A Model of the Effective Dimensions of Interactive Learning on the World Wide Web

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Introduction

The purpose of this paper is to describe a model that illustrates several classes of variables that may account for learning when the World Wide Web (WWW) is used as a vehicle for the design and delivery of a learning environment, specifically in the context of higher education. The model is based upon a model of school learning developed by Carroll (1963) nearly 35 years ago. Pending research results, the new model may be used to guide research, planning, development, and evaluation of the WWW as an interactive learning environment.

The Carroll Model of School Learning

In 1963, John B. Carroll introduced a model of school learning which has influenced educational researchers and developers for three decades (cf., Clark, 1987, Cooley & Lohnes, 1976). In a 25-year retrospective look at his model, Carroll (1989) expressed surprise that the model had attracted as much attention as it had over the years, but also went on to state that "the model could still be used to solve current problems in education" (p. 26). Carroll's original model is a formal and quasi-mathematical one in which three of the five classes of variables that can explain variance in school achievement are expressed in terms of time. The structure of the Carroll Model is represented in Figure 1.

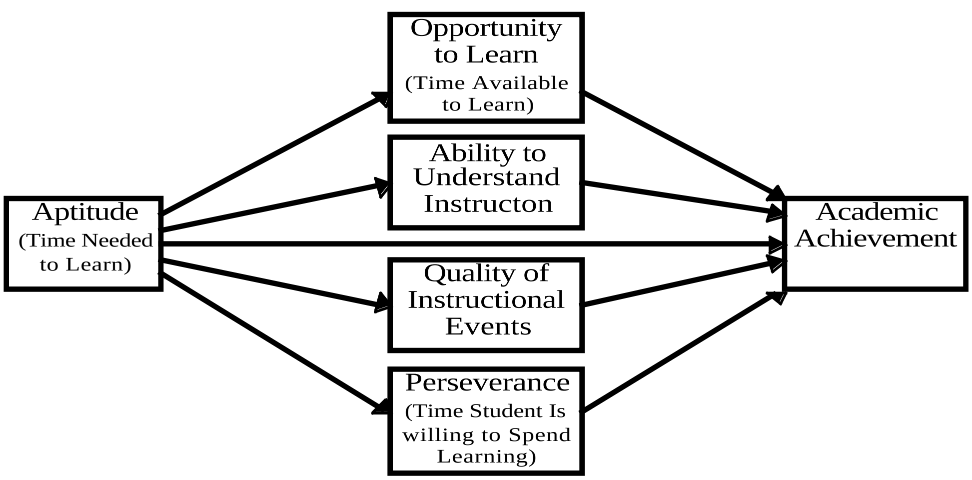

Figure 1. Carroll's (1963, 1989) Model of School Learning.

Academic Achievement: Carroll's model is focused on academic achievement of the kind usually measured by standardized achievement tests or by the grades achieved in academic courses or programs of study. Typical achievement indicators predicted by the classes of variables in

Carroll's model include course grades, grade-point-average (GPA), achievement test scores, high school completion rates, and graduation from college.

Aptitude: Perhaps the most influential variable or factor in Carroll's model is his interpretation of aptitude as "the amount of time a student needs to learn a given task, unit of instruction, or curriculum to an acceptable criterion of mastery under optimal conditions of instruction and student motivation" (Carroll, 1989, p. 26). Rather than viewing aptitude as a score on a standardized test such as the Scholastic Aptitude Test (SAT), Carroll views most learners as capable of desirable levels of academic achievement provided enough time. This temporal interpretation of aptitude has influenced many educational reformers, perhaps none more so than Benjamin S. Bloom (1977), largely credited as the founder of the "Mastery Learning" instructional model.

Opportunity to Learn: The amount of time available for learning within a school curriculum or other educational context defines the "opportunity to learn" variable. Carroll points out that a major weakness of many school schedules (e.g., 180 school days a year divided into 50-minute classes devoted to different subjects) is that they may provide less time than lower aptitude students need to achieve a given set of objectives. Others (cf. Cooley & Lohnes, 1976) have included factors such as the content covered in a curriculum within the opportunity to learn class of variables.

Ability to Understand Instruction: The ability to understand instruction class of variables includes language comprehension and learning skills. These variables are regarded as individual differences that are subject to development or enhancement. For example, learners who develop better learning skills will be able to decrease the amount of time they require for learning, and in effect, increase their aptitude for learning as defined in Carroll's model.

Quality of Instruction: An often misinterpreted factor in Carroll's model of school learning is quality of instruction. Carroll emphasizes structural aspects of instruction such as knowledge of objectives, access to content, and carefully planned and clearly specified instructional events. Carroll (1989) clarifies that this does not mean that learning tasks must be broken down into small steps and subjected to drill and practice, defending his model as encompassing a wide range of instructional events, from direct tutorials to field trips.

Perseverance: The perseverance factor, often viewed as an operational definition of student motivation, also has a temporal interpretation, i.e., it is the amount of time a student is willing to spend on learning a given task or set of objectives. If students have similar aptitudes, i.e., they need approximately the same amount of time to accomplish a certain learning task, any of them who put forth more effort, i.e., spend more time, will attain higher achievement. Of course, if more time is not available for extra effort to be performed, than the perseverance factor will have little impact.

The World Wide Web as a Learning Environment

Higher education faculty, K-12 teachers, and business trainers alike are turning to the World Wide Web as a vehicle for implementing instructional innovations (Khan, 1997; Owston, 1997). Although this paper focuses on applications in higher education, many of the classes of variables in the model described below are relevant within other education and training contexts. The *1996 Campus Computing Survey* (Green, 1996) reports that the use of the WWW continues to expand in higher education, although primarily for information dissemination and marketing rather than for teaching and learning. The survey indicates that only 9% of college courses currently use Web resources to support instruction, a modest growth from 6% in 1995. By contrast, the percentage of academic institutions indicating that they have a WWW presence jumped to nearly 80% from 55% in 1995.

Perhaps the relatively slow development of WWW-based instruction can be attributed to a lack of understanding of the effective dimensions of the WWW as a learning environment in higher education. Some of the common uses academics are making of the Web include:
- enriching access to course materials,
- documenting course discussions,
- posting student writing, art, projects, etc. for critique,
- providing tutorials, simulations, and drills,
- facilitating group work,
- providing remedial support and/or enrichment, and
- enabling reflection and metacognition.

Despite these potentially power uses, there are still misunderstandings among higher education personnel about the potential of the WWW to support learning. As with previous innovations such as interactive multimedia, many faculty assume that the WWW is a “magic box,” and that simply putting a course on the Web guarantees better learning. Commercial interests advertising Web authoring tools encourage this assumption, proclaiming that once instructional materials are on the Web, students will learn automatically. Actually, the WWW does not guarantee learning any more than the presence of a library on campus guarantees learning. The Web is simply a resource which must be designed to support effective instructional dimensions (Reeves & Reeves, 1997). The Web should only be used for delivery of a learning environment when its unique affordances are appropriate to the needs that have been identified for faculty and students. Many effective WWW learning environments will be complemented with more traditional media such as print materials and videotapes rather than trying to force these other media onto the Web. In short, different technologies should be employed for different purposes. For example, the Web is an excellent vehicle for facilitating group work, but it is a lousy vehicle for academic reading. Although this may seem like stating the obvious, new technologies are all too often used to deliver content that should have been left in traditional forms.

A Model of World Wide Web-Based Learning

No model is a perfect reflection of reality, and some might argue that models like Carroll’s are oversimplified and inadequate to capture the complexities involved in teaching and learning. Nonetheless, if the impact of Carroll’s model is any indication, people value even simple models because these models help guide thinking about extremely complex phenomena such as learning. In comparison to Carroll’s model, the model illustrated in Figure 2 may seem to violate the spirit of Ockham’s razor, i.e., the rule that the simplest of two competing theories is preferable. However, it appears that the complexities of inputs, process, and outcomes involved in higher education today demand a more complex representation. Of course, this conjecture must be subjected to rigorous research and evaluation.

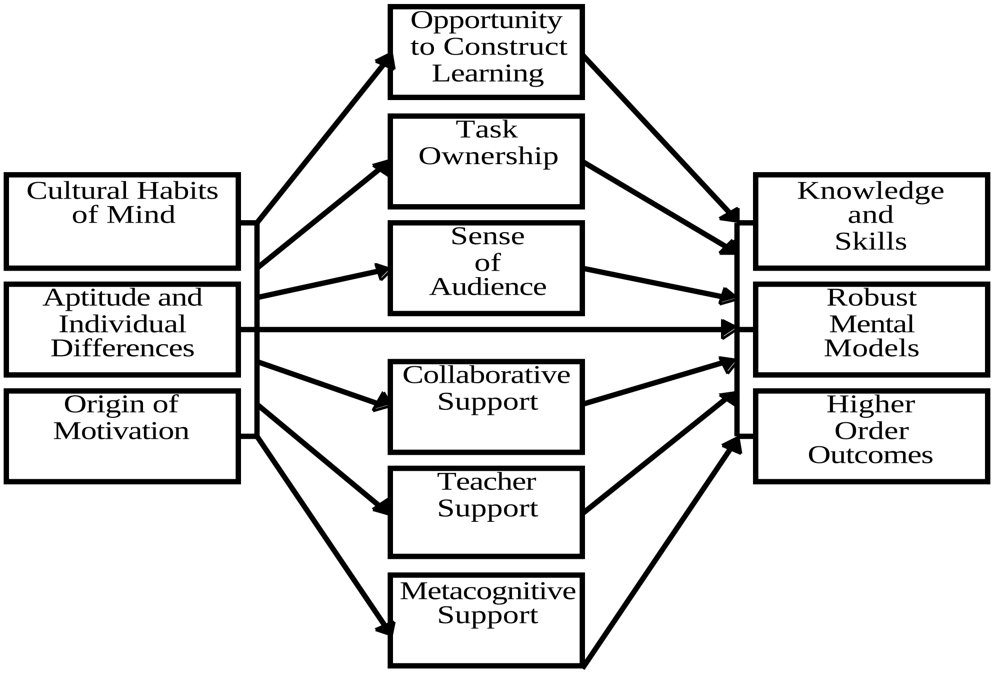

Figure 2. A model of WWW-based learning.

Knowledge and Skills: Instead of the traditional academic achievement indicators included in Carroll's model of school learning, a richer analysis of the outcomes of higher education is needed. The first class of variables is labeled "knowledge and skills." Cognitive psychology has enriched our understanding of the mental states that result from learning to include constructs such as propositions, schema, rules, and skills (Winn & Snyder, 1996). Some variables in this factor of the model can be measured with traditional tests, but others may demand alternative approaches to measuring outcomes such as performance analysis and portfolio assessment (Wiggins, 1993).

Mental Models: At first it may seem strange to separate "mental models" from other types of knowledge and skills, but developing robust mental models is such an important outcome of higher education that it deserves special attention. In virtually every field or profession, people must be able to activate appropriate mental models, use them to interpret new information, assimilate new information back into those models, reorganize the models in light of the newly interpreted information, and use the newly aggrandized mental models to explain, interpret, or infer new knowledge (Norman, 1983). Mental models are the mental structures we use to "understand systems and solve problems arising from the way systems work" (Winn & Snyder, 1996, p. 123). A benefit of mental models is that they can be "run" and "rehearsed." For example, students may develop rich mental models of the theory of chaos that allow the understanding and solution of complex problems in science fields as diverse as astronomy, biology, chemistry, and physics.

Higher Order Outcomes: Although most academics are primarily concerned with the transmission of existing knowledge and skills in their fields, many also intend for their students to develop higher order outcomes such as problem-solving abilities, creativity, curiosity, and the desire for lifelong learning. Higher order outcomes such as the ability to frame and resolve ill-defined problems or the tendency to exhibit intellectual curiosity are rarely directly observable. Although some psychological measures of variables such as curiosity have been developed, these types of outcomes must usually be inferred from students' performance on a range of alternative assessments (Reeves & Okey, 1996).

Aptitude and Individual Differences: Whereas Carroll (1963, 1989) defines aptitude in terms of the time a student requires to learn a task, the new model includes a richer analysis of the characteristics a student brings to a learning environment. The diversity reflected in most college and university populations demands a more complex portrayal. Certainly, aptitude in Carroll's sense is still relevant, but there are numerous other individual differences that should be considered when designing interactive learning environments (Jonassen & Grabowski, 1993). Locus of control, learning styles, anxiety, tolerance for ambiguity, prior experience, interests, attitudes, and disabilities are just a few of the individual difference variables that can be accommodated by improved instructional designs for Web-based interactive learning environments.

Cultural Habits of Mind: Some cultures emphasize rational problem-solving and critique whereas other cultures place more value on normative communication and shared understanding (Hoffman, 1996). The importance of cultural influences on learning has been given increasing attention in higher education in recent years, although relatively few interactive learning environments have been designed to take advantage of cultural differences (Henderson, 1996). Some might argue that cultural diversity is just a passing "fad," a by-product of the current attention to multiculturalism within North American and European universities. Another perspective is that sensitivity to cultural diversity and pluralism is a "meta-value" that should influence virtually every aspect of human activity, including the design and implementation of interactive learning environments. The role of cultural habits of mind in interactive learning is an area of much need of disciplined research.

Origin of Motivation: Two primary forms of motivation are extrinsic (outside the learning environment, e.g., a job if the student graduates) and intrinsic (integral to the learning environment, e.g., intellectual curiosity aroused by a task or problem). Every new educational technology promises to be intrinsically motivating, and the Web is no exception. Intrinsically motivating instruction is elusive regardless of the delivery system, but some proponents seem convinced that the Web will motivate learners automatically, simply because of the integration of music, voice, graphics, text, animation, video, and a user-friendly interface. Others suggest that the learner control afforded by the Web will enhance achievement motivation. The type of motivation affecting the learner is inevitably an important variable in explaining the processes and effects of Web-based learning.

Opportunity to Construct Learning: The debate between instructivist and constructivist approaches to teaching and learning is far from over, but there is considerable evidence that learners learn from opportunities to construct their own knowledge (Jonassen & Reeves, 1996; Kafai & Resnick, 1996). Instructivists stress objectives that exist apart from the learner, sequencing them into learning hierarchies, and subjecting students to direct instruction addressing each of the objectives in sequence. The WWW may be used for direct instruction, but its effectiveness is still unknown (Khan, 1997; Owston, 1997). On the other hand, because constructivists emphasize the primacy of the learner's intentions, experience, and cognitive strategies, the Web may prove to be an even more powerful vehicle for constructivist pedagogy. According to constructivists, learners construct different cognitive structures based upon their previous knowledge and interests. Rather than simply delivering direct instruction, constructivists create learning opportunities around tasks to be accomplished or problems to be solved that have personal relevance for learners. In this approach, the WWW becomes a "cognitive tool" for investigating and representing knowledge. The relative effectiveness of Web sites that have constructivist (tool) structures rather than instructivist (tutorial) ones should be investigated

Task Ownership: Brown, Collins, and Duguid (1989) emphasize the importance of task ownership in situated cognition, i.e., learning that is tied to the retrieval cues in the environments in which the learning will be used. Learning tasks may be primarily academic (writing an essay about the role of women in the Renaissance) or primarily authentic (conducting research on the effects of pollutants on local stream quality). Academic tasks still dominate most higher education courses, regardless of whether the Web is used or not, but the WWW offers faculty and students unique opportunities to focus on authentic tasks. Consider the design of Web sites for science courses. An academic design might depend heavily on having the learners complete traditional academic exercises such as memorizing a table of elements. By contrast, an authentic design might engage the students in practical activities such as analyzing the relationship between chemicals and allergies. Cognitive learning theory indicates that the ways in which knowledge and skills are initially learned affect the degree to which these abilities can be used in other contexts. By emphasizing authentic tasks that students "own" for themselves, web-based instruction can be designed to enhance the transfer of knowledge and skills (Khan, 1997).

Sense of Audience: Surfing the WWW cannot help but lead to an impression that many people regard the Web as a unique means of self-expression. The capacity to share knowledge and creations with anyone anywhere in the world can be harnessed in higher education to give students a powerful sense of audience. This quote from Leon James, a psychology professor at the University of Hawaii, illustrates the sense of audience students may gain from using the WWW as a vehicle for creating and sharing their knowledge:

> In my 25 years of teaching...I have never seen more student enthusiasm and pride for learning than in my course-integrated telecommunications classes. ...In this new medium, students are challenged to find their own voices, to express their own thoughts and feelings in a public and scholarly context. Students see their own writing on the World Wide Web, impressed by the fact that their writings are, in a real sense, "published" and available to millions of browsers. Students are in effect modeling the role of author, scholar, and scientist. They are thus awakened and introduced to intellectual citizenship. (James, http://www.soc.hawaii.edu/~leonj/leonj/leonpsy/leon.html)

Collaborative Support: Collaborative learning refers to instructional strategies whereby learners work together in pairs, small groups, or even large groups to accomplish shared goals. Learners can benefit both instructionally and socially when the WWW is used to structure and guide groupwork. Given an appropriate instructional design, two or more learners working together via the WWW might accomplish more than an isolated learner because the interactions among the learners may have more influence on their learning than the interactions between the learners and the Web-based content. The proliferation of Web-based tools for groupwork make this one of the potentially most powerful factors in this model of interactive learning on the Web. Whereas early developers of interactive learning systems such as computer-assisted instruction concerned themselves with interactions between individual learners and machines, the WWW provides avenues for collaboration that may far surpass the interactive powers of computers alone.

Teacher Support: One of the biggest lies of technology (in addition to the one that technology makes learning effortless) is that technology will eliminate or reduce the roles of teachers. Web-based learning environments can be designed to support a range of roles for teachers from the traditional didactic role of the instructor as "sage on the stage" to the facilitative role as "guide on the side." In 1968, Carroll told us that "By far the largest amount of teaching activity in educational settings involves telling things to students..." (p. 4), and little has changed since then. Part of the problem is that educational technology research continues to be focused on how the computer can be used to present information and judge learner input (neither of which computers do well) while asking learners to memorize information and later recall it on tests (which computers do with far greater speed and accuracy than humans). It is time to assign cognitive responsibility to the part of the learning system that does it best, i.e., the learner (Jonassen & Reeves, 1996). The learner should be responsible for recognizing and judging patterns of information, organizing data, constructing alternative perspectives, and representing new knowledge in meaningful ways; the computer should perform calculations, store information, and retrieve it upon the learner's command; and the teacher should coach or collaborate in the knowledge construction process.

Metacognitive Support: Metacognition refers to a learner's awareness of objectives, ability to plan and evaluate learning strategies, and capacity to monitor progress and adjust learning behaviors to accommodate needs (Flavell, 1979). In short, metacognitive skills are the skills one has in learning to learn. "Metacognitive support" can be designed into Web-based learning environments. For example, a Web site could be designed to challenge learners to solve complex problems such as troubleshooting electrical circuit boards. Metacognitive support integrated into such a site could provide learners with recapitulations of their troubleshooting strategies at any point in the problem-solving process. Much research and development remains before the WWW regularly includes sophisticated metacognitive support, but the potential is enormous.

Agendas for Development and Research

The new model of interactive learning on the WWW described above has several uses. First, consideration of the major input, process, and outcome factors in the model may encourage faculty and developers to conceive new uses of the Web as a learning environment. Most innovations in education are adopted in ways that protect traditional teaching and learning practices (Tyack & Cuban, 1995). The challenge of developing "break the mold" applications of the WWW in higher education is great, but it is being accepted by creative faculty and students around the globe. Hopefully, this model will inspire others to join in this quest.

The potential of the model to promote new research agendas is equally important. Much of the research in educational technology has been atheoretical, e.g., many studies have compared one educational technology with another in the absence of any theoretical framework for understanding how or why different technologies might provide different learning experiences and results for their users. The predominance of analytical experiments unguided by sound, systemic theory renders the vast majority of the research on learning "from" technology of little value, but the WWW provides a unique vehicle for research on learning "with" technology that can have a stronger theoretical foundation (Jonassen & Reeves, 1996). Guided by stronger learning theories and richer instructional models, new research agendas should involve descriptive, qualitative, and developmental as well as experimental approaches. The model described in this paper is a very modest beginning, but every quest starts with the first step.

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