CONSIDERATIONS FOR DEVELOPING CONSTRUCTIVIST WEB-BASED LEARNING

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ABSTRACT

The use of World Wide Web (WWW/Web) as a teaching and learning tool is now rapidly expanding into education. Web-based learning is one of the newest tools for education and other related fields. However, the Web is a confusing technology for beginning computer users because it can be used in so many different ways. Thus, if there is a mismatch in the use of the Web for learning, it can lead to loss of the learner's attention, boredom, information overload, and frustration. In order to employ Web-based learning in an appropriate way, the authors offer five different views of considerations that take into account the constructivist paradigm. These five considerations include pedagogy, instructional structure, interaction, technology, learners' characteristics.

Keywords: World Wide Web, constructivism, instructional structure

INTRODUCTION

Development of Web-based learning has started a revolution in instructional design that is providing new opportunities for education. Instructional design for educational purposes is the systematic design of teaching and learning environments as well as instructional systems. Instructional design may include various facets of didactic methods (such as direct instruction, self-instructional textbooks, and instructional video), and media (such as computer based training, interactive multimedia, Web-based learning, and elements of distance learning) (Gros, Elen, Kerres, Merrienboer, & Spector, 1997). In the wake of the wide application of the Internet, the Web has become more popular for educational instruction. Within the context of K-12 or higher education, instruction designers are usually asked to evaluate whether instructions designed for Web-based environments are at least as successful at fostering students' learning as are classroom teaching techniques used on campus.

In general, constructivist approach focuses more on problem solving and thinking skills. Additionally, it also emphasizes the learners ability, to solve real-life and practical problems. Based on human cognition, the innovation educa-

tional computer programs, like Web-based learning, can be developed constructivist paradigm. If we employed Web-based learning in appropriate ways, it is a revolutionary tool for education. However it is a confusing technology for beginning computer users because it can be used in so many different ways. Thus, if there is a mismatch in the use of the Web for training, it can lead to loss of the learner's attention, boredom, information overload, and frustration (Berge, 1998). So one challenge, for those designing Web-based learning environments is to seriously consider which developing method will best enhance the presentation of information for learners and faculty Thus, the purpose of this study is to offer considerations when developing Web-based learning that is based on constructivist approach.

THE CHARACTERISTICS OF WEB-BASED ENVIRONMENTS

The characteristics of Web-based environments should be addressed before developing a Web-based learning. In general, Web-based environments possess the following five characteristics (Liaw & Huang, 2000):

First, Web-based systems offer a multimedia environment. The information in the Web-based systems can be simultaneously represented in any combination of media format, such as text, image, graphic, sound, voice, and animation. Khan (1997) stated that a Web-based learning course could be designed to address all students' learning styles by incorporating a variety of multimedia.

Second, Web-based systems integrate various kinds of information and construct information bases. The multiple mixed-media nodes in a Web system can be instantly called up in a consistent manner, irrespective of the structure of the information or resources (Yang, 1996). In Web-based systems, several search engines, such as Yahoo, Excite, AltaVista etc., that are integrated with the Web can quickly and easily access information.

Third, Web-based systems support interactive communication. Generally, users of the Web have full control over their own learning situations and this high level of interaction gives users dynamic control of information (Liaw, 1999). Essentially, learner interface interaction addresses the relationship between the learners and the technology that is being used to access instructional materials and to communicate with the instructor and other learners. In Web-based learning, interaction is not just to select simple menus or to click objects on the screen. Instead, the interaction should involve complex activities by the learners, such as engaging and reflecting, annotating, questioning, answering, pacing, elaborating, discussing, inquiring, problem solving, linking, constructing, analyzing, evaluating, and synthesizing (Berge, 1999). Khan (1998) also stated that learners in Web-based environments could interact with each other, with instructors, and on-line resources by Internet tools, hyperlinks, browsers, and authoring programs.

Fourth, Web-based systems support networks to access information. Starr (1997) noted that a Web-based system went beyond static Web pages and page linking, by creating truly interactive networks with information exchange

between users and servers. The Web can be a loose term for presentations containing more complex arrangements than the traditional linear text and is already widely acknowledged to be a promising teaching and learning tool. This nonlinear and random-access network offer a new direction rather than the conventional step-by-step concept. The multi-linkages within, between, and among the nodes as a network permit the nonlinear organization and reorganization of the nodes and allow for multiple dimensional navigations through a body of data. Indeed, the three-tier Web-based database systems could offer more flexibility for the nonlinear and random information networks.

Fifth, Web-based systems provide a cross-platform environment. A cross-platform means Web systems that can be executed independently on various computer operating systems. Starr (1997) stated "The cross-platform distribution of the Web means that the designer of computer-based instruction (CBI) no longer has to worry about producing separate versions of a program for Macintosh, DOS, and Windows." (p.9). In the Web, information and resources from around the world can be accessed by anyone from anywhere in the world as long as she/he has a computer with an internet connection. Based on this open standard cross-platform, the Web allows anyone in the world to create and post Web documents using common script language, such as HTML, Perl, and standard Internet Protocol (IP) addresses (Khan, 1998).

CONSIDERATIONS FOR DEVELOPING WEB-BASED LEARNING

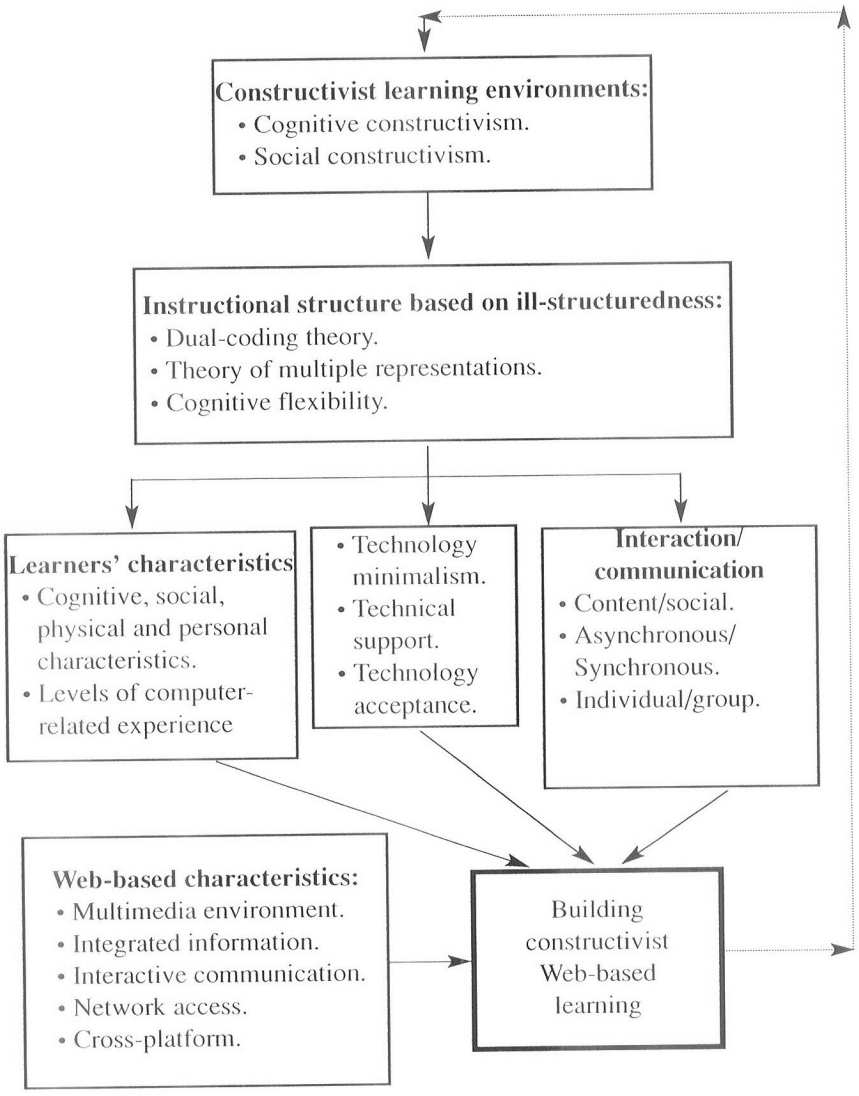
Technology-supported instruction has been traditionally more suitable to step-by-step development processes. Recently, researchers started arguing that the use of the Internet and Web for delivery of instruction has revolutionized the behaviorist approach and allowing more space for constructivist approach. Although developmental models using the Internet/Web given the possibilities for instructional design, some considerations need to be addressed in order to employ Web-based learning in an appropriate way (Liaw, 2000). This paper proposes five considerations in developing Web-based learning environments such as Web-based virtual textbooks or coursewares that could be taken into account the constructivist paradigm. These considerations are highlighted in Figure 1 and detailed in the following sections. These five considerations include: pedagogy, instructional structure, interaction, technology, and learners' characteristics. Figure 1 presents the concept of building constructivist Web-based learning based on considerations.

Pedagogy consideration

The main purpose of pedagogy consideration is to design an effective learning environment. Two general rules in this consideration are: define and describe the learning domain, and define the learning models for each purpose. In general, Web-based learning, like traditional learning, should define its grade level, subjects, and purposes. Additionally, in any teaching model, based on educa-

tional theories such as behaviorism or constructivism, the levels of teacher-control, guided-teacher-control, student-control and group-control that is desired regarding each activity (Berge, 1998),

FIGURE 1. BUILDING CONSTRUCTIVIST WEB-BASED LEARNING BASED ON CONSIDERATIONS



Constructivist learning environments

Constructivist models of computer programs have emerged from the work of such developmental theorists as Jerome Bruner, Jean Piaget, and Lev Vygotsky. One strand might be called cognitive constructivist. It states that learners construct their own knowledge of the world through assimilation and accommodation. Another strand might be called social constructivist. It places more emphasis on the social context of learning (Maddux, Johnson, & Willis, 1997).

Actually, the focus of constructivism is not unique to psychology; instead, it has roots in several areas, such as linguistics, society, and philosophy (Ornstein & Hunkins, 1998). Essentially, individuals actively construct knowledge, within social realms that serve to shape the very knowledge constructed. Constructivists believe that the task for learners is not to passively accept information by mimicking the wording or conclusions of others, but instead to encourage themselves in internalizing and reshaping or transforming information through active consideration (Brooks & Brooks, 1993). Up to this point, meaning is imposed on the world by those who reflect and those who think about the world. But since people view reality differently from the same vantage point or bring identical personal histories to the process of learning and thinking, there can never be total agreement as to the outcome.

While the cognitive constructivist approach focuses on problem solving, thinking skills and learning strategies, the theory of social constructivism emphasizes the student's ability to solve real-life, practical problems. Social constructivism is not unique to psychology. Indeed, it has roots in several areas, including linguistics, sociology, and philosophy. Constructivists tend to focus on projects that require solutions to problems rather than on instructional sequences that requires learning of certain content skills. The job of teachers in this theory is to arrange for required resources and act as a guide to students who formulate their own goals and teach themselves (Roblyer, Edwards, & Havriluk, 1997).

Jonassen (1994) described seven characteristics of Constructivist Learning Environments (CLEs): first, CLEs provide multiple representations of reality. The multiple representations avoid oversimplification and represent the complexity of the real world. Second, CLEs emphasize knowledge construction instead of knowledge reproduction. Third, CLEs emphasize authentic tasks in a meaningful context rather than abstract instruction out of context. Fourth, CLEs provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction. Fifth, CLEs encourage thoughtful reflection on experience. Sixth, CLEs enable context-dependent and content-dependent knowledge construction. And seventh, CLEs support collaborative construction of knowledge through social negotiation, instead of competition among learners for recognition.

Instructional structure consideration

In well-structured instruction, the instruction should be presented in small steps so that one point can be mastered at a time, providing various examples of

the new skills or concepts, modeling of the learning task or giving narrated demonstrations, avoiding digressions, and re-explaining difficult points. However, the use of well-structured instruction should be preceded by effective diagnosis of students' knowledge or skills to be sure that they have the prerequisite knowledge or skills to achieve high levels of instructional materials. In contrast, the use of ill-structured instruction can help learners have opportunities to develop complex cognitive skills, like attaining an understanding of important elements of conceptual complexity, the ability to use acquired concepts for reasoning and inference, and ability to flexibly apply conceptual knowledge to novel situations (Spiro, Feltovish, Jacobson. &,. Coulson, 1995).

The constructivist instruction should be anchored in real-world problems, events or issues that may be appealing and meaningful to learning (Bostock, 1998). Thus, the constructivist learning would like to use ill-structured instruction instead of well-structure instruction. Three instructional theories address this kind instructional structure: dual-coding theory, theory of multiple representations, and cognitive flexibility theory.

Dual-coding theory

Dual coding theory emphasizes that two separate systems can work independently or together for verbal and imagery processing (Butler & Mautz 1996). Dual-coding theory suggests that pictures are easier to remember than words. In addition, when information coding is in both systems, this information is easier to remember than information coded only in the verbal system. For instance, it was found that text materials devoid of pictures are more difficult to understand and recall than the same text materials presented after the presentation of an organizing image (Burton, Moore, & Holmes, 1995). In another study by Stader, Webb, White, Kulhavey, & Stock (1990), the results indicated that iconic representation could not replace the symbolic; however, it has been sufficiently shown that words and images together are a powerful team.

Dual coding theory describes memory and cognition in terms of a highly networked series of nodes that an individual uses to represent information (Burton et al., 1995). This theory consists of verbal and imagery subsystems. The verbal subsystem specializes in presenting and processing language-based events and information. This subsystem includes verbal codes for concrete objects and events, such as books or computers; it also includes representation for abstract, non-concrete information, such as ethical matters. The imagery subsystem specializes in representing and processing information related to nonverbal objects and events. The imagery subsystem includes images for shapes, sounds, actions, emotional responses, and other nonverbal objects and events. A medium, such as the Web, that combined text with animation and hypertext captions results in greater recall, inference, and comprehension (Large, Beheshti, Breuleux, & Renaund, 1995). The dual-coding theory provides a partial explanation of why many think that hyper-media-based instruction will be so effective for learning (Paivio, 1979, 1986). When a learner processes information through both verbal and imagery subsystems, these multi-modal approaches to education are thought

to be particularly effective for accommodating learners with diverse styles and preferences for learning.

Theory of multiple representations

According to the knowledge processing approach from learning and cognitive theories, a monolithic depiction of subject matter from one perspective may not be adequate for ill-structured domains and may not be sufficient for inducing learners to construct a mental representation of subject matter content (Spiro et al., 1995). Multiple representations indicate different conceptual views. It is assumed that cognitive processing of multiple external representations may: first, enhance the likelihood that a particular mental representation may be adequate for solving a particular problem, second, support the construction of context-indexed mental representations, third, enable situated learning experiences for enhancing memory performance and usability of knowledge, fourth, improve the construction of mental representations of different views of subject matters with multiple representational modes, and fifth, enhance cognitive flexibility and knowledge transfer (Tergan, 1997).

Cognitive flexibility theory

Like multiple representations theory, cognitive flexibility theory emphasizes the real world complexity and ill-structuredness of many knowledge domains (Spiro et al., 1995). From an ill-structured aspect of knowledge, advancing knowledge acquisition, such as attaining an understanding of important elements of conceptual complexity, the ability to use acquired concepts for reasoning and inference, and the ability to flexibly apply conceptual knowledge to novel situations, can be facilitated by the principles of this theory. This cognitive flexibility theory is systematically applied to an instructional theory. Generally, this theory has the following characteristics: first, random access. Second, the major learning activity is a nonlinear exploration of the learning environment. And third, multiple representations of the content are presented (Maddux et al., 1997).

Cognitive flexibility theory points out that traditional instructional designs, such as textbooks, lectures, computer-based drill, are inadequate for implementation within ill-structured domains because they depend on organized and linear techniques. For a learner to fully comprehend the complexity and erratic variability of information, it must be accessible to the learner in a manner that more closely mimics the nonlinear nature of the domain (Brown, 1995).

Interaction consideration

In Web systems, the instructional tools include communication and exploration tools. Generally, communication tools, such as E-mail, listservs, chat forums, online conferences, MUD, and IRC, are all appropriate for asynchronous and synchronous social communication. In contrast, exploration tools, such as Web browsers, gophers, and search engines, are all good for individual content interaction. Generally, a Web-based learning environment offers the following six inter-

actions. Table 1 shows the Web-based tools for these interactions.

TABLE 1: WEB-BASED TOOLS FOR INTERACTION

Interaction	Web-based tools
Content interaction	Web browsers, search engines, E-mail, listservs, newsgroups,
Social communication	E-mail, listservs, online chats,online conferences, MUD, IRC
Synchronous communication	Online chats, online conferences, MUD, IRC
Asynchronous communication	Web browser, search engines, E-mail, listservs, newsgroups
Individual interaction	Web browsers, search engines
Group communication	E-mail, listservs, newsgroups, online chats, online conferences, MUD, IRC

Content and/or social interaction

The native attributes of a Web system include the capacity to transfer multimedia files completely intact to anyone or any network (Gilbert & Moore, 1998). Based on the native attributes of a Web system, content and instruction interaction, such as searching instruction, linking content, or reading text with browsers, is able to perform and create. Generally, the nonlinear fashion in Web systems can be instantly called up in a consistent manner, irrespective of the structure of the information or resources (Yang, 1996). Up to nonlinear media form, a Web system allows learners to explore abundant and diverse bits of information in their own ways. In general, when discussing social and interpersonal interaction in a Web system, face-to-face communication is not necessary to happen; instead, individuals can communicate through computer networks. Unlike face-to-face social and interpersonal communication, with a Web system being bound to online systems, such as online chats or online conferences, these multi-user networks provide enormous potential for social and interpersonal communication (Yang, 1996). In a Web system, learners and instructor or learners and learners can engage in side-by-side and online questioning, answering, discussion, debate, or negotiation.

Asynchronous and/or synchronous communication

Asynchronous communication, such as e-mail, guestbooks, listservs, and newsgroups, is in some manner technologically mediated and is not dependent upon instructors and learners being present together at a specific time to conduct teaching and learning activities (Berge, 1998). In asynchronous communication, learners work at their own convenience when or where they want to be. Additionally, learners control the pacing of instruction by themselves. Synchronous

communication occurs in real time, such as online conferences or chat rooms. All participants, including instructors and learners, in the interaction must be presented, although not necessarily at the same physical location. When oral discussion in an online chat, the quality of the arguments is enhanced and thinking is more creative than without this kind of interaction. The online chat or conference in the Web system thus serves the role of thinking device for collaborative construction of knowledge.

Individual and/or group interaction

For learning to occur, based on the constructivist pedagogy, individuals using their experiences as a foundation construct knowledge personally from internal representations. In learning activities, knowledge is based on individual constructions that are not tied to any external reality, but rather to the learner's interaction with an external world (Lacy & Wood, 1993). The multiple linkages and perspectives of Web-based learning provide a learner-objective environment to assist learners to link and search for knowledge that interact with their own prior experiences. Another aspect of individual interaction includes reflection, meaning learners exercise control over what is learned. Group communication is collaborative learning. In general, collaborative learning helps individuals to make progress through their zone of proximal development by the activities in which they engage (Vygotsky, 1978). When learners have opportunities to interact with others and their instructors about the instruction or content, they have opportunities to build their own knowledge. In addition, they share their own knowledge with others. Much of learning inevitably takes place within a social context, and the process includes the mutual construction of understanding (Bruner, 1971). When guestbooks, listservs, newsgroups, online chats or conferences being bound into a Web-based system, the group communication can be offered through either asynchronous or synchronous methods.

Technology consideration

The Web-based learning should be designed to match the participants' comfort with the system and the software. Three general rules in this consideration are: use the principle of technological minimalism, provide adequate technical support and training for both learners and teachers, and understand learners' acceptance of technology When delivering Web-based instruction, access to often complex and expensive technology becomes a serious issue. In general, technology minimalism reduces this issue. Technological minimalism can be defined as the unapologetic use of minimum levels of technology, carefully chooses with precise attention to their advantages and limitations, in support of well-defined instructional objectives (Berge, 1998). Indeed, the more technology needs the greater the need for technology support and training. Furthermore, the technical designers need to take into account the amount of support and training for learners and teachers.

For user acceptance of WBL programs, a satisfactory performance is of great

importance (Hagg, Maylein, Leven, Tonshoff, & Haux, 1999). Besides the hardware performance of client and server computers and the network bandwidth available, the basic techniques and WBL programs used also affect it. First, time is required to start and initialize the runtime environment (such as browser plug-in, virtual machine) necessary to execute the WBL program on client computers. However, this period of time is mostly insignificant, it usually takes only a few seconds. Second, the performance of the runtime environment used has to be considered. In this period of time, a very significant point is the time needed to transmit or download all the necessary WBL program code to client computers. This can constitute a serious hindrance if the network connection is slow or the program is too big. If the complete program code must be transmitted before the program starts it may take a long time. In contrast, if the client computer requests from the server computer only parts of the program necessary at a time, as a result users may have to wait long during the program run. And last, frequency and duration of communication between clients and servers during program run are important factors for the performance of a WBL program. In general, the duration depends on the amount of data to be downloaded from servers to clients.

Learners' characteristics

In developing Web-based learning, the instructor needs to focus on content development based not only on learning objectives, but also on an analysis of the targeted populations. Learners' cognitive, social, physical and personal characteristics need to be identified. Since the course will be delivered through the Internet, focusing on several of the variables, such as cognitive, social, physical, and personal characteristics, will improve learners' performance (Passerini & Granger, 2000). In general, cognitive characteristics include individual computer literacy and prior knowledge, or personal learning styles. Social characteristics include individual attitudes toward collaboration or relationship with peers. Physical characteristics include individual age or gender. And personal characteristics include individual attitudes, motivation, belief, anxiety, and confidence (Passerini & Granger, 2000).

Hill (1999) identified that users could be categorized into three broad categories: first, naive users are low-level users and not understanding the Internet/Web. They also struggle to survive in Web systems. Second, somewhat knowledge users are mid level users and have some understanding of the Internet/Web.They work with direction and have some questioning of Web systems. And third, knowledge users are high level users and have high level of understanding. They are self-directed users and seeking to improve what they do. Web-based environments provide linear and nonlinear structure for more interactive learning circumstances. Many users of Web systems have found that they could not take advantages if they lacked the required computer skills, such as experience using database programs, experience using word processing programs, and experience in the Internet (McGuire, 1994; Reed & Giessler, 1995; Welles, 1997; Zhu, 1995). Form those researches, when users have more computer-related experience, they prefer more loosely structured educational software.

SUMMARY

The purpose of this paper is to offer considerations for creating constructivist Web-based learning environments. Essentially, each medium has its own particular characteristics for training and learning purposes. From the educational viewpoint of Web-based applications in learning, more appropriate use of Web systems for learners and instructors will enable more learners to develop by self-discovery and personal insight. In Web-based learning, the dilemma is that when instructional programs add the complexity needed for the design of instructional purposes, it becomes itself increasingly complex to use (Gilbert & Moore, 1998). In other words, increasing the flexibility of educational purpose will increase the complexity of Web-based learning. Although still having several dilemmas, it is hoped that as Web-based learning development progresses, simple-to-use tools will be developed that will, in turn, allow for the inclusion of complex objections for training. Furthermore, it can be expected that we will see an environment that not only equals traditional instruction but also provides opportunities that go far beyond it.

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