

# The Use of a Web-Based Classroom Interaction System in Introductory Physics Classes

Edgar D. Corpuz, Ma. Aileen A. Corpuz and Rolando Rosalez

*Department of Physics and Geology, The University of Texas-Pan American  
1201 W. University Drive, Edinburg, TX, 78539*

**Abstract.** A web-based interaction system was used in algebra-based and calculus-based physics classes to enhance students' classroom interaction. The interactive teaching approach primarily incorporated elements of Mazur's Peer Instruction and Interactive Lecture Demonstration. In our implementation, students used personal digital assistants (PDAs) to interact with their instructor during lecture and classroom demonstration. In this paper, we document the perceptions and attitudes of algebra-based and calculus-based physics students towards the interactive teaching approach and likewise present data on how this approach affected students' performance on the Force Concept Inventory (FCI).

**Keywords:** interactive teaching approach, web-based interaction system, physics education research

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## INTRODUCTION

The use of polling systems that allow students to respond to multiple-choice type of question has started to proliferate in physics classes. Non-electronic polling system like flashcards [1,2] as well as electronic voting systems like "clickers" [3,4] have been used to enhance the interactivity of lectures in large-enrollment physics classes. The earlier version of electronic polling system was hard-wired in the classroom [5]. Recently, the use of hand-held computers like the personal digital assistants (PDAs) has gotten the attention of instructors because they have different affordances. For example, PDAs offer more flexibility in engaging students in the classroom because it provides for two-way communication between the instructor and the students. The PDA allows students to ask questions by typing on their keypads through a web-based system like the K-State InClass [6].

In this study, we investigated the perceptions and attitudes of students enrolled in introductory physics classes in a predominantly Hispanic institution regarding the implementation of a web-based interaction system using personal digital assistants (PDAs) as interaction devices. In addition, we also investigated how the interactive teaching approach affected students' conceptual understanding as measured by the Force Concept Inventory [7].

## METHODOLOGY

The interactive teaching approach using personal digital assistant (PDAs) as interaction devices was implemented in two algebra-based ( $n=72$ ) and two calculus-based physics classes ( $n=46$ ) to investigate students' attitudes and perceptions of the teaching approach. In investigating the perceptions and attitudes of students, a likert-scale survey was administered around the third quarter of the semester. The survey consisted of items that probed students' perceptions on the ease of use of the system and the usefulness of the PDA system for engaging students in learning as well as their attitude towards the teaching approach.

In looking at how the interactive teaching approach affects students' learning, the FCI was used as a pretest and posttest. The pretest was administered during the first week of the semester while the posttest was administered during the last week of the semester.

### The Web-Based Interaction System

The web-based interaction system used in the study was developed at Kansas State University. This web-based software has an instructor interface and a student interface that interact with the server and the instructor computer using a wireless network as shown in Figure 1.

The instructor begins an *InClass* session and students log in using their personal digital assistants (PDAs). Anytime after students have logged in they are able to send a question or comment to the instructor either anonymously or by name. The instructor checks her/his computer periodically during the lecture to find any questions or comments that have been submitted and responds to them accordingly.

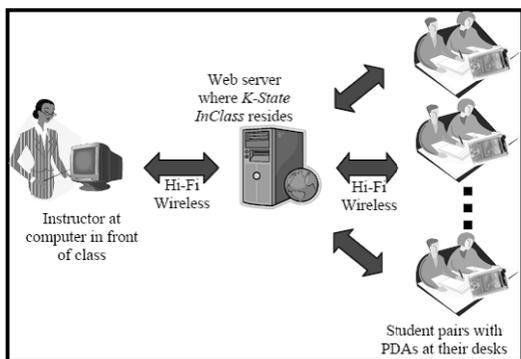


FIGURE 1. The K-State InClass System.

### The Implementation of the Interactive Teaching Approach

At the beginning of each class, students pick up their PDAs in front of the classroom and log into the system. Figure 2 shows how an interactive lecture is typically conducted with the use of the web-based system. The instructor provides a series of short lectures (about 5 minutes each) and offers questions to the students (after each mini-lecture) for them to discuss and answer with their group members. They send their consensus answer to the questions offered through the PDAs. Questions were either multiple-choice or open-ended (numerical problem solving or short answer question) question type. The aforementioned approach is an adaptation of Mazur's Peer Instruction [2] but instead of using flashcards we used Wi-Fi enabled PDAs as interaction devices.

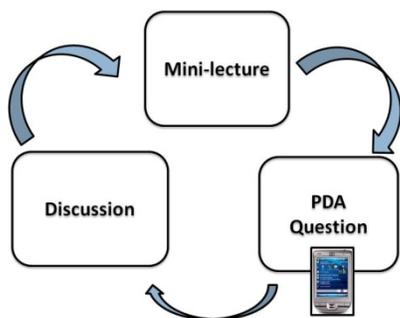


FIGURE 2. Typical implementation of the interactive teaching approach.

Another variation of our implementation is depicted in Figure 3. In this process, the instructor would present a demonstration activity to the students and would ask them to predict the outcome and share their predictions with the other members of their group. The students will then type in their predictions through their PDAs and send to their instructor. The instructor would either show students' predictions through the projection screen or read them out. The instructor would then continue with the demonstration and students would subsequently be asked to explain their observation. Students are further encouraged to share their explanations to their group members and come up with a consensus answer which they share with their instructor and classmates by typing it in through their PDAs. The instructor will proceed with the mini-lecture and subsequently offer a conceptual or problem-solving question which students are expected to answer.



FIGURE 3. Interactive lecture demonstration implementation with web-based interaction system.

### DATA AND RESULTS

Table 1 shows the perception and attitude of introductory physics students towards the use of an interactive teaching approach using PDAs as interaction devices. A one-way analysis of variance (ANOVA) was done to test the difference in the mean ratings of the student groups in the different items in the survey. It can be seen from the table that in terms of the "Ease of Use" the algebra-based and calculus-based physics students had a high mean rating of 4.6 with at least 93% of the students surveyed either agreeing or strongly agreeing that the PDAs are easy to use and the InClass software is user-friendly. Also, from the same table, it can be seen that the calculus-based physics students have a significantly ( $p < .05$ ) higher mean rating for the following survey items compared to the algebra-based physics groups under the "Usefulness of PDAs for Engaging Students" category: (a) the use of PDAs increases my interest to

learn in class, (b) PDAs allow me to participate more actively in class, and (c) class is more enjoyable with the use of PDAs. Meanwhile, under the “Attitude Towards the Teaching Approach” category, a greater percentage of the calculus-based physics students would like continuous use of PDAs throughout the semester.

Overall, all the groups of students had a favorable perception on the usefulness of the PDA system in engaging students and had a positive attitude towards the interactive teaching approach with at least 70% of the students either agreeing or strongly agreeing with the survey statements.

In addition, the most mentioned features of the web-based interactive system that students like include: (1) the comment box on the PDA screen which allows students to type in comments/questions

directly sent to the instructor’s user screen, and (2) the question and answer feature which encourages students to be actively involved in the class. Below are representative comments from the students:

- ”I can ask questions anonymously since I am shy.”
- ”Feature most liked is to ask questions thru PDA and not be hesitant to ask. Some students don’t like to ask aloud for fear of looking dumb or not right to ask.”
- ”Comment box really useful, encourages us to ask questions.”
- ”I have learned and have more interest in class using the PDA.”
- ”It is best to use the PDA in classes; helps me understand better.”
- ”Good idea; involves students; encouraging for us to ask questions anonymously.”

**TABLE 1.** Students’ perceptions and attitudes towards the web-based interactive system

Survey Items (1=strongly disagree; 5=strongly agree)	Algebra-Based (WeightedAverage) <sup>+</sup>	Calculus-Based (Weighted Average) <sup>+</sup>
<b>Ease of Use</b>		
• I find the PDAs easy to use in class.	4.6 (96%)	4.7(93%)
• The software that enables us to answer questions on the PDAs is user-friendly.	4.6 (97%)	4.6(93%)
<b>Usefulness of PDAs for Engaging Students</b>		
• The use of PDAs increases my interest to learn in class.*	3.8 (61%)	4.3 (91%)
• The use of PDAs allows me to participate more actively in class.*	4.1 (77%)	4.5 (91%)
• Responding to questions in class using the PDAs is effective in helping me learn.	4.0 (76%)	4.3 (83%)
• The class is more enjoyable with the use of PDAs.*	4.1 (70%)	4.6 (91%)
• I fully participate during PDA sessions.	4.4 (84%)	4.6 (96%)
<b>Attitude Towards The Teaching Approach</b>		
• I would like to use the PDAs in class throughout the semester.*	4.1 (73%)	4.5 (91%)
• I like the teaching approach where questions are interspersed throughout the lecture and answered through the use of PDAs.	4.2 (80%)	4.3 (83%)
• Interacting with other students while discussing the questions in class is very helpful to my learning.	4.4 (83%)	4.5 (89%)
• I would like my science classes to use the PDAs to answer questions in class.	4.0 (71%)	4.3 (80%)

<sup>+</sup>Number in parenthesis shows the percentage of students agreeing or strongly agreeing about the statement

\* p value < .05

In investigating the effectiveness of the teaching approach in promoting conceptual understanding among introductory physics students, a pretest-posttest comparison group design was used. The experimental group was taught with Mazur’s peer instruction and a variant of Sokoloff’s interactive lecture demonstration [8] using PDAs as classroom interaction devices. The comparison group was taught by the same instructor using traditional lecture. The FCI was used to measure students’ conceptual understanding which was administered during the first week (pretest) and last week (posttest) of the semester. Table 2 shows the descriptive analysis of the mean gain scores of the experimental and comparison group.

The t-test for independent sample means for the pretest scores showed that  $t(35) = 0.463$ ,  $p = .646$  which implies (at .05 confidence level) that there’s no significant difference between the pretest mean scores of the experimental (30.50%) and the comparison group (24.83%). The t-test (independent sample means) of the posttest means scores yielded  $t(35) = -3.166$ ,  $p = .003$  implying (at .05 confidence level) that there is a significant difference between the posttest mean score of the Experimental Group (51.50%), with that of the Comparison Group (32.35%).

It can be seen from the independent samples t-test table that  $t(35) = 4.209$ ,  $p = .0001$ . This implies that at .05 confidence level, there is a significant difference in

the mean gain scores between the experimental (21.00%) and comparison (3.92%) group. It can be concluded that the students taught with the interactive teaching approach using PDAs as interaction devices performed significantly better than those students taught using traditional lecture. This finding is consistent with the results of previous research that increased involvement of students in the classroom promotes the acquisition of better conceptual understanding [1,2,3,5].

**TABLE 2.** t-test of Independent Samples (Gain Scores)

	Experimental*	Comparison*
Pretest Scores Mean	30.50%	28.43%
Posttest Mean Score	51.50%	32.35%
Mean Gain Score	21.00%	3.92%
n	20	17
Std. Deviation	12.89%	11.56%
df	35	
t	4.209	
Sig. (2-tailed)	.0001	

\*Students in each group are enrolled in the first sequence of introductory calculus-based physics.

Furthermore, the FCI data for the calculus-based physics class was compared with that of the algebra-based physics classes taught using the same interactive teaching approach. Both classes were taught by the same instructor. The t-test for independent samples of the pretest scores showed that  $t(58) = 1.563$ ,  $p = .123$  implying that there is no significant difference (.05 confidence level) between the pretest scores of the algebra-based students (24.50%) and the pretest scores of the calculus-based students (30.50%). The t-tests for the posttest scores  $t(58) = 1.723$ ,  $p = .121$  show that there is also no significant difference on the mean scores of the algebra-based students (43.83%) and the calculus-based students (51.50%). Moreover, the t-test for the gain scores (Table 3) shows that there is no significant difference between the gain scores of the two groups,  $t(58) = 0.572$ ,  $p = .569$ . The above results suggest that the interactive teaching approach using the PDAs does not seem to favor any student group.

**TABLE 3.** t-test Independent Samples (Gain Scores)

	Algebra-Based	Calculus-Based
Mean Gain Scores	24.50%	30.50%
Posttest Mean Score	43.83%	51.50%
Mean Gain Scores	19.33%	21.00%
n	40	20
Std. Deviation	9.34%	12.89%
df	58	
t	.572	
Sig. (2-tailed)	.569	

## CONCLUSION

Overall, the use of an interactive engagement teaching approach using personal digital assistants (PDAs) as classroom interaction devices seems to promote positive learning attitudes among majority of life science, physical science, and engineering students and is more effective than traditional lecture in promoting conceptual understanding among physics students as measured by a standardized exam (e.g. FCI). Engineering majors perceive that the use of PDAs increases their interest to learn and seem to enjoy the use of PDAs more than science majors. Further study is needed to determine the relative effectiveness of an interactive teaching approach using PDAs as interaction tool versus an interactive teaching approach using other polling tools like clickers or flashcards in improving the conceptual understanding of students.

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