A Framework for using Multiple Intelligences in an ITS

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Abstract: Research on learning has shown that students learn differently and that they process knowledge in various ways. One such learning theory is Gardner’s Multiple Intelligences which states that different intelligences are used to solve problems and fashion products. EDUCE is an Intelligent Tutoring System that utilises learning characteristics and the Multiple Intelligence concept to provide an individualised learning environment. This paper presents EDUCE’s framework for using Multiple Intelligences. It describes how EDUCE incorporates the Multiple Intelligence theory into its architecture and design and demonstrates how students can choose between Multiple Intelligence differentiated material. It outlines the pedagogical framework it uses for making the jump from Multiple Intelligence principles to implementation and illustrates how content was developed to reflect those principles.

Keywords: Student Modeling, Learning Styles, Pedagogical Framework, Instructional Design, Multiple Intelligences

1 Introduction

Research on learning has shown that students learn differently, that they process and represent knowledge in different ways, that it is possible to diagnose learning style and that some students learn more effectively when taught with preferred methods (Dunn & Dunn, 78, Riding & Rayner 97, Rasmussen 98). However, observing and identifying learning characteristics is difficult and traditionally questionnaires and psychometric tests are used to assess and diagnose learning characteristics (Riding 91, Honey & Mumford 92). Several systems adapting to learning characteristics have been developed (Milne 97, Specht & Oppermann 98, Gilbert & Han 99, Stern & Wolf 00) to date, typically these systems contain a variety of instructional types such as explanations, or fragments of different media types representing the same content, with the tutoring system choosing one based on the model it has of the student. However it is not clear which aspects of learning characteristics are worth modelling, how the modelling can take place and what can be done differently for users with different learning styles (Brusilovsky 00).

Gardner’s Multiple Intelligence (MI) (Gardner 83, 93, 00) concept is a psychological theory that addresses what the brain does with information. It defines intelligence as the capacity to solve problems or fashion products that are of value. It states that there are eight different ways to demonstrate this intelligence with each having its own unique characteristics, tools, and processes that represent a different way of thinking, solving problems, and learning. Its use in the classroom has been significant (Campbell & Campbell 00) but its application to online learning and intelligent tutoring systems is still undergoing research. However, even though it is a theory and has no specific application method or instructional approach it does offer a structure and language in which to develop the student and pedagogical model of an intelligent tutoring system.

EDUCE is an Intelligent Tutoring System that utilises the MI concept and individual learning characteristics to provide a customised learning path (Kelly & Tangney 02a). The word “educate” originates from the Latin “educere” meaning to “lead out, bring out or develop from latent or potential existence”. The motivation behind EDUCE, is that intelligence is not a fixed static entity (Terman 25), but something
that resides inside a person, and can be enhanced significantly through education and awareness. The belief is that matching the instructional methods with the learning characteristics of the student can help this process.

EDUCE offers individualised learning by allowing the learner to take the initiative and choose from a diversity of instructional methods. It makes available a learning environment in which students can choose material according to their needs and preferences. It provides a mechanism through which students can make decisions about which instructional strategy. In the process it dynamically observes all actions the student makes building and updating a model of the student’s learning characteristics.

In the construction of an Intelligent Tutoring System such as EDUCE some key issues need to be addressed. There is the need to develop a framework for using MI and to develop content that reflects its principles. There is the need to investigate the learner’s choice when faced with a selection of MI differentiated instructional material, to identify are there consistent patterns or is it just a random selection. There is the need to develop adaptive technologies that update the student model and allow for flexible delivery in presentation. There is also the need to analyse the learning gain when using an Intelligent Tutoring System with Multiple Intelligence inspired material.

This paper presents EDUCE’s framework for using MI. It describes how it incorporates the MI theory into its architecture and design and demonstrates how students can choose between MI differentiated material. It outlines the pedagogical framework it uses for making the jump from MI principles to implementation and illustrates how content was developed to reflect those principles. The following sections illustrate these points by describing how the MI concept is integrated into the architecture, design and implementation of EDUCE’s student model, domain model, pedagogical model and presentation module, Fig. 1.

![Figure 1: EDUCE Architecture and the Role of MI](image)

2 Student Model

The MI concept inspires the student model in EDUCE. Gardner identifies eight intelligences involved in solving problems, in producing material such as compositions, music or poetry and other educational activities. The intelligences include the logical/mathematical, linguistic/verbal, visual/spatial, bodily/kinesthetic, musical/rhythmic, interpersonal, intrapersonal and naturalist. EDUCE uses four of these intelligences in modelling the student:

- Logical/Mathematical intelligence (LM) - This consists of the ability to detect patterns, reason deductively and think logically.
- Verbal/Linguistic intelligence (VL) - This involves having a mastery of the language and includes the ability to manipulate language to express oneself.
- Visual/Spatial intelligence (VS) - This is the ability to manipulate and create mental images in order to solve problems.
- Musical/Rhythmic intelligence (MR) - This encompasses the capability to recognise and compose musical pitches, tones and rhythms.
The other four intelligences are: bodily/kinesthetic, intrapersonal, interpersonal and naturalist intelligence. Bodily/kinesthetic intelligence is the ability to learn by doing and using mental abilities to co-ordinate bodily movements. The interpersonal intelligence is the ability to work and communicate with other people. The intrapersonal intelligence involves knowledge of the internal aspects of the self such as knowledge of feelings and thinking processes. Naturalist intelligence involves the ability to comprehend, discern and appreciate the world of nature. Currently content is under development in these four intelligences and doubts exist whether some of them, in particular bodily/kinesthetic can be effectively implemented.

Gardner suggests (Gardner 83) that everybody possesses the different types of intelligences to different degrees and that they operate together in an orchestrated way. The theory suggests that even though different intelligences do tend to be stronger in some people, everybody has the capacity to activate all the intelligences and in different situations different intelligences or a combination of intelligences may be used.

EDUCE builds a model of the student’s learning characteristics by observing, analysing and recording the student’s choice of MI differentiated material. Other information also stored in the student model includes the navigation history, the time spent on each learning unit, answers to interactive questions and feedback given by the student on navigation choices.

3 Domain Model

The domain model is structured in two hierarchical levels of abstraction, concepts and learning units. Concepts represent the sections, and subsections into which the knowledge base is divided. Each section consists of learning units that contain the content for that particular concept. Each learning unit is composed of a number of panels that correspond to key instructional events. Learning units contain different media types such as text, image, audio and animation. Within each unit, there are multiple representations of the same content based on the principles of Multiple Intelligences. Each representation uses pre-dominantly the one intelligence. All activities within one unit centre on one topic to ensure that students on completion of topic have basis for answering review questions. A subject expert in the field of Science helped to provide the educational material for EDUCE. The content consists of tutorial in Static Electricity.

4 Presentation Model

In the teaching of a concept, key instructional events are the elements of the teaching process in which learners acquire and transfer new information and skills (Gagné et al. 92). The EDUCE presentation model has four key instructional events, as shown in Fig. 2.

- **Awaken:** This is the process of getting the learners attention
- **Explain:** Different multiple intelligences are used to explain the concept in different ways.
- **Reinforce:** This stage reinforces the key message in the lesson
- **Transfer:** Here learners convert memories into actions by answering interactive questions

At the Awaken stage, to progress onto the next panel, the learner chooses one from four different options. Each choice will lead to material that is meant to embody a particular intelligence. The choices are represented by four symbols

- ![LM](image.png)
- ![VL](image.png)
- ![VS](image.png)
- ![MR](image.png)

At the Reinforce and Transfer stage the learner has the option of going back to view alternative representations. The navigation path is designed to force the student to make a conscious choice in terms of
the preferred instructional style, however the student can navigate back if there is still a desire to see alternative instructional styles. As students choose between Multiple Intelligence differentiated material EDUCE automatically build a model of the learning characteristics and strengths. This model provides EDUCE with the opportunity to facilitate learning by providing an individualised learning path.

The Explain stage in the event model provides for a choice of MI differentiated material. The objective at this stage is to allow for multiple representations of the same content. Different learners can chose different paths through the material. A learner may select one and move through the unit, may return to a second alternative representation if difficulties in understanding arise, or may proceed to view them all to get a complete picture of the content from different angles. Sometimes the material is the same, just represented differently, other times it presents information that is not available in the other representations. It is also used at other times as an entry point into the material. The Reinforce stage is used to summarise the key content message of the learning unit. It may be a short summary or it may be an explanation of the key concept. At this stage the material is presented using a variety of the intelligences together. The Transfer stage consists of short questions requiring one-word answers, fill in the blank questions and multi-choice questions. All the answers to the question are available on the preceding panels. If the learner does not remember the answer it is possible to navigate back to the Reinforce stage or to any of the MI differentiated material at the Explain stage.

Fig. 3 shows the Awaken stages in the unit – “Opposites Attract”. It shows a picture of a bulldog and a poodle. It tries to stimulate curiosity and introduces the concept of “opposites attract” through a visual image. It leads the learner into the topic by encouraging inquiry and by giving the learner an opportunity to construct an initial understanding of the topic. It does not try to explain anything and forces the user to make a conscious choice in how to view the next panel. At this point the learner can choose one of three ways in which to view the next panel. The learner can choose between the LM, VL or MR option. The VS option is disabled as no panel has been created using Visual/Spatial Intelligence for this unit.

Figure 2: EDUCE Instructional Event Model

Figure 3: The Awaken stage of “Opposites Attract”
Table 1: Approaches and implementation techniques for developing MI content
5 Pedagogical Model

MI is a theory with a set of principles. It structures and suggests but does not prescribe a particular pedagogical model or set of instructional strategies. Moving from a theory of intelligence to actual implementation is an act of interpretation and there has been a considerable amount of research done in articulating different techniques that can access each of the intelligences (Campbell & Brewer 91, Armstrong 93, Campbell et al. 96, Carroll 99, Lazaer 99, Wahl 99). However its application to online learning and intelligent tutoring systems is still undergoing research (Dara-Abrams 02). Despite the fact that it has no specific instructional approach it has potential as it offers a structure and language in which to develop the pedagogical model of an intelligent tutoring system. Fig. 4 shows EDUCE’s model for developing MI material. It describes the range of instructional approaches for each intelligence. Four intelligences are used: logical/mathematical, verbal/linguistic, visual/spatial and musical/rhythmic intelligence. Tab. 1 illustrates in more detail the instructional approaches and techniques for promoting the different intelligences.

Figures 5 to 13 show specific examples of these instructional strategies and techniques. Fig. 5 and 6 emphasises the verbal/linguistic intelligence using explanations, descriptions, highlighted keywords, term definitions and audio recordings. Fig. 7 and 8 illustrate logical/mathematical intelligence using number, pattern recognition, relationships, questioning and exploration. Fig. 9 and 10 give examples of visual/spatial intelligence with the use of photographs, pictures, visual organizers and colour. Fig. 11 and 12 accentuate the musical/rhythmic intelligence using musical metaphors, raps and rhythms.

Figure 5: Verbal/Linguistic Intelligence

Figure 6: Verbal/Linguistic Intelligence

Figure 7: Logical/Mathematical Intelligence

Figure 8: Logical/Mathematical Intelligence
6 Conclusion

This paper presents a framework for using Multiple Intelligences within an Intelligent Tutoring System. It describes how it incorporates the Multiple Intelligence theory into its architecture and design and how it informs the student and domain model. It also outlines the mechanism by which students can choose between Multiple Intelligence differentiated materials. Through automatically observing, analysing and recording the student’s choices of instructional strategy EDUCE can build a model of the learning characteristics and strengths. This model provides EDUCE with the opportunity to facilitate learning by providing an individualised learning path.

Multiple Intelligence is a theory with a set or principles but it does not prescribe a specific pedagogical model. In particular for online learning and intelligent tutoring systems it is not clear how to make the jump from a theory of intelligence to actual implementation. This paper outlines the pedagogical framework EDUCE’s uses for making the jump from Multiple Intelligence principles to implementation and illustrates how content was developed to reflect those principles. It describes the variety of instructional strategies possible and illustrates specific examples of how content is developed. It shows that with creativity it is possible to offer choices and multiple ways for students to engage with topics and material that will facilitate their learning. It suggests that the Multiple Intelligence concept is not just for the classroom but can also be adapted to online learning.

Empirical studies have taken place to investigate learner’s responses to Multiple Intelligence differentiated material (Kelly 02b, Kelly & Tangle 03). Future work will involve further empirical work in the pursuit of a greater understanding in how different instructional approaches can affect learning gain. It will examine how Multiple Intelligence differentiated instructional material can contribute to the
student’s learning experience and the value of providing choice to the student. Future work will involve using the adaptive features of EDUCE to compare student performance between when choice is provided and when it is not. It will also evaluate reaction to EDUCE when it adaptively makes choices for the student using an online learning algorithm.

References