes, which suggested that they could not remember where they had been and that they had difficulties in finding the information that they required. The studies described above are consistent in suggesting that novices experience more disorientation problems in hypermedia learning systems. The results lend support to the studies of Hammond (1989) and Rouet and Levonen (1996), which indicate that disorientation is heightened in novices as they lack the conceptual structure of the domain to orient their interaction with the hypermedia system. This may be owing to the fact that novices are unfamiliar with the subject matter, so they cannot rely on prior knowledge to help them determine its structure.

Compared with novices, experts may experience fewer disorientation problems in hypermedia learning systems because their deep levels of understanding of the subject matter enable them to impose structure on the content (McDonald and Stevenson, 1998a). Mohageg (1992) suggested that expert learners navigating in a nonlinear hypermedia system might avoid disorientation because they already possessed a mental representation of the concepts in the domain that they were searching. Therefore, there is a need to provide novices with appropriate content structure and additional navigational support to reduce disorientation problems and support their development of structural representation of the knowledge domain being covered.

3.2 Additional Support

As indicated in the last section, hypermedia learning seems to be more suitable for expert students. Conversely, novice students experience more disorientation problems, so it is essential to provide them with additional support through mechanisms such as advisement, (Shin, et al., 1994), advance organizers (Shapiro, 1999), human support (Vansickle, 2000), graphical overviews (de Jong and van der Hulst, 2002) and structural cues (Hsu and Schwen, 2003). These issues will be examined in turn to explore the value.

An early study Shin et al. (1994) examined an interaction effect between advisement and prior knowledge. 111 second–grade students who had different levels of prior knowledge about the system's content participated in the experiment. Advisement gave learners recommendations on which sequence to follow and offered visual aids to help learners to locate themselves in the hypermedia system. They found that the 'free access without advisement' condition was difficult for all students, but was especially problematic for novices, indicating that the advisement treatment and visual aids are important for helping novices to develop effective navigation strategies in the hypermedia environment.

Shapiro (1999) investigated the effect of advanced organizers (in the form of interactive overviews) on the development of conceptual structure in novices learning from hypermedia. The results indicated that when the learner had no prior knowledge, the influence of an overview was powerful enough not only to guide the structure of a novice's internal representations, but also to overshadow the effect of the learning goal during that process. When learners had some background information, however, the effect of the overview was significantly reduced. This finding seems to suggest that an advanced organizer is helpful for novices learning from hypermedia.

Vansickle (2000) examined the relationships between users' prior knowledge and the use of the World Wide Web, assessing 136 students in terms of their prior knowledge with a 60-question survey. The qualitative results indicated that novice students could develop expertise through mediation support from teachers and librarians.

In addition, a graphical overview is also considered effective in hypermedia learning for learners with low prior knowledge. In the study by de Jong and van der Hulst (2002), a hypermedia environment was enhanced with a graphical overview that represented the basic and inherent structure of the domain, and the layout was designed in such a way that learners were encouraged to follow a sequence of exploration that mirrored the domain structure. The results suggest that visual display of the domain structure is effective in two ways: (1) providing learners with a systematic visual overview of the domain is expected to induce a systematic route through the domain and may thus lead to a better acquisition of the structure of the domain; and (2) visual overviews are supposed to enhance acquisition of domain structure because they display the structure of the domain directly.

Recently, several researchers (e.g., Hsu and Schwen, 2003) have suggested that providing structural cues is beneficial for learners, especially novices. Hsu and Schwen (2003) compare the effects of structural cues derived from single versus multiple metaphors used in designing hypermedia systems. A total of 54 undergraduate students were asked to perform selected information searching tasks. The results showed that the provision of metaphorical cues helped subjects to find a greater number of accurate answers in a shorter period of time.

In summary, the research in this area shows that additional support can be provided to help learners with a low level of prior knowledge in hypermedia learning, particularly in free navigation conditions. Advisement, which provides learners with visual aids and recommended navigation paths, is helpful in preventing disorientation in non-linear hypermedia learning. As novice learners cannot rely on their prior knowledge to help them structure the text, graphical overviews and structural cues are powerful and beneficial in providing navigation guidance so as to ease disorientation problems.

3.3 Content Structure

In addition to providing addition support, another approach to reducing disorientation is to provide learners with appropriate content structure. A number of studies have examined how content structure interacts with learners' prior knowledge, and the

findings suggest that experts and novices differ in their performance depending on content structure in hypermedia learning systems. The results of these studies are summarized in Table 2.

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McDonald and Stevenson (1998a) examined the effect of content structure and prior knowledge on navigation performance in hypermedia learning. Three types of content structure–hierarchical, non-linear, and mixed (hierarchical structure with cross referential links) – were investigated, using 30 university students as the sample. Half were knowledgeable and half were non-knowledgeable about the subject matter of the system. Navigation performance was measured in terms of subjects' speed and accuracy in answering questions and locating particular nodes. The results showed that the performance of knowledgeable participants was better than that of non-knowledgeable participants, as they had a better conception of the subject matter than non-knowledgeable participants did. The results also showed that non-knowledgeable participants performed better in both browsing and navigating in the mixed structure condition than in the non-linear structure condition.

In a similar vein, Calisir and Gurel (2003) also investigated the interaction of three types of content structure – linear, hierarchical, and mixed (hierarchical structure with cross referential links) – with prior knowledge of the learner in hypermedia learning. The same sample size, 30 participants with half being classified as knowledgeable and half as non-knowledgeable, was used in the study. However, in contrast to the study by McDonald and Stevenson (1998a), they examined the influence of text structure and prior knowledge on learning performance (reading comprehension, browsing and perceived control) rather than on navigation performance. The authors' analysis of the findings suggests that a hierarchical content structure is most appropriate for non-knowledgeable subjects, probably because this structure provides a clear insight into the organizational framework of the subject content contained within the hypermedia system.

As described earlier, Shin et al. (1994) examined an interaction effect between advisement and prior knowledge. In addition, they also examined the effects of hierarchical-linking structure and network-linking structure on hypermedia learning: the former provided limited access and information structure was presented as an organization chart; the latter allowed free access, and rich hypertext links were used to present associations between information. Both the quantitative and qualitative results indicated that low prior knowledge students gained more benefit from the hierarchical linking structure than from the network linking structure. High prior knowledge students were able to function equally well in both conditions. In addition, Pazzani (1991) also demonstrated the importance of prior knowledge in hypermedia learning, finding that students with high prior knowledge profited most from a flexible path, whereas low prior knowledge students benefited most from a more structured path. This result is consistent with the study by Gerdes (1997), which found that a linear structure is more effective than a network structure for low prior knowledge students.

In summary, these findings show that experts and novices differ in their performance depending on the structure of hypermedia system and that it is necessary to take learners' prior knowledge into consideration when designing effective content structure for hypermedia learning systems. Experts profit most from a learning system that provides flexible paths, whereas novices seem to benefit more from a learning system that is more structured. This may be explained by the fact that expert learners have acquired a great deal of content knowledge so they are more able to impose structure on the content. On the other hand, novice learners lack the domain knowledge; they prefer content structures that may compensate for their lack of a conceptual structure of the domain. Hierarchical structure is considered as being most appropriate for novice learners (Calisir and Gurel, 2003) as it presents a conceptual structure of the material that help them to structure the text, thus easing the disorientation problem.

3.3 Navigation Tools

Having discussed the structure of the content, it is also important to consider how the content is navigated. Various navigation tools are used in current hypermedia learning systems, most commonly hierarchal maps and alphabetical indices, each of which provides different functions for information access. For example, hierarchal maps

provide a view of the global structure of the context, while alphabetical indices are useful for locating specific information (Chen and Macredie, 2001). Therefore, navigation is a critical design issue in hypermedia learning systems (Machionini, 1998) because it influences how students can develop their learning strategies.

In terms of the relationships between learning strategies and navigation tools, students' prior knowledge is an important factor in determining whether a particular navigation tool is useful. A number of empirical studies have evaluated the effectiveness of different navigation tools for high and low prior knowledge users (Table 3).

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Farrell and Moore (2001) investigated whether the use of different navigation tools (linear, main menu and search engine) would influence users' achievement and attitude. 146 eighth- grade students were placed into three groups based on their knowledge levels (low, middle, high). The results indicated a significant difference for high prior knowledge subjects, who tended to use search engines to locate specific topics. This finding is in line with that of the study by Carmel *et al* (1992), which found that high-knowledge users were more interested in using tools that could facilitate the location of detailed information related to specific entities.

Conversely, low-knowledge users seem to benefit from hierarchical maps, which can facilitate the integration of individual topics (Dee-Lucas, and Larkin, 1995; Möller and Müller-Kalthoff, 2000). A recent study by Potelle and Rouet (2003) investigated the influence of navigation tools on students' comprehension in a hypermedia learning system. There were three versions of the system, which organized information with different navigation tools: a hierarchical map, a network map, and an alphabetic list. The hierarchical map was organized with superordinate and subordinate links from the most general to the most specific topics, the network map was organized by connecting the main topics with semantic links, and the alphabetic list presented the topics in alphabetic order without explicit connections. 47 students with different levels of prior knowledge took part in the experiment, and were assigned to use one of the three

versions. The results showed that the hierarchical map improved comprehension for the low-knowledge participants at the global level.

McDonald and Stevenson (1998b) examined the effectiveness of navigation tools and domain expertise in relation to navigation performance in a hypermedia learning system. Three hypermedia conditions were used, including hierarchical map, contents list and basic hypermedia. Of the 36 participants, all of whom were university students, half were classified as knowledgeable and half as non-knowledgeable. The findings showed that non-knowledgeable subjects performed better in the map condition than in the contents list condition. A possible explanation for these findings is that the map not only reveals the *document structure*, (i.e. the physical arrangement of a document), but also reflects the *conceptual structure*, (i.e. the relationships between different concepts). In other words, the map can help non-knowledgeable learners to incorporate the document structure into the conceptual structure, which helps them to integrate their knowledge (Nilsson and Mayer, 2002).

However, different results are reported by the study of Hofman and Oostendorp (1999), which compared the effects of structural overview and topic list. 40 first-year university students were asked to study a science text on sun radiation by using one of the two presentation conditions. The results showed that the structural overview was disadvantageous for less knowledgeable students in gaining understanding from the local level of a document. Hofman and Oostendorp (1999) argue that this was because the structural overview emphasizes building a global structure and tends to lead users' attention away from the local structure of the document.

The results of the studies in this section reveal that students with different levels of prior knowledge benefit from different navigation tools in hypermedia learning systems. Research suggests that structured navigation tools, such as hierarchal maps and structural overviews, are most helpful for novices, as they help them to overcome their lack of conceptual structure of the domain. As indicated by Nilsson and Mayer (2002), hierarchal maps, which provide learners with structural cues between concepts, can help learners to integrate their knowledge. However, such navigational tools, which provide a global structure, may make the users pay less attention to the local structure of the

content, in turn limiting their understanding (Hofman and Oostendorp, 1999). This suggests that there is a need to provide less knowledgeable learners with navigational tools that present both global structure and local structure of the hypermedia content. The global structure aims to help them find the relevant information and reduce disorientation, and the local structure focuses their attention, with the aim of improving understanding.

4. A Framework for Hypermedia Learning

As discussed in the previous sections, experts and novices benefit differently and show different preferences toward hypermedia learning systems in terms of different content structures and navigation tools. Table 4 presents a conceptual framework drawn from the preceding analysis that illustrates the basic characteristics of experts and novices and their requirements for hypermedia learning systems.

{Table 4 Here}

- *Additional Support:* Experts can rely on their prior knowledge, whereas novices have little or no prior knowledge. The former can exploit their familiarity of the subject content so there is no need to provide them with additional support. In contrast, the latter experience more disorientation problems. Thus, addition support is useful to them, especially from visual cues.
- *Content Structure:* Expert learners have a great deal of domain knowledge so they can impose structure on the content and appreciate flexible paths. On the other hand, as novices lack the conceptual structure of the content, structured paths can help them reduce disorientation problems.
- *Navigation Tools:* Expert learners have a deep level of understanding of the content, so they can get more benefits from navigation tools that are able to find specific information, such as search engines. Conversely, novice learners are short of understanding. Therefore, hierarchical maps, which provide a global picture of the material, are helpful for them to integrate the knowledge.

5. Implications for System Design

The conceptual framework presented in Section 4 can help designers to develop an overall picture of learners' needs in using hypermedia learning systems. With the proposed framework, designers can recognise more easily "what" and "why" learners need and, hence, design hypermedia learning systems that more effectively address the needs of learners with different levels of prior knowledge. In particular, it can give an understanding of how to support novice learners by presenting effective user interface and providing appropriate navigation support. Effective user interfaces can help users to avoid disorientation and appropriate navigation support is useful for them to develop conceptual structure and integrate knowledge. The detailed implications are discussed below.

5.1 User Interfaces

Hammond (1989) suggests that disorientation may be heightened for subjects who are unfamiliar with the knowledge domain of the system. Indeed, Shin et al. (1994) and McDonald and Stevenson (1998a) have shown that subjects who lack sufficient prior knowledge of the text topic demonstrate more navigational problems than subjects with high prior knowledge. Research demonstrates that learners, particularly novices, suffered from disorientation problems such as not knowing where they are, not remembering where they have been, and being unsure where to find the information that they need (Kim and Hirtle, 1995; Last et al., 2001). User interfaces have a very important role in preventing these problems (Dias, et al., 1999). Different techniques can be applied to solve these problems in the design of hypermedia learning systems. These issues are discussed below.

(1) *Where Are They?*

Research suggests that it is important to keep users aware of where they are in the global structure as well as the local structure of the system (Hofman and Oostendorp, 1999). Therefore, their current location can be shown at two different levels: (a) relative to the learning system as a whole; and (b) relative to the specific topics. The former can be shown by providing 'breadcrumbs' which

track the learner's navigation paths, such as listing the topic and subtopic of the pages being visited. The latter can be given by highlighting the area where the current page is located, using different colors or different fonts and sizes. It would also be helpful to provide visual aids for learners to help them to know where they are. For example, an active sitemap might highlight the user's current location as well as visualize his or her trail through the site.

(2) *Where Have They Been?*

This question is usually answered by providing different link colors to give learners information on where they have been. Nielsen (2000) suggests that knowing what links lead to previously visited pages is useful for two reasons: (1) it helps users to learn the structure of the systems, and (2) it prevents them from wasting time going to the same page many times. Another option, suggested by Chen and Macredie (2002), is to provide a check mark to indicate visited pages. In addition, annotated links, which provide some form of comments behind the links, can also be used to outline links to previously visited pages (Eklund et al., 1997).

(3) *Where Can They Go?*

An effective user interface has to help users decide which path can best satisfy their needs. One of the ways is to keep novices on the correct paths by hiding links to pages that the user is not yet prepared able to understand (Eklund, et al., 1997). In this way, novices are restricted to make use of a subset of the available content before going into advanced levels. In addition, providing good labels for the pages will also aid novices. Labels that clearly indicate the role of a particular page may help novices successfully to decide the appropriate coherent path (Lewis and Polson, 1990).

5.2 Navigation Support

Research has revealed that experts and novices show different preferences to, and gain benefit from, different navigation aids. Expert learners, who have a deep understanding of the subject matter, prefer to find specific information in the learning system. They need to have navigation tools that provide them with free navigation and find specific information that they need. Index tools, content lists and search tools are considered

helpful for them. On the other hand, navigation tools such as map and menu tools that present conceptual structure of the material are beneficial for novice learners in hypermedia learning systems. Guided tours, the most efficient support for navigation (Nielsen, 1993), are also considered beneficial for novices.

Apart from providing appropriate navigation tools to accommodate learners with different levels of prior knowledge, other techniques can also be used. For example, navigation metaphors may be a way of helping the novice learners to understand the purpose and function of the information access structures and to help the learners easily to build an internal model of the system (Allinson and Hammond, 1990). In addition, the material can also contain landmarks, such as diagrams or figures, to help the learners navigate. A graphical browser would better represent types of relationships in content, and a structure overview would give learners an overall picture of the lesson. A text-based menu, instead of a graphical browser, could be provided for those who do not respond to graphical representation of content structure.

6. Concluding Remarks

This paper has aimed to develop a framework to integrate prior knowledge into the design of hypermedia learning systems. Research results show that experts perform better than novices in hypermedia learning systems, mostly because of their deeper understanding of the subject matter; they use their background knowledge of the subject domain to guide their exploration. With respect to the disorientation problems, empirical findings show that novices suffer in hypermedia learning. Research suggests that appropriate content structure and navigation aids may compensate for a learner's lack of a conceptual structure of the domain (McDonald and Stevenson, 1998a, Calisir and Gurel, 2003). In addition, providing additional support such as graphical overviews, advance organizers and structure cues may be beneficial in hypermedia learning.

This paper has presented a framework to demonstrate the characteristics of expert and novice learners and their requirements based on the analysis of previous research. The framework can be applied to guide designers in integrating learners' prior knowledge

into the development of hypermedia systems. However, this study is a small step, and other individual difference elements, such as gender differences, cultural background, and cognitive styles, should also be considered in the development of hypermedia systems. As suggested by Chen and Macredie (2002), individual differences are critical to the effective and successful design of hypermedia systems. As such, future research needs to continue to explore the interaction effects between hypermedia system features and individual differences so as to design efficient, effective and satisfying systems to accommodate learners with different characteristics.

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Table 1: Different Learning Characteristics of Experts and Novices

Experts	**Novices**
Global mental models	Local mental models
Directed search	Undirected search (trial and error)
Deep structures	Surface features
Mental simulation of integrated functions and whole application	Mental simulation of isolated functions
Complete analysis deferring details	Incomplete analysis
Depth-first strategies	Breadth-first strategies
Design whole and add pieces	Design pieces
Integrated whole throughout the process	Failure to integrate pieces into a whole …
Find the best solution	Find a (any) solution

Table 2 Content structure and prior knowledge

Author(s)	Content Structure	Sample	Results
Pazzani (1991)	Less structured and more structured	Not specified	Students with high prior knowledge profited most from a less structured environment, whereas low prior knowledge students benefited most from a more structured environment.
Shin, Schallert and Savenye (1994)	Network structure and hierarchical structure	N=110 second –grade students	For low prior knowledge students, a hierarchical-linking structure was more effective than a network-linking condition, whereas there was no difference for high prior knowledge students.
Gerdes, (1997)	Linear structure and network structure	Not specified	For low prior knowledge students, a linear structure was more effective than a network structure.
McDonald and Stevenson (1998a)	Hierarchical, non-linear and mixed	N=30 undergraduate students	Participants in the mixed condition performed better than those in the other two conditions, and the performance of knowledgeable participants was superior to that of non-knowledgeable participants.
Calisir and Gurel (2003)	Linear, hierarchical and mixed	N=30 graduates	The combined findings suggested that a hierarchical hypermedia system is most appropriate for non-knowledgeable subjects.

Table 3 Navigation tools and hypermedia learning

Author(s)	Navigation tools	Sample size	Results
McDonald and Stevenson (1998b)	Map, contents list and basic hypermedia	36 university students	Non-knowledgeable subjects performed better in the map condition than in the contents list condition.
Hofman and Oostendorp (1999)	Concept map and alphabetic topic list	40 first-year university students	The concept map has a negative effect on the comprehension of a micro level for less knowledgeable readers.
Möller and Müller-Kalthoff (2000)	Hierarchical content map and no map	Not specified	Low prior knowledge readers performed better with a hierarchical map than without a map.
Kim (2001)	Embedded links, jump tools (history list, bookmark, back buttons, go option, or the URL location box), keyword search and the home button	48 undergraduate students	Novices tended to use embedded link and home button more frequently, whereas expert participants tended to use the jump tool more frequently.
Farrell and Moore (2001)	Linear, main menu, and search engines	146 eighth-grade students	Search engines were beneficial for users with high prior knowledge, and the main menu was useful for all of the students.
Potelle and Rouet, (2003)	Hierarchical map, a network map and an alphabetic list	47 university students	Low knowledge participants gained improved comprehension in the hierarchical map condition at the global, but not at the local level.

Table 4: Conceptual Framework

Experts		**Hypermedia Learning**	**Novices**	
Characteristics	***Requirements***		***Characteristics***	***Requirements***
High Level of prior knowledge	Needless of providing additional navigation support for them	***Additional Support***	Low Level of prior knowledge	Useful for them to have additional support, especially visual cues
Able to create structure	Suitable to take flexible paths	***Content Structure***	Lack of conceptual structure of domain	Better to have structured paths
A great deal of understanding	Easy for them to find specific information, e.g. search engines	***Navigation Tools***	Short of understanding of the content	Able to help them to integrate knowledge, e.g. hierarchical maps