Dimensions of Learner Control
A Reappraisal for Interactive Multimedia Instruction

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Abstract

The potential benefits of technology for education have frequently been technology driven,. No more so than with the current developments in multimedia which integrated text, graphics, video and audio to provide a comprehensive representation of a content domain on a single display monitor. In this environment, developers are producing applications which reflect significant changes in the way in which information is presented, delivered and accessed. Consequently, new and different problems are emerging in the way in which learners develop an understanding or mental model of both the content and structure of the instructional software being used. With the challenge to facilitate the rapid formation of accurate mental models, this paper reviews the paradigm shifts which have occurred in the critical areas of instructional strategy, learning theory, interaction and interface design and introduces a reappraisal of learner control research in terms of a set of dimensions required for effective multimedia instruction. A new approach to design at both the interface and instructional level is required to take full advantage of both the technology and learner requirements.

Keywords

learner control, program control, interactive instruction

1. Introduction

Multimedia has brought a new dimension to the use of technology in education and training. The integration of audio, video and animation with instructional interactions has extended the ways in which the learner can manipulate and interact with content material through technology. However, this rapid growth in technological capability has not necessarily been matched by a better understanding of human-computer interactions, especially in the educational environment.

Recent research on *mental models* describes the construct by which the learner develops the structure and purpose of the particular multimedia resource. For example, Jih and Reeves (1992, p. 42) assert that 'learners' understanding of the structure and functions of Interactive Learning Systems will have an impact on their navigational behaviour as well as on their learning', suggesting that the speed with which the learner develops a model which matches that of the designer is critical to effective use of the medium. Problems in accessing content items, achieving goals or completing interactions are potential indicators of poorly structured mental models.

Linked to a learner's mental models are the levels of control which they have (or are provided) over the content and structure of the application. Much of the learner control research has focused on the traditional Tutorial and Drill & Practice strategies typical of early computer-assisted instruction (Williams, 1993), and only recently has there been an attempt to assess learner control with respect to interactive multimedia applications (e.g. Arnone, Grabowski and Rynd, 1994). Results from research have been inconclusive, with no consistent evidence to advise when and where learner control is best used within interactive environments. A recent review queried the methodologies of learner control research (Reeves, 1993). The following discussion examines a range of factors with specific reference to aspects of learner control and the formation of mental models.

2. Learning Theory: From Behavioural to Cognitive

How people learn, acquire knowledge and develop skills has been debated for years. Within the interactive learning field many of the underlying theories have involved emphasis on behavioural (e.g. Skinner, 1954), cognitive (e.g. Brown, Collins and Duguid, 1989; Taylor and Clark, 1992) and motivational approaches (Keller and Kopp, 1987). However, the current trend is towards cognitive models focusing on the notion of situated, contextual and discovery learning, supported by scaffolding, learning from errors, modelling, explaining and reflecting (Clark, 1994). The constructivist approach (Jonassen, 1991), which places more emphasis on the learner as controller and developer of knowledge, is also popular. The shift from a behaviourist model is manifested in the designs which developers are now using for multimedia applications. Rather than the concept of a series of frames or transactions (Merrill, 1987; Grabowski, 1994), the emphasis is on the instructional metaphor or landscape (Hedberg and Harper, 1991). Rather than learner control focusing on the ability to select a transaction or move between frames, it frequently involves navigating or moving around and / or through a contextual environment which contains objects relevant to the instruction.

3. Instructional Strategy: From Tutorial to Discovery

One of the definitive texts of computer-assisted instruction (Alessi and Trollip, 1991) describes in detail the models for five instructional strategies: Drill, Tutorial, Instructional Game, Test, and Simulation. Each of these strategies could be linked to aspects of the instructional design process, which defined specific tasks to appropriate instructional strategies (Merrill, 1983). While these strategies were implemented for learner control research, the majority of the findings are linked to applications which adopted a tutorial or drill approach for presentation (Williams, 1993). Assuming a shift in learning theory, the emphasis on discovery learning environments in which learners are encouraged to explore the elements of particular domain and develop individual conclusions has significant ramifications for learner control. Being able to determine sequence or pace does not match such strategies, which may have no predetermined path for users follow. Therefore, it is critical to develop an understanding of the controls required by learners to effectively navigate the new information and / or instructional landscapes being developed.

4. Learner Control

The preceding discussion has identified factors integral to interactive learning which are shifting as a result of changes in technology and research findings. The options provided by developers for learners to assist in the control of the application have also increased, and the options which the learner has control over extend beyond the traditional elements of pacing, content and sequence (Milheim, 1990; Milheim and Martin, 1991). Reeves (1992, p. 108) asserts that ‘learner control refers to the options in ILS that allow learners to make decisions about what sections to study and / or what paths to follow through interactive material’. However, while this statement neatly summarises much of the learner control research, there is no discussion of the control provided to the learner once a section has been selected or the end of the path reached. There are additional dimensions of learner control which interact during interaction with the content or instructional environment.

Many research studies have adopted a **binary** approach to learner control, with the option for control either present or absent. The following assessment reviews learner control research with respect to the paradigm shifts identified, introducing a series of dimensions which extend learner control understanding into the multimedia environment.

4.1 Control over content

This option generally refers to the selection of topics or objectives associated with a specific lesson, although it does not extend to a choice of which content items are displayed. This component of learner control does not focus on the micro level of interaction, in which the learner must make certain choices in response to questions or problems. Therefore, while the learner has control over the content selected for study, the actual presentation of that content has generally remained instructor driven. Thus, there would appear to be two levels of content control—that where the learner chooses a module of study, and that where the presentation and associated display elements are also under learner control. Based on the evidence for the identified paradigm shifts, it is suggested that additional design emphasis is required on the control options available as learners work with interactive instructional environments.

4.2 Control over sequence

This component is significant, although there may be a conflict with instructional prerequisites if provided. Sequence control refers to the order in which the content is viewed, and often is defined in terms of being able to move to and fro among content items, such as those described by Gray (1988). Apart from a potential conflict with an instructional design strategy which does not tolerate learner-controlled sequencing, it would appear that sequence control can vary from moving forward and backward along a linear sequence of content or provided by hypertext and hypermedia links. In terms of the shifts discussed, the notion of sequence is becoming fuzzy, as many applications have no predefined or logical sequence of instruction. Instead, the learner has the options to explore an environment and move about that environment. The challenge for developers is to provide control options which support these new display metaphors.

4.3 Control over pacing

Another element considered is the ability to control pacing—the speed and time at which content is presented. Despite firm standards for interactive design, it is accepted that users should always have control of this process, and that program controlled timing (information without the user's consent) is not advised. Although some reports have found support for external pacing:

> External pacing can increase attention and motivation, resulting in improved learning, but it must be paced moderately ... Students may not be the best judges of what instruction they need, and how much instruction they need, for effective learning to take place. (Belland, Taylor, Canelos, Dwyer and Baker, 1985, p. 197)
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> Too much sequence control may serve to distract the student, causing two complex decisions to be made with each decision screen, instead of one: what decision to choose and then where in the CAI to travel to subsequently. (Gray, 1987, p. 56)

Thus there would appear to be some confusion between pacing and sequence. It is critical that the user does not lose detail from the display as a result of an arbitrary instructor-defined time-limit. Gray (1988) suggests that the complexity of the options provided will affect the success of control.

4.4 Context within which to learn

Additional options for learner control have been described by Schwier and Misanchuk (1993). The first of these provides options which allow the content to be placed into a context with which the learner is familiar. For example, mathematical problems may be linked to basketball, shopping or football situations and the learner can choose in which environment the problems will be studied. While this option is a subset of Control of Content, once the selection has been made, the content cannot be altered. While the shifts described previously do not directly support the facility for learners to choose from a series of contexts, the design philosophy is moving towards the construction of environments in which the content is contextually based, and which should therefore be meaningful to the learner.

4.5 Method of presentation

Providing the learners with the option as to which strategy to adopt in delivering the content is an attempt to match learning styles with delivery, and has been demonstrated with the TICCIT system as well as more recent applications of expert systems (Merrill, 1994). This form of learner control has been facilitated by interactive multimedia, as learners may have the choice as to whether to study content through text, graphics, video or sound. Again, with the shift towards metaphor-based environments, the emphasis is being placed on the learner to discover information, rather than developing a strategy from a fixed set of options. For example, Merrill (1994) suggests that this mode of control would enable students to study in Rule-Example-Practice, Example-Practice-Rule or Rule-Practice-Example sequences. The more recent examples of instructional software might focus on learners discovering the rule by exploring variables within an environment.

4.6 Provision of optional content

The majority of interactive applications provide additional material for the student which may be accessed as required. This may be more related to support systems, navigation, problem solving and interaction rather than learner control specifically. As shown in the following discussion on learner control dimensions, the range of support can be embedded in such a way that it supports both the novice and experienced learner. This option for learner control is also linked to **advisement**, whereby the learner receives feedback as to performance and appropriate paths to follow (Clariana, 1993) as well as choosing a particular **level of difficulty** and determining the amount of **practice** required.

4.7 Locus of control

With all these learner control options, there is the additional influence of locus of control, which refers to the extent to which the lesson is under the control of the learner or the computer (instructor). Based on the discussion of paradigm shifts, it would appear that the move is towards providing learners with as much choice as possible—although the application will always be the product of the developer and instructor. As Duchastel (1988, p. 63) notes, the computer, by prompting the learner, controls the rate of presentation and forces the student to interact with the information. It thus imposes a learning strategy on the learner, which introduces the importance of mental models, as the learner, in working with the application, must develop a clear picture of the tasks and structures embedded in the instructional software.

5. Instructional Transactions

In developing interactive instruction, it is clear that applications no longer adhere to the concept of instructional frames, but rather the importance of an instructional transaction (Tx) in which the learner must perform some action or undertake an interaction resulting in feedback to a response or an update to the existing display (Schwier and Misanchuk, 1993 and Sims, 1994). Within this Tx, there are also elements of learner control which have not been assessed. Using the original work of Merrill (1983, 1987), a recent discussion of transactions within interactive media (Grabowski, 1994) defines three criteria (cognitive load, learner response, computer feedback) on a continuum from low to high which contribute to the efficacy of an instructional transaction. If this is linked with the controls which a learner may have at any one time, then it is also critical to focus learner control search not only on the selection or sequencing of content, but also on the ways it can be manipulated within a transaction. In addition, if the notion of a transaction is accepted, there continues to be debate as to what defines a transaction. For this discussion, a Tx is defined as an event which cannot be interrupted by branching or learner control, and which is also associated with a discrete component of content, such as the identification of a molecular structure, the construction of distillation apparatus or simulating a 747 instrument landing. While the discussion of transactions is useful when developing sequenced instructional material, the development of learning environments means the transaction has to be reconceptualised as an interaction with an object on the screen, and that the process of interacting with objects is structured to support a development of understanding within a particular content domain.

6. Dimensions of Learner Control

Based on the previous analysis of research into various elements of interactive learning, the following discussion introduces a series of dimensions integral to reconceptualising learner control for interactive multimedia environments. These dimensions provide a means for extending an application from a binary state to a flexible, user-relevant situation.

Instructor **Learner**

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First, there is the overall dimension of control, which can range from complete control by the instructor or developer to complete control by the learner. While this range of control is theoretically possible, in practice there will always be some fixed instructor-based elements over which the learner has no control. For example, the design of a background or virtual environment. With respect to learner control research, it has been argued that there are conditions under which learner control should be provided and other conditions which require instructor control. While this position is supported, the following dimensions illustrate the complex set of controls which can be made available to the learner beyond that of simple sequencing or content selection.

Linear **Hypermedia**

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This dimension links most closely with the original sequence descriptor for learner control. In most applications, learners will be able to perform a range of actions to access the information available, ranging from a simple linear sequence to a complex network of hypertext or hypermedia links. Perhaps one of the most critical things to avoid with hyperlink options is the possibility of “losing” the learner’s sense of direction. The extent to which the learner can move via links to access information will depend on the instructional strategies and designs built into the application. In those applications which use learning environments, the control made by the learner will relate to moving to another “place” or examining a particular “object”.

Viewed **Constructed**

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Interaction has been described as the critical component of successful instructional software, and can range from the simple viewing of content material to the completion of tasks which involve complex problem-solving components or construction requirements. At the low end of this dimension, control would be similar to linear Informational Access; however, at the high end, the learner must also be provided with a number of tools which complete the task, such as accessing a “toolbox” and using a thermometer to measure temperature at certain points of a simulated environment.

Discrete **Integrated**

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The way in which information is structured will also affect the control which the learner must apply to the interaction. In some applications, information may be treated as discrete components, without being associated with a particular context or situation. Alternately, the information be embedded within a learning environment, with instructor-enabled facilities by which the learner can access information. For example, many applications use simple virtual reality representations to simplify access—if the learner wants to see a video, they click on the video player.

Informative **Self-Paced**

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In controlling individual progress through a course, learners are usually provided with a form of performance support mechanisms, usually in the form of context sensitive help, which is at the Information Provision end of the dimension. However, as a number of studies have shown that experienced learners require less support and novice users more support, it is essential to consider the extent to which all learners will be supported through an instructional interaction. It is suggested that the range of options is required so that learners can have access to (i.e., control) the help they receive at any particular time.

7. Conclusions

By better understanding the controls available to learners, we will be able to implement applications which minimise the cognitive load required to make interactive or control decisions. By doing this, we will facilitate the development of accurate mental models (both of content and navigation) which will enhance the instructional efficacy of the product. The formation of accurate mental models of both the content structure and system functionality is largely dependent upon the implementation of selected options over which the learner has potential control. The level of control available to either program or learner will largely depend upon the context in which the instructional transactions are being applied.

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