The Promise of Multimedia: A Synergistic Learning System

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Abstract

This paper seeks to define the scope and functioning of Multimedia Learning Systems and includes specific examples and types. The main focus of this paper will include information about learning theories in general and will specifically center on Behaviorism, Cognitivism, Objectivism and Constructivism as they relate to teaching and learning using multimedia tools and techniques. The benefits and challenges of teaching and learning using multimedia are discussed as well. Questions are raised about whether current learning theories are appropriate for multimedia learning system design and delivery. Adaptive systems are also considered, with two examples offered: InterBook, and KnowledgeTree. Finally, a proposal is made for a more advanced learning system that accommodates learning theories, learning styles, teaching styles, and considers a recursive process for accessing and outputting information. A model of what such a system might look like is illustrated.
Introduction

No matter how advanced the equipment, how wonderful the video streaming capabilities, how the crisp audio, or how attractive the font and images, Multimedia Learning Systems are useless if the content is built without the end-user (the learner) in mind. How many times have we encountered the dreaded “please consult your system administrator” message in a Microsoft tutorial that was supposedly created to answer our question? Often, it’s as if information that was designed for a live classroom environment is converted to an electronic format without first considering the fundamental shift in the pedagogical approach necessary to facilitate student learning using a different medium. This fundamental shift requires a redesign that considers how people learn.

Multimedia learning systems come in many shapes and forms to meet the differing training needs that users have when choosing to interact with a system: from tutorials available at the touch of a key such as “help” systems associated with software, to fully developed bachelor and master’s degrees offered at a distance. The notion of an extended classroom that can offer education to the multitudes is a tantalizing one, but the trend has been to design multimedia learning systems using the latest and greatest (often flashiest) proprietary equipment simply because it exists. This can actually achieve the opposite desired effect by distracting learners from accessing the most important part of a multimedia learning system: the content. This creates a struggle for instructors who want to use the most contemporary tools at their disposal, because the tools themselves do not actually provide a true “back-end” design and support system that helps instructors promote or enhance student learning. As a result, many instructors may simply adapt their old content in a “cut and paste” fashion rather than engage in a complete redesign because they do not have the guidance that theory provides in creating student-centered learning. To date, the use of multimedia systems
as a pedagogical tool has not been wholly addressed by a specific learning theory. Rather, these theories have been cut-and-pasted into different multimedia learning environments in an analogous fashion with how some instructors cut and paste content: plunk it in where possible and hope that it works. This paper will review the theories of behaviorism and cognitivism and the philosophies of objectivism and constructivism, and how they may be utilized to assist instructors in designing a learning experience using the tools and benefits that multimedia systems offer.

**Benefits of Multimedia Learning Systems**

Wiesenberg (1999) discusses the benefits of using multimedia instruction, based on the assumption that the system is well designed: a) Convenience, especially if instruction is online and does not require any face-to-face interaction; b) Scheduling flexibility, depending on whether the technologically mediated instruction is synchronous or asynchronous; c) The learning environment (if structured correctly) becomes one of collaboration rather than competition; d) An increase in interaction between student and instructor as well as student and student; e) A decrease in turn-around time for feedback; f) The possibility that the quality of instruction and learning is amplified, which allows for a deeper, more thoughtful interaction with material; and g) Access to resources, such as databases, may increase with technologically mediated instruction.

Likewise, and again assuming that the learning system is well designed, there will be many benefits available to the instructor as well. For example, multimedia learning systems might include just-in-time upfront assessments of students’ learning needs with the ability to evaluate those needs instantaneously using electronic automated features. Another benefit, taking oneself out of the role of “sage on the stage” to “resource in the wings” (as cited in Wiesenberg, 1999, p. 151), helps students become less dependent and
more self-directed. The elimination of classroom constraints, such as not enough
desks/chairs, issues with physical classroom design, etc. can have an enormous
advantage, allowing the instructor to focus on content delivery, transfer, and retrieval of
information. And, finally, the ability to automate such tasks as taking attendance can
free up an instructor’s time to focus on his/her students.

Of course, when there are benefits for any one type of teaching and learning,
there are always challenges. Wiesenberg (1999) identifies several limitations that
students would face in such a learning environment, like dissatisfaction with the
necessary reliance on technology and the support/lack of support received in
troubleshooting, the feeling of “information overload” (p. 151) when strings of messages
must be read in order to understand a concept, a “frequency of miscommunication due
to the loss of visual cues” (p. 151), and a feeling of information that is disjointed in an
asynchronous learning environment. Additionally, content from a face-to-face class may
not be redesigned for an electronic environment, resulting in overhead-type bulleted
information that is “plunked” in and clearly out of context or the learning environment
itself may be too distracting and actually get in the way of learning (“death by
PowerPoint”).

Consistent with the challenges for learners, instructors may experience all of the
above and more. With no face-to-face contact with their students, instructors may feel
that a technologically mediated learning environment is impersonal, and out of touch.
Also, instructors must carefully manage the flow of information from all sources,
remaining vigilant in managing cognitive overload. And because students are familiar
with bulletin board-type software, asynchronous learning environments may need to be
moderated and kept on track more than a face-to-face classroom. Coupled with this
challenge and unique to online communication, the lack of intonations so innate to
verbal language is missing and can cause misunderstandings among students. Besides
all these challenges, there is no all-encompassing theory from which to work in designing technologically mediated instruction.

**Review of Learning Theories**

**Behaviorism**

Behaviorism focuses on observable changes in performance (Driscoll, 2000) and on strengthening, weakening, or maintaining a desired response to a specific stimulus (Ertmer & Newby, 1993). Neither the learning style nor cognitive structure of the learner are considered when creating instruction using a behaviorist theory, rather the environment in which people learn receives the most attention. Learners are “assessed…to determine at what point to begin instruction as well as to determine which reinforcers are most effective for a particular student…the most critical factor…is the arrangement of stimuli and consequences within the environment” (Ertmer & Newby, 1993, p. 55). Behaviorism is most often used as an instructional method when separate, concrete steps are needed to complete a specific task.

Though behaviorism does not directly address the role of memory in learning, it does consider “the acquisition of ‘habits’” (Ertmer & Newby, p. 55). Reinforcement schedules are instituted in order to maintain behavior (Driscoll, 2000). Not all behaviorists can be considered “pure” in their strict focus on the external. Estes (1972), for example, connected behaviorism and cognitivism, and thus linked the learner’s inner world with the environmental focus of more “orthodox” behaviorists, by stating that in order to maintain desired behavior, rewards for the behavior must not only be present, but must also have importance or meaning to the learner (as cited in Driscoll, 2000).

**Cognitivism**

Now at the forefront of most instructional design, cognitivism has taken over as the preferred method for assessing learning and transfer (Ertmer & Newby, p. 59).
Cognitivism considers the student’s learning needs and outcomes with its emphasis on cognitive processes like “thinking, problem solving, language, concept formation and information processing” (Ertmer & Newby, 1993, p. 57), rather than only how instruction changes behavior. While cognitivism also stresses the importance of environment on the learner, it is more concerned with what learners know and how they come to know (Ertmer & Newby, 1993). Memory and mental activities play a large role in cognitivism, specifically how information is connected to previously learned material, the storage and retrieval of information, and how information is organized cognitively (Ertmer & Newby, 1993).

Cognitivism is better suited to “explaining complex forms of learning” (Ertmer & Newby, 1993, p. 59) than are those described using the behaviorist point of view. For example, instructors teaching from this paradigm might use an advance organizer, which introduces learners to content materials before they are expected to be learned. This encourages learners to link previously held information to new, incoming material (Driscoll, 2000). Where behaviorism would be used in the instruction of discrete and ordered concrete tasks, cognitivism applies to abstract material that is expected to be synthesized and transferred to wide-ranging situations.

**Constructivism**

The two theories discussed above are considered objectivistic in nature in that knowledge is outside the learner and that the learner is a “sponge” and is said to be “fed” information (Clark, Zuckerman, 1999, p. 569). A paradigm shift has begun to occur in which instructional designers now question the basic assumption that behaviorism offered: “as one moves along the behaviorist-cognitivist-constructivist continuum, the focus of instruction shifts from teaching to learning, from the passive transfer of facts and routines to the active application of ideas to problems” (Ertmer & Newby, 1993, p. 62). This has led to constructivism, which views learning in a holistic manner, and
Constructivists argue that the learning of content is situational and meaningful (Ertmer & Newby, 1993). Constructivism is not a new methodology, but “has multiple roots in the philosophical and psychological viewpoints of this century, specifically in the works of Piaget, Bruner, and Goodman” (as cited in Ertmer & Newby, 1993, p. 62). Some would say that constructivism is a theory while others argue that it is more a holistic and philosophical way of looking at learning. Therefore, rather than being specific to a set of beliefs, it accommodates several theories under its umbrella-like structure (Brandon, 2004).

Constructivism encourages learning in “realistic settings” (Ertmer & Newby, 1993, p. 62) and promises the idea that the essence of learning is found in the specific meaning that content has for individual learners. Learning from this perspective is the process of memory changing and expanding as a result of situational experiences that require the learner to engage with the world and the new information on a deep personal level. Previously learned material is integrated and subsumed to incorporate these new experiences, creating a cumulative effect in which the learner achieves a broader and, at the same time, deeper store of knowledge and experiences that they can later draw upon (Ertmer & Newby, 1993).

Modern instructional design may be based in one or all three of the above mentioned paradigms, however, designers who have incorporated multimedia as a tool for student learning, such as in e-learning, will likely gravitate more toward a constructivist approach. Table 1 (adapted from Brandon, 2004, p. 3) summarizes and compares how each of the two theories and the learning philosophy interact with learning, the instructor, and the student.
<table>
<thead>
<tr>
<th>Perspective</th>
<th>Behaviorism</th>
<th>Cognitivism</th>
<th>Constructivism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is learning?</strong></td>
<td>Individual acquires a desired response to a stimulus.</td>
<td>Change in knowledge stored in memory.</td>
<td>Change in meaning, new ideas, concepts constructed from prior knowledge and experience.</td>
</tr>
<tr>
<td><strong>How does learning occur?</strong></td>
<td>Occurs when individual acquires desired response to stimulus</td>
<td>Information is encoded and transferred to long-term memory, retrieved for use as needed.</td>
<td>Construct knowledge by solving problems, usually collaborative with other people.</td>
</tr>
<tr>
<td><strong>What is the role of the teacher?</strong></td>
<td>Arrange contingencies (questions, stimuli, and feedback), present them to the learners, reinforce the desired behavior.</td>
<td>Guide and support cognitive processes that support memory and transfer.</td>
<td>Provide situation in which learners can collaborate or otherwise obtain experience.</td>
</tr>
<tr>
<td><strong>What is the role of the learner?</strong></td>
<td>Learner’s role is passive, a receiver of stimuli and feedback.</td>
<td>Learner participates by selecting information, processing and storing it, and retrieving information in order to apply it.</td>
<td>Learner is active in creating knowledge and meaning from experience and in connecting new knowledge with prior knowledge.</td>
</tr>
</tbody>
</table>

**Table 1: Perspectives on Learning Theory**

Adapted from Bill Brandon’s Perspectives on Learning Theory

**Objectivism and Two Instructional Architectures**

Instructional Architectures are “the frameworks for training design that work best with different levels of expertise and different performance outcomes, based on specific philosophical assumptions about the learning process and the outcomes of learning” (Clark & Zuckerman, 1999, pp. 566–567). Ruth Clark and Preston Zuckerman in their article, Multimedia Learning Systems: Design Principles, discuss two instructional architectures that can be categorized into an objectivistic paradigm.

The first, Receptive Instruction, is an architecture in which the learner is a “sponge” (Clark & Zuckerman, 1999, p. 569) that soaks up knowledge from the instructor. In this way, knowledge is thought to be outside the learner and accessible.
only through the instructor in the role of “sage.” A multimedia-enhanced learning environment that can be classified as receptive instruction is found in the support and registration department of Sony. The learner is offered a movie-like tutorial on how to hook up a new cable box to their television set, which runs from beginning to end without aid or interference from the end-user. This particular tutorial does not assume that the learner has any previous experience with coaxial cables or hooking up a cable box. It provides illustrations and instructions as if it were the sole resource for the learner. Receptive instruction is best suited to teach concrete, linear procedures that the learner can apply to abstract problems in a range of settings.

Similar to receptive, directive (i.e. programmed) instruction, is the architecture described by Clark and Zuckerman (1999) in which information is chunked into manageable bits and fed to students in a linear fashion. This approach could be considered more sensitive to the needs of learners as directive instruction pays closer attention to how current models of memory are thought to be structured. In programmed instruction, tasks are situated into small steps that progress from simple to complex based on a response from the learner (Driscoll, 2000). This can be likened to the way in which working (or short-term) memory is thought to perform. Working memory allows us to hold approximately seven “chunks,” plus or minus two, of information at a given time (Atkinson & Shiffrin, 1971) and when it is full, “there is a limited capacity for rehearsal...learning will be blocked, and the learner’s attempts to process new information will lead to frustration” (Clark & Zuckerman, 1999, p. 579). Programmed, or directive, instruction recognizes this inherent limitation in the student’s neurological ability to take in new information.

Directive/Programmed instruction is epitomized in the computer-based multimedia classes offered through the office of Distance Education at Boise State University. The classes require that students pass a knowledge exam before moving
Interventions of an Instructional Nature

from one learning module to the next. Learners are given three opportunities to pass each lesson exam before being required to go back and review the material again. At the end of the course, students are given a final exam and then are required to print and either fax or mail a “certificate of completion.” The software is delivered via a CD and is loaded onto the student’s computer. In this way, the instructor is taken completely out of the picture unless students have problems they need to resolve with a live person. Learning is directed by an electronic, multimedia-enhanced environment. Directive instruction is best suited to teach material that is not readily available to the beginning learner, and in situations where expert training is required.

Constructivism and Two More Instructional Architectures

Guided discovery, the goal of which “is to help learners acquire mental models similar to those of experts in a discipline” (Clark & Zuckerman, 1999, p. 571) could arguably be considered to fall in the middle of the behaviorist-cognitivist-constructivist continuum. It certainly contains characteristics of both objectivistic and constructivistic leanings: knowledge is outside the learner in that there is an “expert” from which to learn, but learners are expected to build on their already-held beliefs and knowledge. Ausubel (1961) characterized discovery learning as a situation in which the learner rearrange[s] a given array of information, integrate[s] it with existing cognitive structure, and reorganize[s] or transform[s] the integrated combination in such a way as to recreate a desired end product or discover a missing means-end relationship. After this phase is completed, the discovered content is internalized just as in reception learning (as cited in Driscoll, 2000, p. 117).

And while Ausubel believed that discovery learning was applicable in some situations, he also “believed that such methods ‘hardly constitute an efficient primary means of transmitting the content of an academic discipline’” (as cited in Driscoll, 2000).
An example of a multimedia learning system built on the principle of guided discovery is Boise State University's Instructional and Performance Technology online learning environment created in Lotus Notes. Guided Discovery focuses on situated learning that at least mimics real-world problems or events (Clark & Zuckerman, 1999). Students are often placed in groups and given a real-world problem to solve. “Learners are given some flexibility in solving these problems, with instruction support (sometimes called scaffolding) available to assist the learning” (Clark & Zuckerman, 1999, p. 571).

An example of a far “left” architecture on the constructivist – objectivist scale, is exploration, which relies on the assumption that all learners have unique mental structures from which to construct individual meaning (Clark & Zuckerman, 1999). This approach gives ultimate control to the learner and expects “the learner to construct a unique mental model” (Clark & Zuckerman, 1999, p. 573). Instruction using this architecture is often targeted toward people who are already considered “experts” in their field. Clark and Zuckerman (1999) present the example of a tutorial that offers experienced Visual Basic programmers a large database of information from which the learner can pick and choose the information they need. It is assumed that the expertise of the programmer is already such that they do not need to be guided or told what information they are seeking.

**The Fusion of Theory and Technology**

And now the question becomes: are all these theories and philosophies, with their assumptions about teaching and learning, applicable to building multimedia learning systems that can reach across multicultural boundaries and offer effective instruction to learners in different domains, situations, and with different learning styles? Ecklund and Woo (1998) argue that cognitive learning theories, such as cognitive flexibility, activity theory, discourse theory and conversation theory can be applied to the design of
multimedia learning environments. They state that many multimedia learning environments do not take into consideration the knowledge-base of the learner. Acknowledging the real-world needs of the learner and the variations among learners has led to the quest for adaptive systems. The authors caution that the most critical aspect of designing an adaptive system is that it be structured “to reflect the knowledge of the expert as well as that of the student” (Eklund & Woo, 1998, p. 185). They maintain that the reason so many multimedia learning systems have such innate difficulties is because they are not built using cognitive-based theories.

Like Ausubel believed about learning environments in general, Eklund and Woo (1998) suggest that multimedia learning environments should “reflect the cognitive structures of the learners” (p. 184). Ausubel believed cognitive structures are hierarchical, that a learner cannot comprehend, for example, how mayonnaise is made without first understanding the concept of cooking (as cited in Driscoll, 2000).

Similarly, Brandon (2004) believes that the constructivist philosophy answers most of the problems posed when creating multimedia learning systems. He assures us that “the one thing that we can be sure of is that constructivist design will never involve simple recipes or cookie-cutter approaches” (p. 7). Though Eklund, Woo, and Brandon take slightly different views on how multimedia learning systems should be constructed and with which learning theory or philosophy, all lean toward the notion that they should be adaptive.

Adaptive systems consider the individual learner with built-in features that adjust “on the fly.” These systems learn from the person using them, from the instructor or instructional designer’s contributions of content, and even from their basic design structure. Well-designed computer games are excellent examples of adaptive multimedia learning systems. In one first-person “shoot ’em up” game - *Max Payne* - the player’s level of difficulty is created and modified “on the fly” depending on how
quickly they pass each challenge. It also offers the option of making game play easier based on a player’s poor performance. Rather than getting stuck on any one level endlessly until the player has to use cheats to continue the game or give up in frustration, it facilitates playing so that it is always moving at an optimum pace for the player.

Eklund and Woo (1998) discuss an adaptive multimedia learning environment that strives to offer similar parameters, but without the level of entertainment offered in *Max Payne*. *InterBook* “is a system for authoring and delivering textbooks on the Web using adaptive link annotation as a form of navigation support” (Eklund & Woo, 1998, p. 185). The system was developed at The University of Trier in Germany, drawing on Discourse Theory for its underlying structure. Discourse Theory (a cognitive approach) espouses the notion that there is articulation between reason (why we do what we do) and individual meaning (Eklund & Woo, 1998). With this in mind, *InterBook* was developed with a table of contents, a glossary, and a search interface. What makes *InterBook* adaptive is that it “integrates features of an index and a glossary. These links are not stored in an external format but generated ‘on the fly’, in other words dynamically, by a special module that takes into account the student’s current state of knowledge represented by the user model” (Eklund & Woo, 1998, p. 185). Basically, *InterBook* takes textbooks, puts them on the Web with navigational tools and then offers individualized assistance as users access the system.

The main idea behind *InterBook* is to help prevent learners from getting lost in cyberspace with no hope of fulfilling their learning objectives. The user model in *InterBook* contains specific information about the learner’s goals and interests. As the user navigates through, the system adapts according to these parameters. Similar to programmed instruction, the learner is required to answer specific questions and pass tests to create their individual user model (Eklund, 1997)). The user model is then accessed throughout the time a learner is steering through content. In this way,
InterBook adapts to the learner’s individual needs on the fly. Figure 1 shows the model of a hypermedia learning system delivered via the web as adapted from Alenka Kavčič’s article, which is very similar to the model used by InterBook.

**Figure 1: Hypermedia Learning Systems on the Web**

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**Real World Application of Theory and Technology**

Distance Education is a type of organization, often found on college campuses, that is based on the concept of extending the traditional classroom using electronic media; whereas, Distributed Learning is an organization typically employed by specific industries and corporations that “tends to focus on the needs of individuals looking for immediate access to information, performance support tools, and instructional opportunities” (Wagner, 1999, p. 630) These two types of organizations probably make up the largest group of providers of multimedia learning systems in existence. With e-learning, online tutorials, electronic job aids, and electronic performance support systems available at learners’ fingertips, more than simple learning management systems that employ a “one size fits all” model are desperately needed.

Peter Brusilovsky (2004), an instructor at the University of Pittsburgh, suggests using an architecture that is distributive and adaptive for e-learning. He argues that the
traditional Learning Management Systems (LMS), like Blackboard and Web CT, are services that offer no individualized support to learners. All users have access to the same information, in the same order. Individual knowledge and preferred learning paths are not taken into account. Brusilovsky’s article (2004) focuses on KnowledgeTree as a potential answer to the problem of adaptive individualized instruction. The learning environment capitalizes on portals that are built by students and instructors from the launch of the software. Instructors determine student-level access for each course offered according to the relevancy of the information. So, from the beginning, a huge database of information and knowledge is being built, which can be reused in each subsequent class offered. The architecture of this distributed learning system “assumes the presence of at least four kinds of servers: activity servers, value-adding services, learning portals, and student model servers” (Brusilovsky, 2004, p. 105). The most important function of KnowledgeTree is its re-usability of information. Individual learners pick and choose the information they need to complete their goals and objectives. In this way, KnowledgeTree is “just in time, just for me”, which characterizes distributed learning and is utilized in educational markets for the purpose of distance learning. KnowledgeTree grows and evolves as questions are asked and answered.

**Conclusion: One Possible Solution**

Wagner (1999) explains, “...developing learner-centered designs involves a significant philosophical and methodological shift from behavioral to cognitive perspectives, and from objectivist to constructivist perspectives” (p. 635). Likewise, this shift is absolutely necessary in the design of all multimedia learning systems. From small tutorials to fully accredited academic degrees, “e-learning” is the wave of the present and the future. Designing good instruction electronically with the end-user in mind can facilitate a learning environment of cooperation and success. Taking into
consideration how learners learn up front, as well as theories and philosophies of learning, may help solve technological instructional design problems later. In other words, an integration of theory and application needs to occur. Not only is a paradigm shift from objectivist to constructivist thinking needed, but new, tangible tools that are built into the design of multimedia learning systems must be available to instructional designers, instructors, and students alike.

Extending the adaptive system paradigm, a synergistic (the whole working together to create a total effect) learning system can be available to instructional designers, instructors, and students. This system would include a recursive process for building instruction that would contain a user model and an instructor model—a model incorporates theory, research, and previously attempted applications. Models, therefore, are synergistic systems that integrate multiple domains of information. Additionally, a synergistic design approach includes a “teaching palette”, which functions as a help system that would prompt an instructor or designer during the process of building content. In a synergistic learning system, this information would be available with a user-friendly interface that evolves from the beginning of initial design, to the input of content, to the delivery of information, to completing and evaluating course content. This system would be an essential resource to both instructors and students alike.

The user model would assess and consider the expertise of the student in relation to the material being delivered as well as the way the student interacts with the system and their preferred learning style. The user model can “engineer” the social structure of the environment (like e-Harmony for learners), encouraging learners to make connections with other learners with similar styles, abilities and levels of expertise. Further, the system could take into account the cultural backgrounds of learners to encourage social connections and networking.
The instructor model would consider the instructor’s preferred style of teaching, their level of technological knowledge, and could train them in the most current learning theories and techniques while they deliver instruction. Therefore, this system is additionally synergistic in that it trains the trainer. The system also learns through this process and refines its own techniques, creating an ever-evolving fund of knowledge.

The teaching palette help system would consider everything the user and instructor model does and would prompt instructors and designers as they are building content to consider different modalities of presenting information. For example, if an instructor or designer is building content using only visual cues, the teaching palette might suggest also including audio to enhance and deepen a student’s understanding of the course material. The teaching palette could also be extended to a learning palette that helps students with study skills.

Similar to current adaptive systems, both the content and teaching palette areas would continually evolve. Students and teachers would have complete access to all preceding material. For instructors and designers, this would mean having access to a history of techniques that were suggested and used by other instructors/designers, including data on how effective it was. To promote evaluation and gather data on effectiveness, instructors and designers would be asked to offer feedback on what worked for their students and what did not. In such a system, no one would be required to continually reinvent the wheel. Figure 2 illustrates a picture of what such a teaching and learning model might look like.

Some industries, like higher education, that utilize adaptive multimedia learning systems appear to be moving toward such a model. A shift toward a unified approach in the application of multimedia learning systems can facilitate collaboration across professional domains. Currently, many such professionals are implementing multimedia tools (i.e. multimedia applications), but the development of a synergistic approach would
facilitate multimedia learning systems and would promote the collaboration of instructional designers, technophiles, instructors, and students in one cooperative effort.

Figure 2: A synergistic learning system


References


*Adult Basic Education, 9*(3), 149-162.