The branching structure for individual learning skills differences in instructional hypermedia

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Keywords

Internet, Learning, Skills, Self-managed learning

Abstract

In this article, the branching structure of hypermedia is addressed for the purpose of accommodating individual learning differences. Learning from the learner's perspective is discussed. Future research directions in hypermedia learning are suggested.

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http://www.emeraldinsight.com/1468-4527.htm

Online Information Review
Volume 26 · Number 2 · 2002 · pp. 73–78

DOI 10.1108/14684520210424539

Introduction

Hypermedia is used in this article to refer to a computer teaching system that presents the structure of information using nodes and links. The term branch point is used to refer to a node that contains more than one link to other nodes. The most significant nature of hypermedia is its interactivity through the branching structure. This type of branching structure allows students to access various instructional units (cases of modelling, coaching, and examples) they need or are interested in viewing (Spiro and Jehng, 1990).

The *raison d'être* of hypermedia is that it is a type of learning environment that is capable of interacting with a learner. The type of interaction of interest here is one that improves learning. The assumption is that individuals learn differently and that when a learner is in a learning environment appropriate to his/her type, learning will be improved.

Therefore, instructional hypermedia learning specifically refers to instructional units which were designed to cater to students' individual differences via branch points; students thus interact with a set of "buttons" that enable them to make decisions about their own learning process (Kolodner, 1993; Schank, 1993). It is assumed that effective learners use these branch points to achieve their learning goals (Schank, 1993).

Systems that focus on problem solving may consist primarily of a sequence of increasingly complex cases that model situations, and cases where students solve similar situations and receive feedback on their performance (coaching). The next decision is when to offer these experiences. Branching, which provides students with opportunities to select a variety of instructional units, is one way of structuring learning units. The student selects a unit that seems appropriate to his/her skills, begins working at this unit, but then, depending on the feedback received, is able to jump to subsequent units that seem best suited for facilitating learning.

The nature of the interactivity to the learners should depend on the specific information being presented and the characteristics of the learners (Recker and Pirolli, 1992). Students differ in aptitudes

Refereed article received July 2001
Approved for publication 17 January 2002

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relevant to learning (Jonassen and Grabowski, 1993). They need different kinds of support to acquire the information presented to them (Jacobson and Spiro, 1995). Hypermedia uses its branching structure as an index to treatments prepared for different types of learners. The promise of hypermedia to accommodate individual differences can be fulfilled.

The major reason for branch points is that they make possible different learning patterns for students. The value of such systems has been stated by several researchers (Edelson, 1996; Lawless and Kulikowich, 1996, 1998). At branch points, students can branch to other sections of the program depending on their interests, prior knowledge, or other learner variables (Andris, 1996; Last *et al.*, 1998; Lawless and Kulikowich, 1996, 1998; Paolucci, 1998). Students choose to use different sub-sections of the program. There is no single fixed sequence of instruction for all students (Cleave *et al.*, 1993; Lawless and Kulikowich, 1998). Essentially, a learner navigates the terrain of hypermedia, choosing linear or non-linear paths, to optimise his/her learning goals by using the resources of the environment.

As may be expected, hypermedia is not an effective learning tool if students lack the ability to employ self-learning skills. Students do not naturally develop a repertoire of learning skills:

> When left to regulate learning on their own, students often inadequately monitor the level or completeness of their learning (Butler and Winne, 1995, p. 261).

Also, these students erroneously believe learning to be a simple process (Jacobson and Spiro, 1994; Butler and Winne, 1995). Consequently, they persist in using rudimentary learning skills that are inadequate for more complex learning tasks (Jacobson and Spiro, 1995). In fact, all students are self-regulated to some degree. Students know how to self-judge in order to monitor and, in turn, to direct subsequent activities. But those students with poor self-learning skills perform worse on more complex learning tasks with hypermedia systems than they would on linear systems (Pirolli and Recker, 1994); they cannot generate appropriate internal feedback and, thus, have trouble reasoning or solving problems. Students with good self-learning skills learn complex knowledge more effectively from hypermedia instruction than students with poor self-regulated learning. (Castelli *et al.*, 1998; Recker, 1994). Complex knowledge refers to either many relevant concepts in a typical knowledge application situation or the application of a concept or combination of concepts which varies widely across different case situations. They can follow a path that leads them to reason or solve a problem.

Problem

Early approaches attempted to identify some general categories of individual differences, such as field-dependence versus field-independence (Witkin, 1973), as variables that would affect learning. But after hundreds of studies, the applicability of these categorisations to learning is still unclear (Ayersman and von Minden, 1995). Currently, researchers in human-computer interaction are still struggling to identify variables that would consistently improve learning. However, years of research have not resulted in an adequate understanding of what is required to make interaction effective (Alexander *et al.*, 1994; Lawless and Kulikowich, 1998).

In the absence of adequate understanding of instructional hypermedia learning, Winne *et al.* (1994) propose that, in order to understand learning skills, we should monitor the cognitive activities of students as they study. One approach to exploring this proposal is to collect students' data as they work through a hypermedia system. In this hypermedia, the computer can record activity for later analysis. Because higher-level thinking processes (complex learning skills) underlying external behaviours (branch point behaviours) are not directly available for recording, other means must be used to understand them. By directly monitoring which student behaviours support learning and by correlating user differences, it may be possible to begin the identification of learner variables that have the greatest impact on learning.

Conceptual framework

Researchers (Butler and Winne, 1995; Jonassen and Grabowski, 1993) have

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identified two types of variables that, if effectively incorporated into hypermedia instructional materials, should better account for individual differences. One type of variable is student knowledge of a repertoire of learning skills and the ability to monitor and select appropriate skills (Butler and Winne, 1995). Certainly, students who can manage their learning will be more effective learners. The other type of variable is the learner's prior knowledge of the content presented by a specific learning task. This variable is strongly supported by numerous studies in cognitive science (e.g. Chi *et al.*, 1989; Akanabi and Dwyer, 1989; Pazzani, 1991; Last *et al.*, 1998; Paolucci, 1998). Both of these types of variables are important for effective complex learning to occur (Bielaczyc *et al.*, 1995). They are interconnected because performance is influenced by both of them (Jonassen and Grabowski, 1993; Bielaczyc *et al.*, 1995).

Self-regulated learning

The self-regulated learning (SRL) model proposed by Butler and Winne (1995) attempts to explain how learners manage their learning processes. This model is well developed and more elaborate than other SRL models, e.g. Mithaug (1993). They have formulated a new approach to study individual differences, particularly the differences involved in learning complex skills (Winne, 1996). They have argued for investigating specific parts of the learning process itself. This model describes the metacognitive processes, which students need in order to effectively learn complex knowledge. It focuses on a deliberate, judgmental, and adaptive process. It posits that the major goal of learning is to become a self-regulated learner. A self-regulated learner is capable of effectively managing most learning situations without depending on outside assistance.

This theory identifies a complex set of skills that are needed to be a self-regulated learner. These skills are: interpreting the task; setting goals for upgrading knowledge; selecting tactics and strategies; monitoring; and use of feedback (reflecting on the appropriateness of one's actions and possibly modifying one's model of appropriate behaviour). Figure 1 gives a general picture of how self-regulated learners manage to complete an academic task. This process is made up of a series of events, which are self-directed by the self-regulated learner. The process relies on the self-regulated learner's cognitive system and its interaction with the environment. The process is used to interpret learning tasks based on its prior knowledge and sets its goals based on these interpretations. Once it has determined goals, it thinks about what strategies or tactics to employ to achieve these goals. Monitoring, including analysis of feedback, allows the learner to see if a change is needed and then influences what he or she does. During monitoring, students may change their goals or figure out new strategies or create new procedures ("[what] they create generates internal feedback", Butler and Winne, 1995, p. 248). External feedback could come from the learning environment, instructors, or peer groups. If external feedback is provided, it might help to confirm, add to, or conflict with the learner's interpretations of the task and path of learning. As a result of monitoring task engagement, students make decisions to alter knowledge and beliefs, which, in turn, might influence subsequent self-regulation (Butler and Winne, 1995).

In all, instructional designers need to understand how self-regulated learners manage to complete an academic task by using SRL variables: interpret the task, set the goals, employ strategies or tactics, monitoring, and internal/external feedback. Differences in learning behaviours will not be measured by responding to general instruments prior to participating with the instructional environment. Rather they are deduced from SRL theory from the actions taken by a student as he or she responds to the instructional environment. The use of an SRL model to interpret students' branch point behaviours to reveal their SRL process is one of the significant contributions of this study. With the results of these different SRL patterns, instructional designers are helped to better understand the effect of individual learner differences.

Prior knowledge

Prior knowledge is one of the strongest and most consistent individual difference predictors of achievement (Jonassen and Grabowski, 1993). It relates to specific content domain of either knowledge or skills. When the instructional information presented meshes with the student's level of prior

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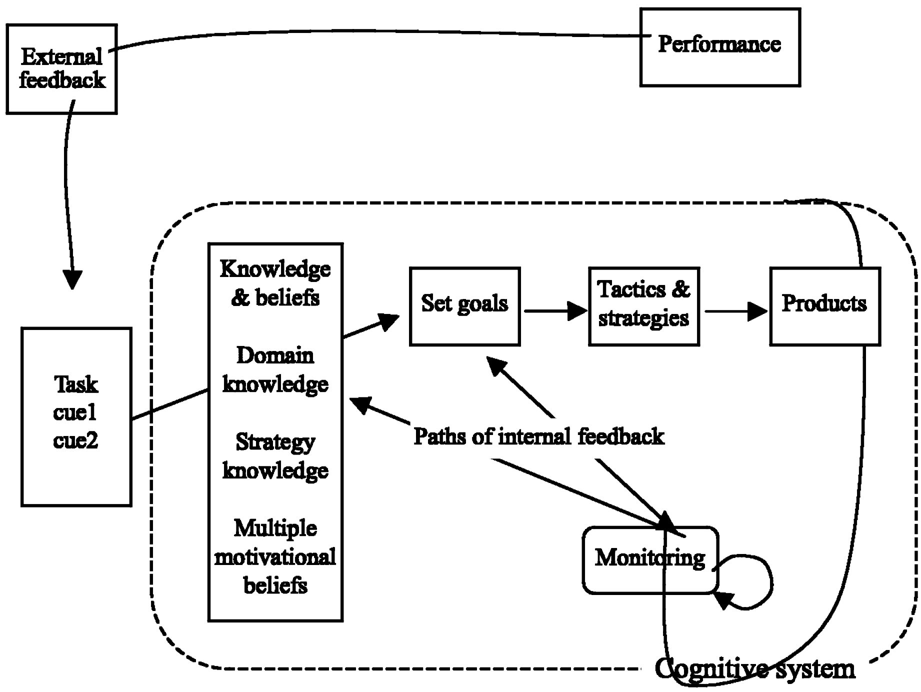
Figure 1 A model of self-regulated learning



knowledge, achievement will be enhanced. While a student is learning, he or she is trying to integrate the new information presented by the environment with his/her prior knowledge (Chi *et al.*, 1989). Students lacking appropriate prior knowledge may not significantly benefit from such instruction at all (Tobias, 1981). The more prior knowledge that one has, the better one can employ strategies to competently process related text (Lawless and Kulikowich, 1996, 1998). Thus, instructional designers need to understand the relationships between prior knowledge and learning and instruction:

> As the level of prior knowledge increases, the need for instruction decreases, and learning increases. Conversely, as the level of prior knowledge decreases, the need for instructional support increases (Jonassen and Grabowski, p. 417).

Conclusions

The goal of using hypermedia to accommodate differences in the way individuals acquire knowledge from the information presented is to give them various kinds of support through the branching structure. This system should be able to interrelate effectively with individual differences incorporated in the design. In other words, it is important to design a hypermedia learning environment that incorporates both SRL and prior knowledge that have important effects on learning.

The assumptions are:

- students possess the appropriate self-regulation skills to effectively control their own learning; and
- how students interpret the information presented by hypermedia depends on their prior knowledge of the specific content being presented.

Exploring students' patterns of SRL processes according to the extent of prior knowledge relevant to the current learning tasks would be a potential research topic. In terms of effects of SRL and prior knowledge, the behaviours of a student as he/she responds to the instructional environment can be interpreted.

To sum up, the characteristics of future research will include:

- dealing with complex learning tasks (complex knowledge);
- focusing on students' branch point behaviours and hoping to identify key steps in them to infer students' learning processes;
- focusing on the type of hypermedia with its branching structure and the options selected by different students. It should develop cases for various teaching/ learning functions (such as modelling, coaching, and scaffolding);

- choosing SRL and "prior knowledge" as the most important variables in hypermedia learning;
- identifying the differences in students' SRL repertoire.

It is important to apply a strong SRL theory to interpret the data collected from log files. A log file is a chronological record of interactions occurring in one tutorial with one student. Then, based on students' branch point behaviours, we can use SRL theory to interpret their learning processes. These data will be obtained while students are learning. Thus, it is most appropriate at using hypermedia as a research tool to study individual differences, particularly using the SRL model to explore the differences involved in learning complex skills (Winne, 1996).

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