

# **Integration of Simulator Programs into Web-based Curriculum**

**By**

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## **Abstract**

The development of sophisticated computational computer programs; graphic interfaces; and simulators for the design, analysis, and optimization of physical systems has the potential to transform teaching and learning methods. Technological advances do not necessarily transfer into effective teaching and learning without a thoughtful consideration of instructional delivery. A deliberate and careful curriculum design is necessary to incorporate technology into improved learning outcomes.

**Keywords:** simulation, learning outcomes, evaluation, instruction

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## **Introduction**

Computational programs model systems and allow instructors and learners to concentrate on theory and application rather than on mathematical calculations and programming particulars (Bechem, 1999). Instructors teach Microprocessor Architecture and Programming (MAP) in the Electrical and Computer Engineering Department at Christian Brothers University (CBU) to sophomore engineering and computer science students. Students learn to design control systems using an HC11 microcontroller, a programmable single-chip integrated circuit used in controlling many types of equipment ranging from washing machines to laser printers (Spasov, 1999).

This research paper examines the curriculum of Web-based instructional systems that utilize simulation technology to model physical systems. The analysis of the curriculum is based on Stoffebeam's (1995) CIPP Model and consists of four major activities: (a) context – analysis of the target environment and learner's needs, (b) input – series of specifications for effective and suitable learner environment, (c) process – development of learner and management tools related to curriculum, (d) products – evaluation of the outcomes related to curriculum. In addition, Gustafson (1997) adds a fifth activity of examining the curriculum in varied settings over an extended period of time.

## **Context**

Lesh (2000) states that the characteristics of a successful distance learning student include: (a) high literacy, (b) self motivation and belief in success, (c) ability to work alone, (d) goal oriented, (e) self directed, (f) responsible for learning objectives, and (g)

possess a fundamental understanding of programming. The prerequisites for MAP are Calculus I and II, Computers in Engineering Problem Solving, and Digital Design. In addition, students would have taken Chemistry, Physics, Electric Circuits and Differential Equations and possess the same traits described by Baillie (1998) and Lesh (2000) for distance learners. These characteristics of CBU engineering students enable the successful use of educational tools found in distance learning environments.

Instructors teach the operation of the microcontroller on an HC11 evaluation board, a test board that allows students to program the HC11, and a computer simulation program (Harper, 2000), a software program that models the HC11. Students learn to program in assembly language, the operations of the central processing unit, register interaction, memory layout, analog to digital conversion, input/output interfacing, and to design and construct engineering system projects using the HC11 microcontroller as prescribed in the MAP syllabus (Christian Brothers University, 2000). A design component of the curriculum is to meet the needs of industry that requires engineers and programmers that are capable of designing and implementing microcontroller in consumer products (Karapetrovic, 1998).

MAP courses contain 30 to 40 students and meet three times a week for 50 minutes. Instructors lecture for 10 minutes and use stored digital files for an audio/visual presentation of instructional material (Herson, 2000) for the remaining 40 minutes on two days and present instructional material on the use of the simulator on the third day.

Students also attend four labs per semester for two hours to build engineering projects with the evaluation board (Lenschow, 1998).

### **Input**

Spasov (1999) states that the concepts and operations of microcontrollers are the equivalent to the understanding of the operations of a personal computer at the binary level and present a formidable task for learners. Instructional delivery for the MAP course contains two educational components: an instructivist component, based on elaboration theory, utilizes well-organized instructional material and step-by-step instruction in increasing order of complexity (Jackson, 1995; Parker, 1993); and a constructivist component, based on situated learning theory, introducing activity, perspective, collaboration, opinion, and reflection (Artemeva, 1999; Herrington, 2000; Khan, 2000; Land, 2000).

The instructivist component regulates the cognitive load to optimize learning outcomes (Kashihara, 2000) using the simulation program. Instructors teach the editing, assembling, simulating, and debugging programs using the simulation program in a lecture environment, rather than a laboratory environment, thus maintaining control of instructional delivery. The simulator program models the operations of the microcontroller, allowing the student to test their assembly language programs before attending lab.

The constructivist component, using the simulation program and evaluation board, provides: (a) real world environment – students are programming, testing, and designing control systems for a digital voltmeter or alarm clock; (b) students work as teams to complete projects in one to two week time frames; and (c) students have access to sophisticated modeling systems—such as elevator and traffic signal controllers (Herrington, 2000).

Selected categories of instructional material, as well as some learners (McClanaghan, 2000), fit instructivist formats, while other instructional materials, as well as learners, fit constructivist formats. Complicated design problems may require instructional material that requires instructivist and constructivist components, and then the instructional process is cyclical. A cyclical instructional process for a complicated design problem that requires several levels of knowledge would proceed as follows: first, the design problem is presented in a relevant setting with direct instructions for procedural advancement in the learning process, and the learner proceeds in carrying out these direct instructions to facilitate and advance in level of knowledge; second, the learner is presented with open-ended and challenging instructions and encouraged to collaborate, reflect and voice opinions on the design problem and demonstrate an advancement in level of knowledge; and third, steps one and two of the process are repeated until the learner obtains the desired learning outcomes and the system is designed.

The Web-based environment and computer modeling expose the students to a high-level perspective of the use of controllers. Further, the simulator allows students to reflect,

collaborate, and articulate the research methodology with fellow students (Herrington, 2000). In addition, the Web-based environment enables coaching and scaffolding for students by instructors and provides a continuous assessment of student learning (Lesh, 2000). The MAP curriculum also contains other important features: (a) learning is the center of activity; (b) learning is in small groups, although some students take the course alone online; (c) instructors are facilitators; (d) the learning is problem and design oriented; (e) design problems lead to the development of problem-solving skills; and (f) learning skills are developed through self-directed learning (Land, 2000).

### **Process**

The object of the MAP curriculum is to teach the operation and design concepts of microcontrollers. The MAP curriculum utilizes the THRSim11 (Broeders, 2001), a microcontroller simulation program, and WebCT (WebCT, 2000), an online course management program.

Harry Broeders (2001) developed the THRSim11 to operate in a windows environment and students learn to edit, assemble, simulate, and debug programs for the HC11. It also simulates evaluation board peripherals such as timer operations, analog to digital conversion, and parallel and serial port input/output operations. The THRSim11 permits the attachment of simulated external components, such as LED's switches, analog sliders, and serial transceivers (Chapman, 1999). Students form peer groups to design systems with the THRSim11 and evaluation board to enhance learning outcomes (Foote, 1998).

WebCT is a sophisticated Web-based software program that allows custom course presentation (WebCT, 2000): timed assignments, bulletin boards, chat rooms, e-mail, hyperlinks, and course dependent passwords for the instructor and students (Lesh, 2000). The distribution of partial notes using viewgraphs, as described by Potts (1993), provide definition, elaboration, and enhance learning outcomes.

### **Products**

School-wide evaluation forms measure student reaction to instructor performance and learning outcomes (Sailor, 1997). A WebCT specific evaluation form measures student response to Web-based teaching and managerial methods. Evaluation surveys, as described by Kolitch and Dean (1999, contain: (a) instructor encouragement of students to express ideas, (b) student co-creation of curriculum, (c) curriculum that reflects the identities of a diverse group, (d) caring behavior of instructor, (e) response to student needs, (f) historic content of subject materials, (g) cooperative learning, (h) intellectual rigor, (i) student responsible for learning, and (j) social justice. In addition, evaluation persona, as described by Owlia and Aspinwall (1998), contain quality measurements of tangibles, such as equipment, access, and support services; competence of instructor; attitude of instructor; delivery, such as presentation, consistency, and fairness of examinations; and reliability of instructor with respect to trustworthiness, promises, complaints, and solving student problems.

The Accreditation Board of Engineering and Technology (ABET) accredits CBU's electrical engineering program and ABET criteria, available at <http://www.abet.org/>, for

engineering curriculum is maintained and improved. Besterfield-Sacre et al. (2000) discuss the new learning outcome guidelines, which became effective beginning with the 1999-2000 school year, for maintaining ABET accreditation. The guidelines form an evaluation framework based on Bloom's taxonomy on the following learning outcomes: (a) ability to apply knowledge acquired, (b) ability to conduct experiments, (c) ability to design systems, (d) ability to formulate and solve problems, (e) understand professional responsibility, (f) ability to communicate, and (g) understand engineering problems in a global context (ABET, 2000).

### **Recommendations and conclusions**

Future studies will include an examination of instructional delivery using simulator computer programs in a Web-based teaching environment over varied sets of instructors, students, and computer-aided technologies to improve instructional design and learning outcomes (Gustafson, 1997). Long-term studies enable the development of design problems with a recognized group of students, instructors, resources, and community and provide for effective learning cycles.

The MAP curriculum utilizes learning theory and the systematic design of instructional content in incorporating computational technology in instructional delivery to enhance learning outcomes. The instructor assumes the role of a facilitator, serving as a cognitive coach by monitoring, probing, and challenging students (Berg, 2000). Tornkvist (1998) suggests that engineering curriculum contain: modern educational theory; humanistic

attitudes by instructors; problem based learning; sociology, history of technology, and anthropology; and experienced instructors who do not do research.

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