Overview of Research Study in Applying Multi-Intelligent Adaptive Hypermedia to Online Learning

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Overview of Research Study for
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This paper provides an overview of the research undertaken for the Ph.D. in Computer Science and Educational Psychology that is described in the dissertation entitled *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning* (Dara-Abrams, 2002a). Readers interested in further information about the research study can read the companion papers describing the prototype online learning system (Dara-Abrams, 2002c) and the conclusions and implications of the study (Dara-Abrams, 2002b) as well as the dissertation itself (Dara-Abrams, 2002a). These documents are available online at http://www.brainjolt.com/.

<u>Rationale for Study</u>

Advances in adaptive hypermedia technology and Web-based asynchronous communication provide the technology foundation for online learning environments, which not only deliver content in a time- and distance-independent manner but which also adapt content according to a user model based on cognitive theory and educational methodology. Though user models in educational hypermedia applications have been used to adapt content based on a user's background and level of understanding, this study examines whether the cognitive Theory of Multiple Intelligences can be used to develop a user model supporting adaptation in an online learning environment. The study was therefore undertaken to answer the research question:

<div style="border:1px solid black; padding:10px; text-align:center;">

Can the cognitive Theory of Multiple Intelligences be used to support adaptation in an online learning environment?

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<u>Theoretical and Technology Foundation</u>

As depicted in Figure 1, the research is built on theories of cognition and learning, educational methodologies derived from these theories, and technologies to construct an artifact embodying these methodologies. The foundation of the research lies in the fields of Computer Science and Educational Psychology. The technology foundation is based on user modeling and adaptation technologies in educational hypermedia (Brusilovsky, 1998) as well as multimedia technologies and asynchronous, self-directed learning in Web-based environments (Harasim, 1999). In addition, prior work in Intelligent Tutoring Systems (ITS) underlies the development of educational adaptive hypermedia applications (Goettl, Halff, Redfield, & Shute, 1998).

The theoretical foundation of the research is based on the cognitive Theory of Multiple Intelligences (Gardner, 1983/1993) and the learning theory of constructivism (Bruner, 1960, 1966, 1986; Papert 1980/1999; Piaget & Inhelder, 1969; Perkins, 1992). The educational methodologies are based on these theories of learning and cognition. The methodologies employed in the prototype learning framework include: the Entry Point Framework and multiple representations (Gardner, 1999a), and the Teaching for Understanding Framework (Perkins, 1998).

Figure 1 Foundations and Components of Research
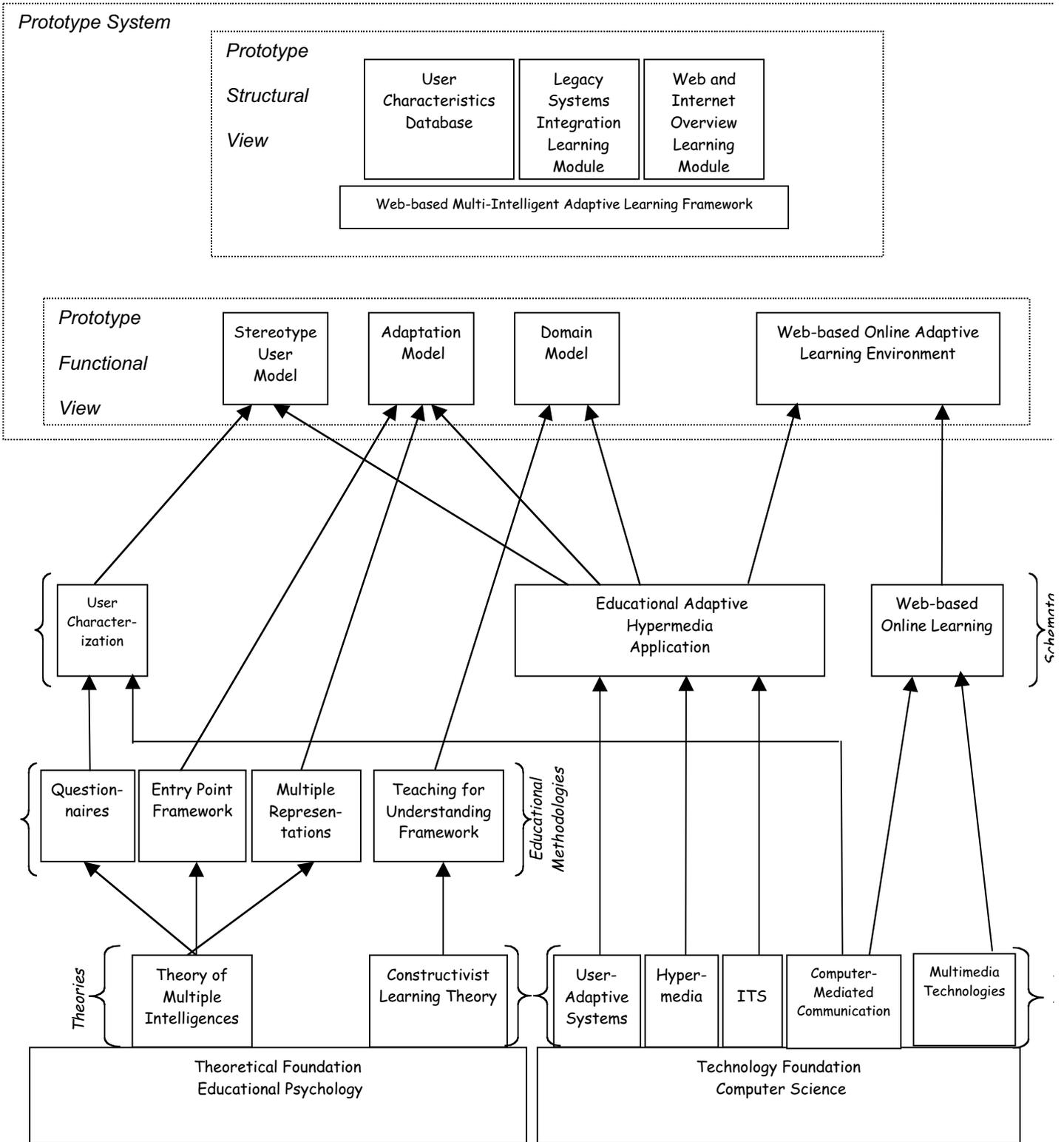
Statement of Problem

Online learning approaches have been developed and have been used with varying degrees of success and acceptance. However, online learning technology generally fails to consider the characteristics of individual learners, delivering content and educational materials to each learner in a manner that is supported by the technology rather than in a manner that is necessarily suitable to the learning of a particular individual. While some online learning systems consider the background and experience of the learner, each person seeking to learn particular subject matter through an online learning system is presented with the same type of learning materials. The application of the Theory of Multiple Intelligences in classroom environments has demonstrated that individuals with varying sets of most developed intelligences benefit from the use of multiple entry points and multiple representations of material when learning new subject matter (Gardner, 1999a). However, at the present time, individuals using existing online learning systems do not have the opportunity to benefit from the supportive approaches to learning offered by these educational methodologies.

Purpose of Study

This dissertation seeks to offer a new approach to online learning through content presentation customized according to a user characterization based on the three most developed intelligences and technical background of each individual learner. The research ties together work in the fields of Computer Science and Educational Psychology in order to:

- Make a contribution to the field of Computer Science by integrating learning and cognition theory and educational methodology and practice from the field of Educational Psychology into online learning technology.
- Make a contribution to the field of Educational Psychology by developing a prototype online adaptive learning framework and online learning modules to formatively evaluate an approach for practitioners and researchers in the field to use.
- Develop a prototype for an "anyone, anyhow" approach to online learning, seeking to thereby eliminate constraints due to varying development of intellectual faculties.

Methodology

In order to answer the research question, the study was conducted in three parts:

- Development of understanding goals and user characterization based on the three most developed multiple intelligences and technical background of each participant
- Development of prototype learning framework and two prototype learning modules
- Formative evaluation of multi-intelligent adaptive hypermedia learning modules

The procedure followed in the study was to construct a Web-based framework for the research study and to recruit participants for the study via email and Web communities. Through online questionnaires, participants were asked to provide data for the development of individual

characteristics based on the three intelligences that appear to be the most developed in each individual. Participants were divided into a technical and a non-technical group. A user model was developed based on the most developed intelligences and technical background of each learner.

The prototype development process followed Software Engineering Methodology, proceeding though requirements analysis, design, and implementation stages. Learning outcomes were defined for two learning modules on Legacy Systems Integration for technical participants and on an Overview of Web and Internet Technology for non-technical participants. The learning modules were then designed based on the understanding goals developed through the Teaching for Understanding Framework. Participants were asked to use the online learning modules through the Web-based multi-intelligent adaptive learning framework and comment on their learning experience, providing feedback for the improvement of the prototype learning modules and framework.

Prototype Development

In designing the research study to answer the research question of whether the cognitive Theory of Multiple Intelligences can be used to support adaptation in an online learning environment, a prototype was designed for a multi-intelligent adaptive hypermedia learning environment. Two prototype learning modules were designed, one for a technical audience and one for a non-technical audience. In the formative evaluation stage of the research study, participants provided feedback on the prototype learning modules.

A stereotype user model was developed as a database containing the three most developed intelligences and the technical background of each participant. Content and link adaptation methods and techniques from adaptive hypermedia technology were used to deliver content. Through adaptive text presentation and adaptive multimedia presentation, the prototype employed attribute values in the user model to modify the content of the learning module pages so that the content presentations activate each user's three most developed intelligences. The method of explanation variants and the adaptive hypermedia technique of page variants provided support for multiple representations and different entry points, depending on user characteristics.

Formative Evaluation

The study focused on online learning for an adult population, using research subjects 17 years of age and older. Of the 34 participants in the first stage of user characterization, 33 participants completed the study, using one of the learning modules and providing feedback on areas in which the prototype learning modules can be improved. The feedback received from participants is suggestive of the usefulness of applying the Theory of Multiple Intelligences to online learning. Based on participant feedback, the prototype could be improved by allowing for multiple levels of technical proficiency, adapting to the level of understanding by providing more explanations for novice users and more challenging content for advanced users. To address

difficulties in determining the most developed intelligences, the prototype could be improved by making the user model adaptable, allowing users to examine and update their user attributes. This would allow the individual to serve as the authority rather than the questionnaires, as recommended by multiple intelligence theorists (Armstrong, 1993/1999).

Participants, particularly those with well-developed Bodily-Kinesthetic Intelligence, requested more interaction and online testing. Other participants, particularly those with highly developed Naturalist Intelligence, suggested the use of metaphors in the presentations. Users, particularly those with well-developed Spatial or Musical Intelligence, found the animated graphical presentations helpful and suggested greater use of graphics, animation, and sound effects in the content presentations. In addition, overview information, upfront instructions, and examples were requested to help users achieve their understanding goals.

<div align="center">Assumptions and Limitations</div>

Questionnaires were used to develop the user characterizations in terms of the three most developed intelligences. These self-report questionnaires make two assumptions:

1) participants can answer questions with an understanding of their own skills
2) answers can be used to determine a participant's three most developed intelligences.

The prototype learning modules incorporate only a small subset of the potential representations and entry points that can be used for explanation variants of the subject matter. A limitation of developing a multi-intelligent adaptive hypermedia schema is that each variant must be individually designed by a person knowledgeable in the subject matter, in the educational methodologies of multi-intelligent approaches, and in Web and hypermedia technologies. The prototype is necessarily a simplification of the design for fully multi-intelligent learning modules.

<div align="center">Significance of Study</div>

Feedback from the formative evaluation indicates that improvements can be made to the learning modules and framework by increasing the use of the Entry Point Framework and multiple representations educational methodologies based on the Theory of Multiple Intelligences so that modules embody fully multi-intelligent approaches to content presentation. The research study contributes to the field of Computer Science by offering a new approach to online learning with the user model based on the three most developed intelligences and technical background of the learner. The study also makes a contribution to the field of Educational Psychology by providing the scaffolding for a framework in which additional prototypes of multi-intelligent adaptive hypermedia learning modules can be designed, prototyped, and evaluated.

An affirmative answer to the research question and the instantiation of the Theory of Multiple Intelligences in the prototype user and adaptation models demonstrate the feasibility of building a personalized online learning environment that considers differences among individuals in thinking and learning. The prototype forms the basis for the development of an "anyone,

anyhow" approach to online learning, with the study indicating improvements that can be made in the multi-intelligent adaptive hypermedia approach to increase accessibility to "anyone" through greater use of multi-intelligent "anyhow" approaches to content delivery.

Bibliography

Armstrong, T. (1993/1999). *7 kinds of smart: identifying and developing your multiple intelligences*. NY: Plume.

Bruner, J. (1960). *The process of education*. Cambridge, MA: Harvard University Press.

Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.

Bruner, J. (1986). *Actual Minds, Possible Worlds*. Cambridge, MA: Harvard University Press.

Brusilovsky. P. (1998). Methods and Techniques of Adaptive Hypermedia. In P. Brusilovsky, A. Kobsa, & J. Vassileva (Eds.), *Adaptive Hypertext and Hypermedia*. Dordrecht, NL: Kluwer Academic.

Dara-Abrams, B. (2002a). *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning*. Ph.D. Dissertation, Union Institute & University, http://www.brainjolt.com/.

Dara-Abrams, B. (2002b). *Conclusions and Implications of the Research Study in Applying Multi-Intelligent Adaptive Hypermedia to Online Learning*. http://www.brainjolt.com/.

Dara-Abrams, B. (2002c). *Prototype Designed for the Research Study in Applying Multi-Intelligent Adaptive Hypermedia to Online Learning*. http://www.brainjolt.com/.

Gardner, H. (1983/1993). *Frames of Mind: The Theory of Multiple Intelligences.* NY: Basic Books.

Gardner, H. (1999a). *The Disciplined Mind: What all students should understand.* NY: Simon & Schuster.

Goettl, B., Halff, H., Redfield, C., & Shute, V. (Eds.). (1998, August). *Intelligent Tutoring Systems. 4th International Conference*, San Antonio, TX. Berlin, Germany: Springer-Verlag.

Harasim, L. (1999, September). A Framework for Online Learning: The Virtual-U. *IEEE Computer*. Retrieved June 16, 2001, from the World Wide Web: http://www.telelearn.ca/g_access/news/r9044.pdf

Papert, S. (1980/1999). *Mindstorms, Children, Computers and Powerful Ideas*. NY: Basic Books.

Perkins, D. (1992). *Smart schools: from training memories to educating minds*. NY: Free Press.

Perkins, D. (1998). What is understanding? In M.S. Wiske (Ed.), *Teaching for understanding: Linking research with practice* (pp. 39-57). San Francisco: Jossey-Bass.

Piaget, J., & Inhelder, B. (1969). *The Psychology of the Child*. NY: Basic Books.