# Initial Experiences Using an Interactive Classroom Participation System (CPS) for Presenting the Iron Cross Biomechanics Module

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## Abstract

The Classroom Participation System (CPS) is an interactive, computer-based instructional tool that allows the instructor to poll the class on important topics during a live lecture. Each student is issued a handheld responder that looks like a television remote-control device. The faculty member can pose a multiple-choice question to the class during a lecture, and each student in return presses a button corresponding to their answer to the question. Using a classroom computer or laptop hooked up to a projector, the CPS registers all the responses to the question, calculates class data, and then projects it onto the screen. This paper reports some initial classroom experiences using the CPS during a one-hour lecture on the biomechanics of the Iron Cross gymnastics maneuver. The lecture was presented in a series of Powerpoint slides. Interweaved between the slides were ten different questions posed with the CPS in place. After the initial lecture, the class performed an individual homework problem related to calculating the muscle strength needed to hold the Iron Cross position. Then a week later the Powerpoint lecture was repeated and the same CPS data were gathered as a post-test measure. In addition, survey questions were asked concerning student attitudes towards using the CPS live in the classroom environment.

## Introduction to the Iron Cross Module

The Iron Cross (IC) challenge is "What muscle strength is needed for an athlete to hold this position?" with a picture of the iron cross position shown (see below Figure 1). The challenge is implemented through a series of Powerpoint slides. The original idea came from Professors Bob Roselli and Sean Brophy at Vanderbilt University. Professor Ron Barr modified the module to a set of 42 Powerpoint slides, and embedded ten class questions in the show in preparation for the CPS system.

The Iron Cross (IC) slide presentation follows the "How People Learn" (HPL) Legacy Cycle[1,2] approach to education that has been popularized by the NSF VANTH bioengineering education coaltion.[3] It starts by presenting the *Challenge* and then encourages students to *Generate Ideas* about possible solutions to the problem. *Multiple Perspectives* from experts in the field are then presented. For this IC challenge, the students receive perspectives from a surgeon, a mechanical engineer, a sports physical therapist, and a biomedical engineering graduate student. The students also see a video of an amateur gymnast who attempts the Iron Cross maneuver.

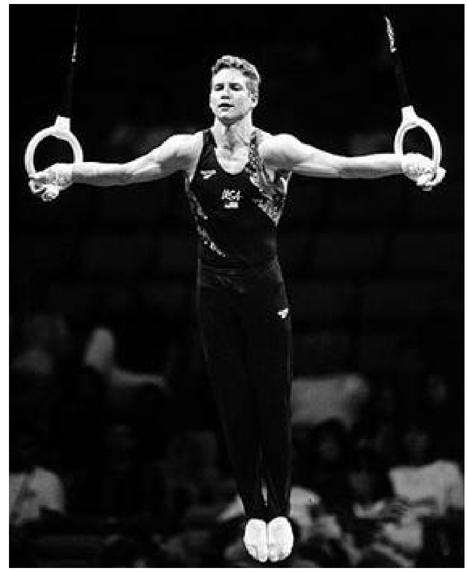

**Figure 1:** The Iron Cross Position.

The students next conduct a *Research and Revise* phase of the Legacy Cycle. The students study potential muscles that are involved in the Iron Cross, which leads to one of the CPS in-class questions (see Figures 2 and 3). They next are asked to formulate a free body diagram (FBD) of the forces and moments generated at the shoulder joint during the IC position. This compels them to think about the mechanics of the position and leads to another CPS question (Figures 4 and 5) concerning the correct free body diagram.

These early research and revise exercises ultimately lead to a major concern about the IC problem, namely the static equilibrium condition that is caused by multiple muscle actuators across the shoulder joint. Thus, the students must make some initial assumptions, such as equal stress in all muscles or each muscle is activated to its maximum force. To test their assumptions, the students are encouraged to make some initial calculations of the forces at the shoulder joint. They are given anthropometric data about the shoulder (Figure 6), such as muscle origin and insertion points. They are then presented with an initial formulation of the problem (Figure 7).

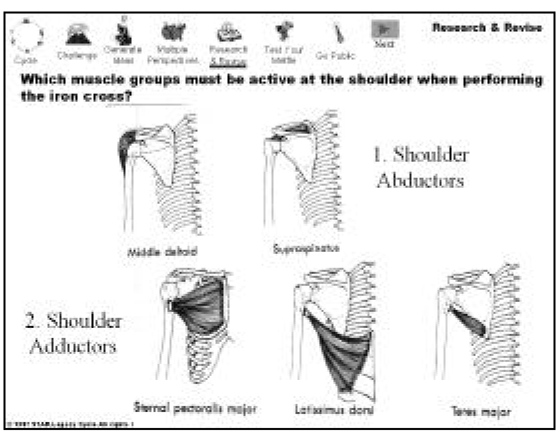


**Figure 2**: Shoulder Muscles.

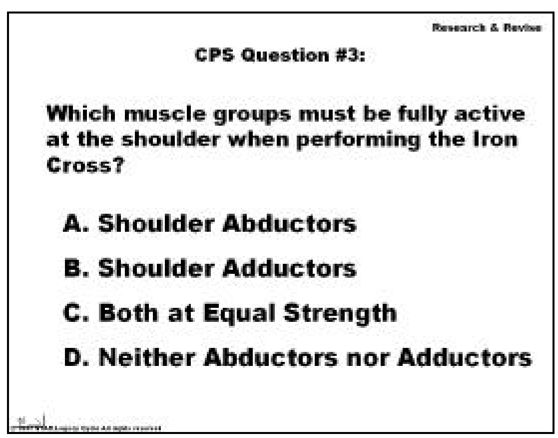


**Figure 3:** CPS Question About Shoulder Muscles.

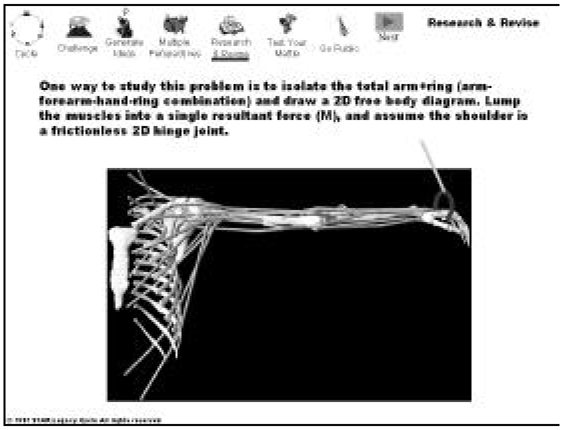


**Figure 4**: The Free Body Diagram (FBD) Problem.

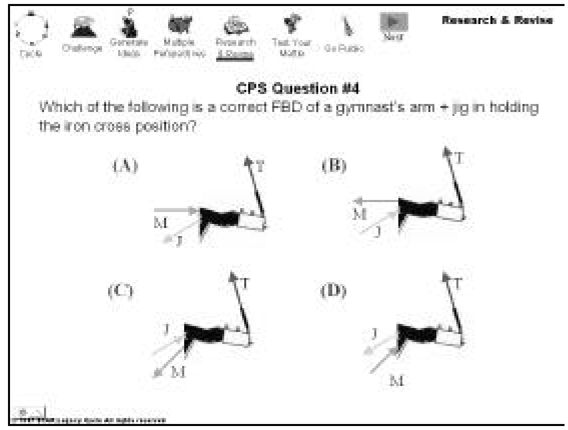


**Figure 5:** The CPS Question About the FBD.

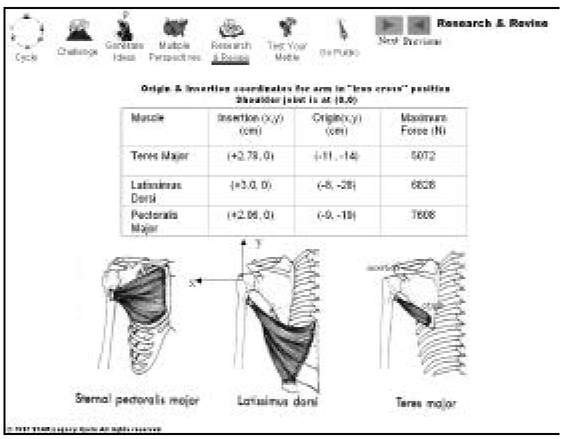


**Figure 6**: Anthropometric Data About the Shoulder Muscles.

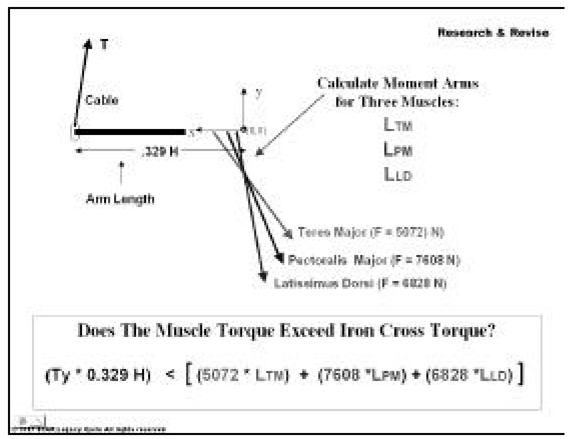


**Figure 7**: Initial Formulation of the Problem.

After the formulation of the simplified problem, the biomechanical complexities of the Iron Cross are explored in depth. As can be seen in the initial problem formulation (Figure 7), the concept of a moment arm is crucial to understanding the biomechanics of the Iron Cross module. The students notice that muscle moment arm is a function of the angle the arm makes with the vertical position. They review moment arm versus angle curves, and muscle force versus length curves. Incorporating this new data into the solution, the students conclude with the *Test Your Mettle* phase of the Legacy Cycle, which constitutes the homework assignment (see Testing the Iron Cross Module section).

## The "Biomechanics of Human Movement" Class

The course ME 354M, "Biomechanics of Human Movement," is an undergraduate technical block elective in Mechanical Engineering for students who want to specialize in the Biomechanical Area of ME. In the Fall 2002 semester, twenty-eight students were enrolled in the course. Twenty-five of the students were ME undergraduates, two were natural science undergraduates, and one student was an ME graduate student. The course is taught in a traditional format with chalkboard lectures, some use of overhead transparencies, and a few handouts are distributed as needed. There is no required textbook for the course and the primary lecture content has been prepared over the years by the first author. The major lecture topics covered in the course include:

1. Musculoskeletal Physiology and Anthropometrics;
2. Analysis and Simulation of Human Movement;
3. Biomechanical Systems and Control;
4. Computer Graphics Modeling in Biomechanics; and
5. Experimental Techniques in Biomechanics.

In the Fall 2002, several new teaching strategies and methodologies were tested in this ME354M course. One of these strategies was the use of the CPS in presenting the Iron Cross module.

## The CPS System

The Classroom Participation System (CPS) is an interactive, computer-based instructional tool that allows the instructor to poll the class on important topics during a live lecture. Each student is issued a handheld responder that looks like a television remote-control device. The faculty member can pose a multiple-choice question to the class during a lecture, and each student in return presses a button corresponding to their answer to the question. Using a classroom computer or laptop hooked up to a projector, the CPS registers all the responses to the question, calculates class data, and then projects it onto the screen. Typically, this can be conveyed in the form of a bar chart showing the number of responses to answer A, B, C, or D. The students can then instantly see how their answer corresponded to their classmates' answers. The correct answer can be discussed and the students gain valuable feedback, essentially in real-time. The instructor can also save the data gathered during a CPS session for further study and analyses. It also can help the instructor identify and improve the content of topics that are difficult.

## Testing the Iron Cross Module

Before the Iron Cross module was presented, the instructor handed out a reflective activity sheet in class with some probing questions that the students should study. This was intended to get them to think about the biomechanics of the Iron Cross maneuver and to think about which muscles are involved. At the beginning of the next class, the students were issued a hand-held personal responder for the CPS experiment. The student's name and responder number were logged on a sheet, but during on-line usage, the CPS responses were anonymous. The instructor presented 42 Iron Cross Powerpoint slides, stopping at each one of the ten multiple-choice questions when they appear. The CPS was active during the lecture and when a question was encountered, the student responded to their chosen answer (A, B, C, D, etc.) by pressing the appropriate key on the hand-held device. The whole class response was then immediately displayed on a bar chart on the screen, and the data were saved. This set of data was deemed the Pre-Test data. The slides were continued until the Powerpoint lecture was completed. The whole process took about 45 minutes.

The homework was then assigned. It consisted of accessing the IC slide show on the website at at http://pro.engr.utexas.edu/ with simple user name and password protection. They used information on the slides to solve the IC homework challenge (see Figure 8 below).

Assignment: Tim can lower his body down until his arms reach a critical angle of 50 degrees. What is the maximum torque his shoulder adductors can generate at this position? Based on this performance, at what hook position (1" intervals) on the "jig" from the distal end could he hold the standard Iron Cross position? Tim's total arm length is 23". Tim's weight is 160 lb, neglect weight of arm.

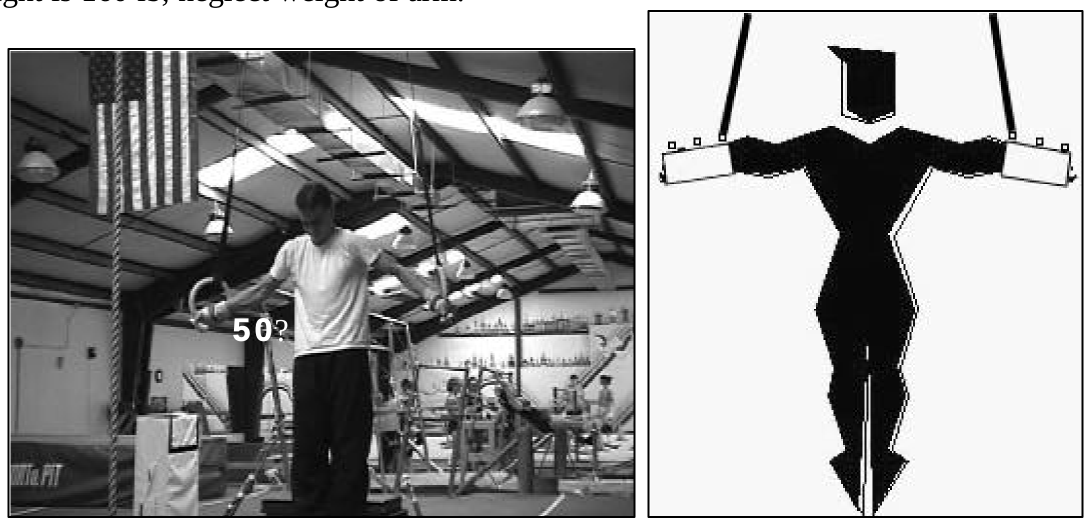


**Figure 8:** The Iron Cross Homework Assignment.

One week later, they submitted the completed assignment in class. The students were re-issued the same numbered personal responder for the CPS system. Then the instructor repeated the same IC slide show and asked the same ten questions again. The class responses were immediately displayed as a bar chart on the screen and the data were saved in the computer. This set of data was deemed the Post-Test data. The TA then graded the assignment for all students using a common key and the assignment scores were recorded.

## Results of the Iron Cross Study Using the CPS

The main investigation focused on two areas: 1. class performance on the Pre- and Post-Tests, and 2. students' attitudes about using the CPS system. After the fact, two of the ten questions were deemed to have multiple correct answers (or least different correct opinions), so they were not scored. The remaining eight questions were scored for correctness across all subjects. The results of the Pre- and Post-Test scores are shown in Table 1 for each of the students based on their responder numbers. As can be seen, the average class score went from a 67.6 percent Pre-Test score to 81.0 percent Post-Test score. Next, the Pre- versus Post-Test score for each student was plotted and is shown in Figure 9. As can be seen, most but not all, of the students improved their score. For example students 3 and 25 scores went down, and several student scores stayed the same.

| **Table 1:** Results of IC Questions Using CPS. | | |
|---|---|---|
| **Responder Number** | **Pre-Test (% correct)** | **Post-Test (% correct)** |
| 01 | 62.50 | 62.50 |
| 02 | 62.50 | 87.50 |
| 03 | 87.50 | 75.00 |
| 04 | 87.50 | 87.50 |
| 05 | 75.00 | 75.00 |
| 06 | 75.00 | 75.00 |
| 07 | 62.50 | 75.00 |
| 08 | 75.00 | 87.50 |
| 9 | 75.00 | 87.50 |
| 10 | 62.50 | 87.50 |
| 11 | 75.00 | 75.00 |
| 12 | 50.00 | 87.50 |
| 13 | 87.50 | 87.50 |
| 14 | 50.00 | 75.00 |
| 15 | 75.00 | 87.50 |
| 16 | 62.50 | 87.50 |
| 17 | 75.00 | 87.50 |
| 18 | 40.00 | 75.00 |
| 19 | 87.50 | 87.50 |
| 20 | 62.50 | 87.50 |
| 21 | 50.00 | 75.00 |
| 22 | 50.00 | 100.00 |
| 23 | 50.00 | 75.00 |
| 24 | 75.00 | 75.00 |
| 25 | 75.00 | 62.50 |
| Average | **67.60** | **81.00** |

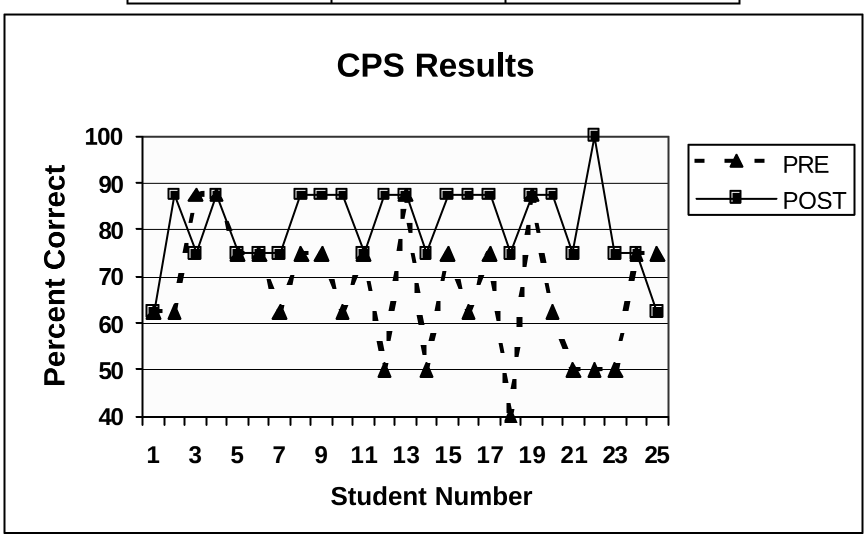


**Figure 9:** Plot of Pre- and Post-Test Results of CPS.

The CPS Post-Test score was also plotted versus the IC homework grade and is shown in Figure 10. There does not appear to be much correlation between the homework assignment grades and the Post-Test scores. For example, the two students who had the lowest CPS Post-Test scores (62.5%), actually had homework grades above the median score of 23.3. Further, the highest Post-Test score (100%) had a homework grade below the median. Thus it is unclear if the CPS system can be used for testing and grading purposes, per se.

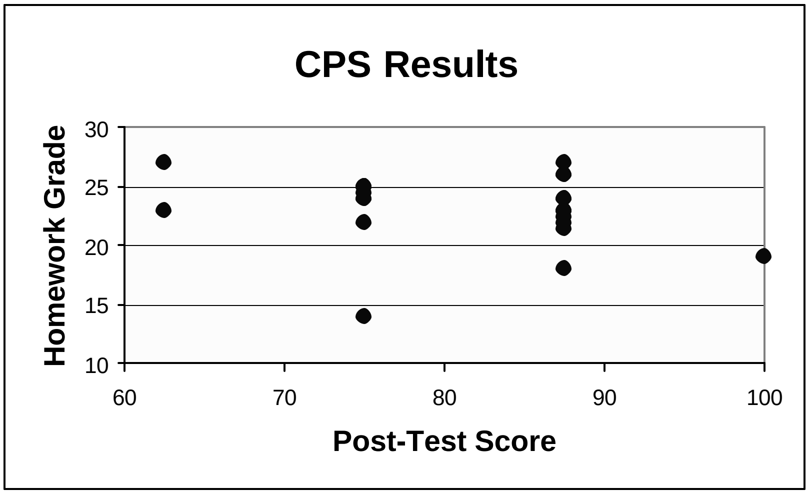


**Figure 10:** Comparison of Homework Grade with Post-Test Score.

A survey form was created to measure the students' impressions about using the CPS in class. The survey form posed ten statements about the CPS and asked the students to rate each statement from 1 (strongly disagree) to 5 (strongly agree). The results of the survey are shown in Table 2 and in the bar chart of Figure 11.

**Table 2:** Results of the Student Survey Concerning CPS.

| No. | Statement Concerning CPS | Rank |
|---|---|---|
| **1.** | Overall, I thought the Classroom Participation System (CPS) worked well in the class. | 4.48 |
| **2.** | Results from CPS questions stimulated me to think more about the problem. | 4.19 |
| **3.** | Seeing others' responses to CPS questions helps me to clarify my own ideas. | 3.74 |
| **4.** | The CPS system makes me pay closer attention to what is being presented in class. | 4.26 |
| **5.** | I like the CPS system because it is anonymous. | 4.27 |
| **6.** | The CPS system worked well with the Powerpoint slide lecture. | 4.48 |
| **7.** | The CPS system technology was easy to understand and use. | 4.74 |
| **8.** | The CPS system could be used for taking on-line quizzes in class. | 3.77 |
| **9.** | The CPS system is a better way to present the material than regular chalkboard lectures. | 3.30 |
| **10.** | The CPS system would be useful in many of my other engineering classes. | 3.70 |

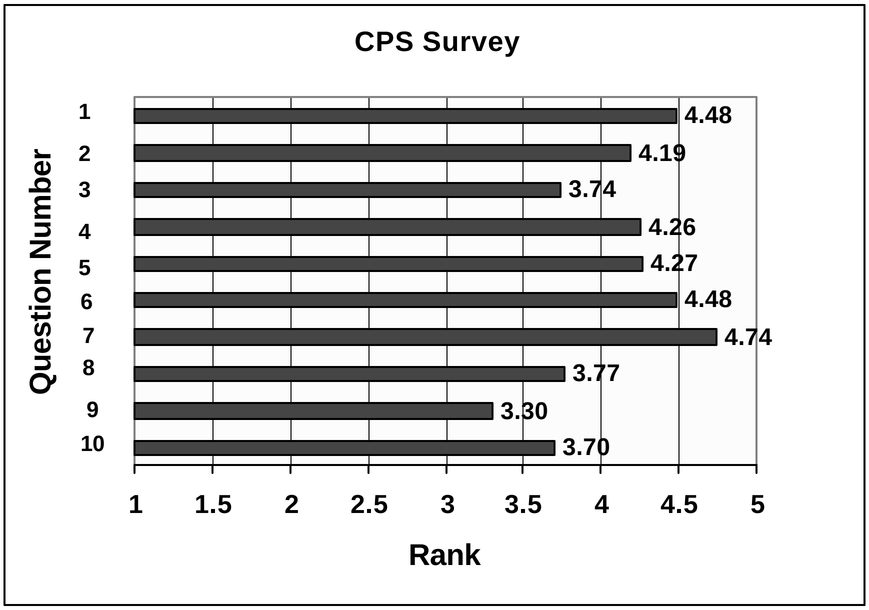


**Figure 11:** Results of CPS Survey (Question Numbers refer to Table 2).

In general, the students liked the CPS experience. Six out of ten questions were ranked above 4.0 (Agree). They particularly agreed that the CPS technology was easy to understand and use, and that it went well with the Powerpoint slides method of presenting the lecture (questions 7, 6, 1). On the other hand, they were not convinced that CPS and Powerpoint were necessarily better ways to present material than chalkboard lectures (question 9) nor would it necessarily work well in their other engineering classes (question 10).

## Conclusions

The Iron Cross biomechanics module is an effective challenge for engineering students. It sequentially probes deeper into the complexity of the musculoskeletal system in solving static equilibrium problems. Fundamental knowledge of engineering mechanics, coupled with empirical physiological data, are integrated to formulate and solve the problem. Indeed, there is a certain open-ended nature to the problem that some students liked, while others did not like it.

In testing the IC module, it was clear that the students' liked the use of the CPS system. They found the technology easy to use and they agreed that the IC Powerpoint slides can be effectively presented with this new classroom technology. Perusal of the survey results of Figure 11 clearly supports this contention, since all ten questions were ranked above the median score of 3.0 (neutral agreement).

In comparing the Pre-Test and Post-Test CPS results (Figure 9), a general improvement in scores is seen across the class, although it is not all uniform. In contrast, there appears to be very little correlation between the CPS Post-Test score and the IC homework grade. Consequently, it is not clear if the CPS was used appropriately in this case as an educational research tool, and more thought needs to be given on how to use CPS to gather meaningful educational research data.

## References


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2. Schwartz D.L., Brophy S., Lin X., and Bransford J.D. (in press). "Software for managing complex learning: Examples from an educational psychology course." *Educational Technology Research and Development.*

3. Harris, T.R., Bransford, J.D. and Brophy, S.P. (2002): Roles for Learning Sciences and Learning Technologies in Biomedical Engineering Education: A Review of Recent Advances. *Annual Review of Biomedical Engineering,* 4: 29-48.


## Biographical Sketches

**Ronald E. Barr** is a Professor of Mechanical Engineering at the University of Texas at Austin, where he has taught since 1978. He received both his B.S. and Ph.D. degrees from Marquette University in 1969 and 1975, respectively. His research interests are in Biosignal Analysis, Biomechanics, and Engineering Computer Graphics. Barr is the 1993 recipient of the ASEE Chester F. Carlson Award for innovation in engineering education. Barr is a Fellow of ASEE and a registered Professional Engineer (PE) in the state of Texas.

**Justin Cone** develops multimedia and internet applications for The University of Texas' Faculty Innovation Center. Justin has five years experience with various forms of new media as both a designer and a producer. He received his B.A. in English-Creative Writing from the University of Houston.