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The Effects of the Classroom Performance System on Student Participation, Attendance, and Achievement

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The Classroom Performance System (CPS) is an instructional technology that increases student performance and promotes active learning. This study assessed the effect of the CPS on student participation, attendance, and achievement in multicultural college-level anatomy and physiology classes, where students' first spoken language is not English. Quantitative method and quasi-experimental design were employed and comparative statistic methods and pre-post tests were used to collect the data. Participants were college students and sections of study were selected by convenience sampling. Participation was 100% during most of the lectures held while it did not strike above 68% in the control group. Attendance was significantly higher in CPS sections than the control group as shown by paired- samples t-tests. Experimental sections had a higher increase in the pre-post test scores and student averages on lecture exams increased at a higher rate than those of the control group. Therefore, the CPS increased student participation, attendance, and achievement in multicultural anatomy and physiology classes. The CPS can be studied in other settings where the first spoken language is English or in other programs, such as special education programs. Additionally, other variables can be studied and other methodologies can be employed.

The Classroom Performance System (CPS) is a low-cost radio-frequency instructional technology developed by eInstruction Corporation with an underlying goal "to elicit feedback or responses from a live audience in a classroom" (Gill, Myerson, & El-Rady, 2006, p. 2). Similar systems with different names based on the manufacturers that make them are included in current literature. Some of the names are group response system, student response system, audience response system, audience voting system, classroom communication system, classroom response system, electronic response system, and personal response system (Gill et al., 2006; Han, 2006). In order to use the CPS in classroom, an instructor needs three main things: (a) response pads (i.e., clickers), (b) a receiver, and (c) CPS software. Students use the response pads, which have the same role as that of the remote controls; accordingly, CPS may be called the "clicker" system by some researchers (Han, 2006). The receiver can be mounted in the ceiling like a projector or brought to class every time an instructor needs it; it must be also connected to a computer using a serial or USB port. Typically, one receiver is enough for a classroom with about a 90- to 100-student capacity; larger classes need more than one receiver. The software is provided by eInstruction Corporation, and once installed in the computer, it allows the instructor to take attendance; make and edit quizzes or surveys; give quizzes or surveys using a projector; record results and grades; generate reports for attendance, grades, and participation; and export results to a spreadsheet format (Gill et al., 2006). The CPS software makes a code for every response pad used in the class and creates a profile for every user so that instructors would be able to know students' identities if needed (Eastman, 2007). However, in front of the class, student anonymity is protected because the identity is not linked with the answers as the software displays the clickers' numbers, which is only known by the respective students (Eastman, 2007). The CPS is effective especially when used with PowerPoint® presentations in which students are asked questions directly after the instructor finishes explaining an important concept (Mahler & Wegenast, 2003).

Literature Review

The use of instructional technology tools stem back to 1960s and 1970s, and since that time, many articles have been published to attest that, with certain enhancements, such systems can have significant effect on student understanding of the course materials (Judson & Sawada, 2002). About one hundred projects funded by the government have been conducted to test the efficiency of technology on students (Nelson, Palonsky, & McCarthy, 2006). The projects have indicated that technology may improve "student outcomes in cognitive knowledge and information access" (Nelson et al., 2006, p. 318). Moreover, in 1999, Mann reported that students who used technology in classroom achieved higher grades on standardized basic knowledge tests than students who did not study with technology (Nelson et al., 2006). Instructional technology tools are used to increase student performance by promoting the active learning process and shift students from traditional methods (Duncan, 2005; Siegel, Schmidt, & Cone, 2004). Traditional teaching methods involve passing information during lectures in which students listen, receive the information, and take notes without giving their opinions or opening a space for constructive discussions (Greer & Heaney, 2004). This is classified as passive learning because sitting and listening are what students do. Active learning, on the other hand, involves an interactive environment in which questions, participations, and critical thinking are essential (Paschal, 2002). Accordingly, teaching strategies were developed for the purpose of making the class an active learning experience to students, through the integration of group work and problem-solving activities. The efforts exerted to increase engagement are extensive, yet there is still a problem in instigating students' involvement and interest as well as enhancing their understanding (Greer & Heaney, 2004). According to Greer and Heaney (2004), the CPS is one way to address the issue of student engagement and to promote effective learning. With the CPS, an instructor can ask and gather answers from all students and get an immediate perception about their understanding of lecture materials and concepts (Paschal, 2002). This immediate feedback has been suggested to increase interactivity between an instructor and students because it encourages students' engagement "in the learning situation and perceive more hands-on learning and higher levels of professors' flexibility" (Predmore & Manduley, 2006, p. 8). Greer and Heaney (2004) used the CPS to encourage participation, enhance communication and collaboration, develop problem-solving skills, and increase attendance. After its implementation for four semesters, a significant increase in attendance was achieved by making the CPS activities worth 15% of students' final grade.

The CPS encourages attendance, enhances attention to lectures, increases interest in the material that is being delivered, and promotes interaction (Gill et al., 2006). El-Rady conducted a comparison between students' mean scores on the same exam before and after the use of the CPS in biology classes during two different semesters. The mean score was 60 before the introduction of the CPS technology and 73 after its introduction with a $p < .001$, meaning that the change is positively significant (Gill et al., 2006). Moreover, attendance increased from about 50-60% to 80-90%, and students had a positive experience as reflected in the comments on the system (Gill et al., 2006). However, despite the effective use of the CPS by many institutions in different courses, some institutions have not been as successful as others. For instance, when the CPS was used at the United States Military Academy in one of the advanced chemistry classes, students had higher satisfaction, but preparation for the class was not improved (Siegel et al., 2004). Yet, a considerable number of recently conducted researches indicated the effectiveness of the system in college-level courses, in general, and science classes in particular (Duncan, 2005).

Recently, instructional technology tools such as the CPS have become attractive teaching strategies because they are efficient in enhancing student performance, efficient in making the class enjoyable to students and the instructor, and their cost effectiveness (Patry, 2009). Duncan (2005) stated that the wise use of the CPS would help the instructors to accurately estimate student understanding of a course material and enable them "to sample the thinking of students, at any time, without students having to risk embarrassing themselves in front of their peers" (Duncan, 2005, p. 1).

The CPS has been successfully implemented in a number of institutions nationwide for improving learning and teaching (Caron & Gely, 2003; Woods & Chiu, 2003). In the United States, around 150 institutions are using this technology in different courses such as chemistry, physics, psychology, and others (Bunz, 2004). One of the important benefits of the CPS is that it eliminates students' embarrassment every time instructors ask questions (Predmore & Manduley, 2006). Surveys obtained by Nooriafshar (2005a) indicated that 88% of participated students would like to see the CPS system implemented in the learning material. Among those students who experienced the CPS, 80% *strongly agreed* on its interactivity, and about 80% *agreed* that the CPS encouraged participation and discussions and eliminated embarrassment (Nooriafshar, 2005a). What encouraged students to participate in discussions was the anonymous feedback provided (Nooriafshar, 2005b). Students were more comfortable in participating because answers were not disclosed to peers; hence, embarrassment was eliminated. Moreover, the immediate feedback helped students through reevaluation of the answers if they were wrong and through immediate confirmation if the answers were right (Nooriafshar, 2005b). According to Barber and Njus (2007), the number of instructors using such systems is increasing because the CPS helps engage students in active learning. Even though the system can simply be used for taking attendance and delivering short quizzes at the beginning of a class to check on student preparedness, it can be more effectively used by triggering student critical thinking analysis about a subject. Barber and Njus (2007) suggested that using the right CPS questions would help instructors get a better idea about student understanding of certain concepts. In a study conducted by Teeter, Madsen, Hughes, and Eagar (2007), 96% of students who participated in a questionnaire about the CPS indicated that the system increased enjoyment in class, and 93% of students indicated that their main satisfaction with the CPS was because of the immediate feedback provided. In addition, 57% of students indicated recommendations of the CPS for other students and instructors, and 32% stated that the CPS should be used by more instructors (Teeter et al., 2007). Another study indicated that students like the system because it increased participation, and they asked to implement the CPS in all other classes (Mahler & Wegenast, 2003).

Increase in student attendance and participation are among the main benefits of the CPS (Lopez-Herrejon & Schulman, 2004; Lowery, 2005). Student participation in lectures and in-class discussions is an essential determining factor for achievement (Owens, 2009). When the CPS is used, students who usually do not participate by raising hands or who avoid eye contact when the instructors ask questions are “no longer off the hook” (Davis, 2003, p. 305). However, the quality of student participation may not be ensured because some students may just randomly hit any button on the clicker and hope for the best. For this reason, depending just on the CPS questions, without a change in the overall pedagogical approach, may limit the effect of this system. Therefore, instructors usually prepare the CPS questions in a way that promotes small group discussions to enhance the quality of student participation and develop critical thinking skills (Davis, 2003; Dufrense, Gerace, Leonard, Mestre, & Wenk, 1996; Fies, 2005; Nicol & Boyle, 2003; Reay, Bao, Li, Warnakulasooriya, & Baugh, 2005).

The two main factors that make this technology effective in increasing student participation are anonymity and group learning (Fies, 2005). David (2003) explains that *anonymity* means students can participate by providing answers to questions “without their identity being associated with that information” (p. 301); only the instructor can identify students and the information or answers provided. Anonymity is essential in increasing student participation because of the ability in decreasing stress and embarrassment in answering a question in front of all peers (Cue, 1998). The anonymity granted by the CPS allows students to think and answer a question without being affected by other students’ answers, and it may help them concentrate “on the merits of the contributed idea rather than its source” (Liu, Liang, Wang, & Chan, 2003, p. 319).

According to Wang and Gearhart (2006), the “reciprocal dependencies” generated by group learning helps students “grow more individually and perceive greater self-efficacy than they do in competitive and individualistic settings” (p. 64). Studies conducted by Davis (2003) and Nicol and Boyle (2003) indicated that most students prefer to work in small groups when answering a question or solving a problem rather than working with the whole class. Students may become more accountable when working and discussing questions in small groups (Davis, 2003). Working in groups helps students to think together, articulate current thinking, elaborate on certain thoughts, and evaluate different perspectives (Dufrense et al., 1996).

The CPS encourages group discussions (Cummings & Hsu, 2007). The CPS questions can take different forms: true/false, multiple choice, and problem solving and critical thinking questions. The critical thinking questions produced by an instructor and embedded in the CPS can ask students to form small groups to discuss each question before deciding on an answer. To answer such questions, students would need to search the lecture notes and the textbook, as well as share opinions about the topic before they take a decision on the final answer. Once they decide on an answer, students in the group would submit the answers individually (Cummings & Hsu, 2007). Additionally, because the CPS provides immediate feedback, groups who get the answer right would get a prompt confirmation while groups who missed the questions would be motivated to put more effort on next questions (Woods & Chiu, 2003).

The importance of attendance, which is the second most important thing encouraged by the CPS, is that it is linked to student achievements and grades on tests because of the increased opportunities for learning and understanding the course materials (Epstein & Sheldon, 2002). Romer (1993) stated that there is about a full letter grade difference between a student who regularly attends class and another who sporadically shows up. A study by Owens (2009) indicated that student attendance increased after utilizing a strategy which divided students into small groups. Students were more motivated to attend class, and preparation for tests enhanced as well. Students also found an opportunity to socialize and make friends (Owens, 2009). Consequently, group work made the class an enjoyable, proliferative, and interactive experience, and student attendance had an impact on final grades.

Best Teaching Strategies in Anatomy and Physiology

Learning anatomy and physiology is a process that requires detailed understanding of the human body (Gar, 2005). Instructors play an important role in stimulating students’ interest in the course materials and in stimulating critical thinking (Gar, 2005). The best way to teach college-level students is to make the classroom an active learning environment where students actively participate in lecture and discussions and have hands-on experiences (Wood, 2009). To make learning effective, a number of factors should be taken into account. The constructivist view of learning is one of the factors (Wood, 2009). According to the constructivist view of learning, students should be able to link new information with prior knowledge to understand things better (Wood, 2009). For instance, whenever students learn a new anatomical or physiological concept, the instructor should relate this point to previous points and show how to apply the information in real life. Group discussions can enhance the learning process, especially if small groups contain diverse students who may be of different learning experiences and different cultural backgrounds (Wood, 2009). Prompt and frequent feedback is also of important value for both the students and the instructor in this context (Wood, 2009). Therefore, the CPS is a good teaching strategy in college anatomy and physiology classes because it protects students' anonymity, promotes group discussions, and provides immediate feedback. However, questions developed by the instructor should be "conceptual and challenging . . . and should assess higher Bloom's levels of understanding" (Wood, 2009, p. 104). Bloom's taxonomy or Bloom's levels of understanding, which were developed by Benjamin Bloom, divides understanding into six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation (Callister, 2010). According to Bloom's taxonomy, evaluation is the highest level of understanding and cognition, which builds upon all the other abilities that precede it (Crowe, Dirks, & Wenderoth, 2008). Bloom's taxonomy is used in biology classes in rubrics development to evaluate student performance, develop "formative assessment questions at the appropriate cognitive level" (Crowe et al., 2008, p. 369), and revise course design.

Methodology

In this study, the CPS effectiveness was studied in relation to participation, attendance, and achievement of students in multicultural Anatomy and Physiology classes at South Texas College. To promote participation, the CPS questions were delivered as a mix of simple true/false, multiple choice, and group work-based questions. Approximately five questions were true/false and straightforward multiple choices and were delivered at different times during a lecture to check on student understanding of the main points and keep engagement in class. Each question was timed and lasted around 20 to 60 seconds. On the other hand, one to two group work-based questions were delivered right in the middle or at the end of the lecture. Group work-based CPS questions lasted for five to 15 minutes and required critical thinking and active participation in a group with the use of available resources before reaching the answer. Once all members in a group decided on the best of the presented answers, clickers were used to choose and send the answers. Immediately after the question period ended, the correct answer and a histogram of the class performance were presented.

A quantitative method and quasi-experimental design were employed for this study. Varied data-collecting approaches were followed to test the effectiveness of the CPS on student participation, attendance, and achievement. Both comparative statistics and pre-post tests were used to increase the validity of the study. The study was conducted in four experimental classes, and one was a control. However, all students in all sections were taught equally by meeting the same teaching standards. The only difference was the use of CPS. Students of the control group were asked the same questions and given the same activities but without the use of the CPS. Students had to use their notes and the textbook in order to provide their answers on a piece of paper that was turned to their instructor. Feedback and grades were returned to students of the control group on the succeeding lecture session. The control class and one experimental class were delivered by the researcher, and the three experimental classes were delivered by two other instructors during the fall semester of 2010. The use of four classes delivered by different instructors with different ages and teaching experiences was intended to eliminate bias.

Measurement through comparison is a basic principle by which values of two or more variables are compared with each other (Trochim, 2006). In this study, ordinal measurement was used to assess the differences in student grades and attendance among the experimental sections and the control group. Attendance was measured by comparing sign-in sheets between all classes studied. Attendance reports were collected on a daily basis from the experimental classes in which the CPS was implemented. The attendance reports were automatically generated and saved in each class period. In the control class, attendance was taken using traditional sign-in sheets. Participation was measured by counting the number of participating students based on the number of used clickers shown in the CPS data after every lecture. The number was divided over the total number of students, so the percentage of participating students was obtained. The same method was used for all lectures to keep track of student participation. To encourage participation, students worked in groups of three to four students to encourage active learning and decrease embarrassment of discussing the answer in front of the whole class. Once students decided on the best answer, the clickers were used to click on the letter button which corresponded to the answer. Achievement was measured in this study through students' grades on four lecture exams. Grade averages were compared for each lecture exam between the experimental sections and the control group. Highest and lowest grades as well as averages or means for all lecture exams were compared. Moreover, achievement was evaluated through pre-post tests in which students asked 10 questions both at the beginning and at the end of the semester. Biology faculty members at South Texas College developed the

10 questions of the pre/posttests that have been in use for 10 years. They are copyrighted for South Texas College, so permissions were obtained from the Dean of Mathematics and Sciences Division and the Chairperson of the Biology Department.

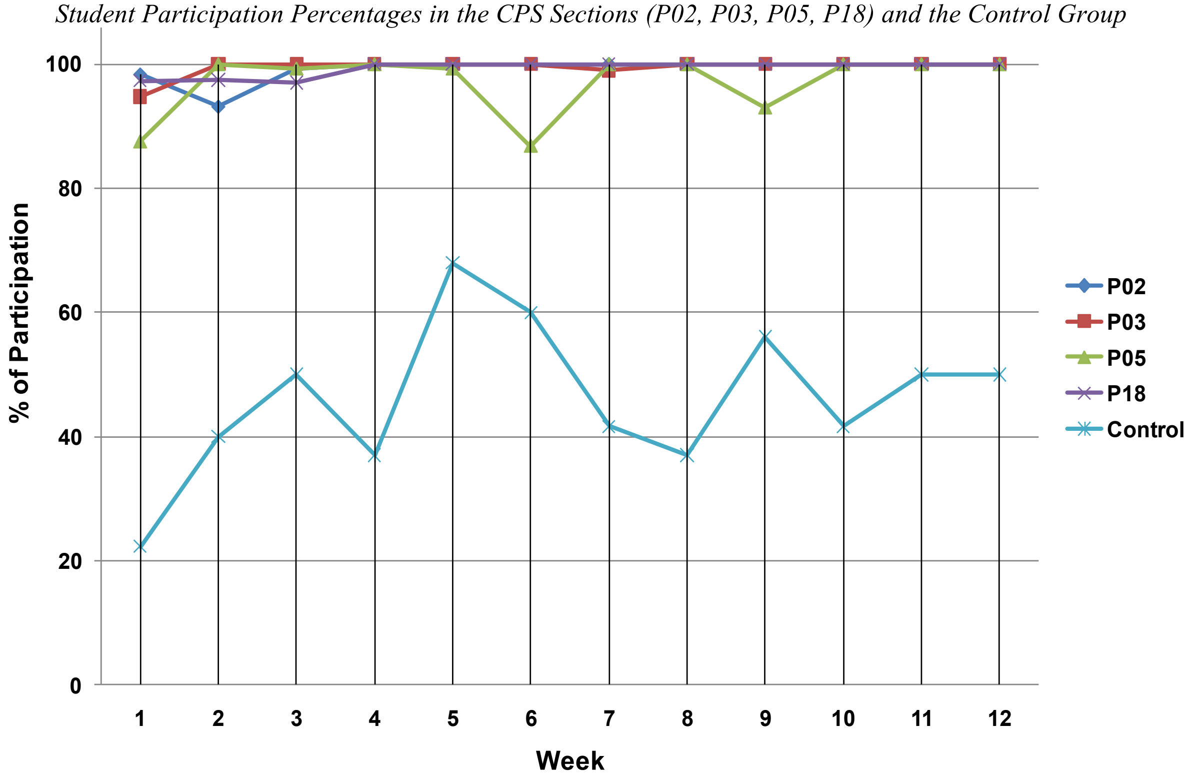
All sections were held in the same lecture room because the CPS was only ready to be used in one classroom; thus, convenience sampling was followed. At the beginning of the semester, 129 students were enrolled in the four experimental sections, and their consents to participate in the study were obtained. Among the 129 students, 120 students signed the consent forms, and only 115 showed on the first week and took the pretest. The nine students who did not sign the consent forms had never showed up to class. The control group included 32 students, and all attended the first week of the semester and took the pretest. The consent forms were handed to students at the first class meeting after the researcher explained the research process, students' rights and responsibilities, and its possible impact on student performance. The consent forms were developed both in English and Spanish; the choice was left to students to choose the version based on language preferences. Students were assigned clickers with a specific clicker for each student to be used over the entire semester. Clickers or the CPS response pads were used to answer CPS questions, which were posted during the course of lectures. During the lectures, there were between five questions and one involved group discussions. All students, including students in the control group, were asked to participate in taking the pre/posttests at the beginning of the semester.

Results

Participation

The four CPS experimental sections had high percentages of participation, which did not go below 86.8%, while, in the control group, participation did not exceed 68% as shown in Figure 1. Figure 1 indicates that the highest participation rate in the control group occurred on week 5, and the rate reached 68%. However, the difference in participation was 20% to 25% higher in the experimental sections. Figure 1 summarizes student participation over the 12 weeks of the semester during which the lectures were delivered. Descriptive statistics of student participation is also shown in Table 1.

Figure 1
Student Participation Percentages in the CPS Sections (P02, P03, P05, P18) and the Control Group



Note. Students who studied with the CPS had a significantly higher percentage of participation as compared to the control group.

Table 1
Descriptive Statistics of Student Participation

	n	Minimum	Maximum	*M*	*SD*
P02PART	12	93.10	100.00	99.20	1.99
P03PART	12	94.80	100.00	99.48	1.50
P05PART	12	86.80	100.00	97.15	5.07
P18PART	12	97.00	100.00	99.31	1.24
CONTPART	12	22.30	68.00	46.12	12.15

Note. P02PART = participation of the experimental section P02; P03PART = participation of P03; P05PART = participation of P05, P18PART = participation of P18; CONTPART = participation of the control section.

Lectures were given to the control group without the use of the CPS. Average participation for the experimental section P02 was 99.2, *SD* = 1.99. Average participation for the experimental section P03 was 99.4, *SD* = 1.50. Average participation for the experimental section P05 was 97.15, *SD* = 5.07. Average participation for the experimental section P18 was 99.2, *SD* = 1.24. The average of participation for the control group was 46.12, *SD* = 12.15. The numbers indicate that students who studied with the CPS had higher average of participation as compared with students who studied without the CPS.

Attendance

Over the semester, there was at least a 10% higher attendance rate in the experimental sections than that of the control group. In the control group, attendance dropped to as low as 68.7% and had an average of 78.5%. Yet, the lowest attendance in the CPS sections was 76.5%, and the lowest average of attendance among the four CPS experimental sections was 87.5% (see Table 2 and Figure 2). A paired-samples *t* test was used to compare the means of scores of each experimental section and the control group. The experimental sections were titled P02, P03, P05, and P18 based on course schedule sequence developed by the Biology Department at South Texas College. The control group was section P10.

A paired-samples *t* test was calculated to compare the mean of the experimental section P02 and the mean control group. The mean of the experimental section P02 was 92.15, *SD* = 4.05, and the mean of the control group was 78.53, *SD* = 6.77. A significant increase in attendance was found in the experimental section P02 as compared to the control group, $t(11) = 9.665$, $p < .001$. A paired-samples *t* test was calculated to compare the mean of the experimental section P03 and the mean control group. The mean of the experimental section P03 was 92.33, *SD* = 6.47, and the mean of the control group was 78.53, *SD* = 6.77. A significant increase in attendance was found in the experimental section P03 as compared to the control group, $t(11) = 3.839$, $p < .05$. A paired-samples *t* test was calculated to compare the mean of the experimental section P05 and the mean control group. The mean of the experimental section P05 was 87.50 (*SD* = 4.94), and the mean of the control group was 78.53, *SD* = 6.77. A significant increase in attendance was found in the experimental section P05 as compared to the control group, $t(11) = 3.371$, $p < .05$. A paired-samples *t* test was calculated to compare the mean of the experimental section P18 and the mean control group. The mean of the experimental section P18 was 88.85, *SD* = 8.61, and the mean of the control group was 78.53, *SD* = 6.77. A significant increase in attendance was found in the experimental section P18 as compared to the control group, $t(11) = 2.764$, $p < .05$.

If the significance level was greater than .05 for a 2-tailed *t* test for any of the pairs, the results would not have been significant in such a pair. Paired-samples statistics are represented in Table 3. The paired differences between each of the experimental sections and the control group are shown in Table 4.

Achievement

Pre/Posttest. The pre/posttest hypotheses are as follows:

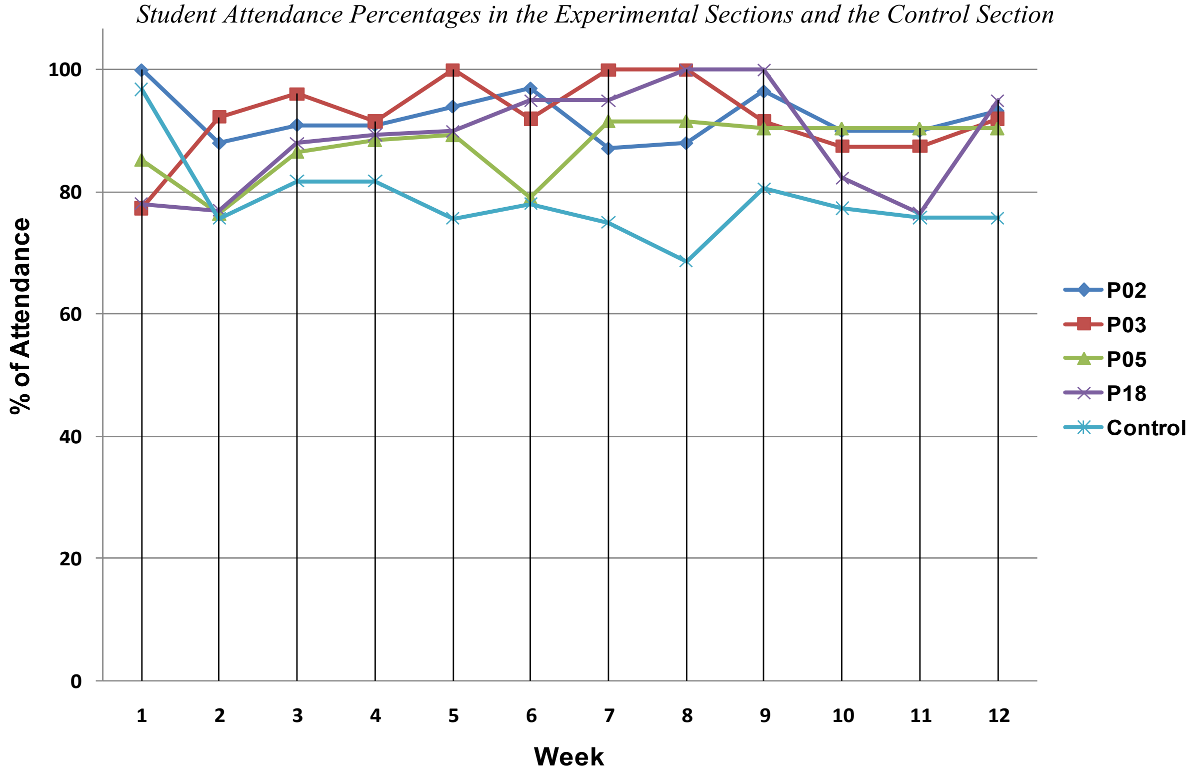
- Null Hypothesis (H_0): Students who studied with the CPS did not have a significant difference in the averages of the pre/posttest as compared with students who did not study under the CPS.
- Alternative Hypothesis (H_1): Students who studied with the CPS have a significant difference in the averages of the pre/posttest as compared with students who did not study under the CPS.

At the beginning of the semester, 129 students were enrolled in all experimental sections; however, only 115 showed up on the first week and took the pretest. The control group started the semester with an average of 2.93 on the pretest which is the second

Table 2
Descriptive Statistics of Student Attendance

	n	Minimum	Maximum	*M*	*SD*
P02	12	87.10	100.00	92.15	4.05
P03	12	77.40	100.00	92.33	6.47
P05	12	76.50	91.60	87.50	4.94
P18	12	76.50	100.00	88.85	8.61
Control	12	68.70	96.80	78.53	6.77

Figure 2
Student Attendance Percentages in the Experimental Sections and the Control Section



Note. Student attendance percentage in sections used the CPS was higher than student attendance percentage in the control section. The CPS was not used during the first week. The last day to drop the class was on November 19, which was during week 10. This would explain the drop in attendance in all sections. The rosters were updated on week 11, and week 12 was the fourth lecture exam date. Attendance rate kept in decreasing during week 11 because some students decided to take the Thanksgiving break early.

Table 3
Descriptive Paired Samples Statistics of Student Attendance

		M	*n*	*SD*	*SEM*
Pair 1	P02	92.15	12	4.05	1.16
	Control	78.53	12	6.77	1.95
Pair 2	P03	92.33	12	6.47	1.86
	Control	78.53	12	6.77	1.95
Pair 3	P05	87.50	12	4.94	1.42
	Control	78.53	12	6.77	1.95
Pair 4	P18	88.85	12	8.61	2.48
	Control	78.53	12	6.77	1.95

Table 4
Levels of Significance of Student Attendance Summary

		M	*SD*	*SEM*	95% CI *LL*	95% CI *UL*	*t*(11)	*p*
Pair 1	P02-Control	13.62	4.88	1.40	10.51	16.72	9.66	.000
Pair 2	P03-Control	13.79	12.44	3.59	5.88	21.70	3.83	.003
Pair 3	P05-Control	8.97	9.21	2.66	3.11	14.82	3.37	.006
Pair 4	P18-Control	10.32	12.93	3.73	2.10	18.53	2.76	.018

highest score among the assessed groups (see Table 5). The average of the control group was 10.15% higher than the average of the experimental section P02, 1.73% higher than the experimental section P03, 16.26% higher than the experimental section P18, but 12.28% lower than the experimental section P05. On the posttest, the highest increase or improvement in averages was for the CPS experimental section P02, which scored the second lowest average on the pretest with a percentage of increase of 97.36 on the posttest. The percentage of increase indicates the level of achievement in the class. The second highest average was scored for the CPS experimental section P03, with 96.2% increase. The third highest increase was for the experimental section P18; with 81.74% increase, and the lowest increase among the CPS experimental sections was for section P05 with 77.1% increase, which, surprisingly, scored the highest on the pretest (see Table 6). However, all experimental sections' averages on the posttest were higher than that of the control group that had 74.74% increase even though the score average on the pretest was the second highest!

Lecture exams. The student performance on the four lecture exams was compared between the experimental sections and the control group. Table 7 shows the highest and lowest grades scored by students on every exam as well as the means or the averages, medians, and standard deviations. For the experimental section P02, the average was 65.2 on the first exam, 74.3 on the second, 68.3 on the third, and 73.8 on the fourth. There was a 9.1% improvement on the second lecture exam as compared to the first lecture exam. The average dropped by 6% on the third lecture exam and increased by 5.5% on the last lecture exam. For section P03, the average was 65.8 on the first lecture exam, 70.4 on the second, 71.5 on the third, and 72.3 on the fourth exam. There was a 4.6% improvement in the average on the second lecture exam as compared to the first lecture exam. The average increased by 1.1% on the third exam and by 0.8% on the fourth exam. For section P05, the average was 55.6 on the first lecture exam, 72.5 on the second, 67.8 on the third, and 70.1 on the fourth lecture exam. There was a 16.9% improvement in the average on the second lecture exam as compared to the first lecture exam. The average dropped by 4.7% on the third as compared to the second exam and increased by 2.3% on the fourth exam. For section P18, the average was 63.3 on the first lecture exam, 68 on the second, 70.2 on the third, and 76.2 on the fourth lecture exam. There was a 4.7% improvement in the average on the second lecture exam as compared to the first lecture exam. The average increased by 2.2% on the third exam and by 6% on the fourth exam. For the control section P10, the average was 68.7 on the first lecture exam, 71.8 on the second, 71.9 on the third, and 73 on the fourth lecture exam. There was a 3.1% improvement in the average on the second lecture exam as compared to the first lecture exam. The average increased by 0.1% on the third exam and by 1.1% on the fourth exam.

Discussion and Conclusions

The study was conducted to assess the effects of the CPS on student participation, attendance, and achievement in a multicultural college-level Anatomy and Physiology classes. Most students at South Texas College use English as a second language and are underprepared to use English in academia. The language barrier increases shyness and embarrassment and reduces participation in lectures. Multiculturalism, in this study, was reflected by the students' different cultural backgrounds and native languages. The majority of students in all sections were Hispanic, but some students were White Americans, African Americans, Filipinos, Indians, Chinese, and others. The researcher concentrated on the anonymity provided by the CPS and small group discussions to conquer the language barrier, promote effective participation, and increase attendance and achievement. Careful analysis of the results and the data gathered during this study helped draw clear conclusions about the effectiveness of using the CPS. Student participation was at least 18.8% higher in classes used the CPS and 100% participation was encouraged during most of the lectures. In some sessions, the participation percentage was less than 100% because when some of the CPS questions popped up on the screen, a student or more may have stepped out of the class for personal breaks. If one of the clickers had a low battery, a student was asked to write down the answer on a piece of paper and turn it in to the instructor once the question time ends.

Table 5

Paired-Samples t *Test of the Pre/Posttests*

		M	*n*	*SD*	*SEM*
Pair 1	P02PRE	2.66	28	1.48	.279
	P02POST	5.25	28	1.91	.362
Pair 2	P03PRE	2.88	23	1.04	.217
	P03POST	5.65	23	1.82	.380
Pair 3	P05PRE	3.29	23	1.36	.284
	P05POST	5.82	23	2.38	.497
Pair 4	P18PRE	2.52	17	1.50	.364
	P18POST	4.58	17	2.31	.562
Pair 5	ControlPRE	2.93	24	1.20	.245
	ControlPOST	5.12	24	1.32	.271

Note. P02PRE = experimental section P02 results on the pretest. P02POST = P02 results on the posttest. P03PRE = P03 results on the pretest. P03POST = P03 results on the posttest. P05PRE = P05 results on the pretest. P05POST = P05 results on the posttest. P18PRE = P18 results on the pretest. P18POST = P18 results on the posttest. ControlPRE = control section results on the pretest. ControlPOST = control section results on the posttest.

Table 6

Pre/Posttests Results Summary

	P02	P03	P 05	P18	Control
Average of Pretest	2.66	2.88	3.29	2.52	2.93
Average of Posttest	5.25	5.65	5.82	4.58	5.12
Difference	2.59	2.77	2.53	2.06	2.19
Percentage of increase	97.36	96.20	77.10	81.74	74.74

Table 7

Summary of Student Performance on the Four Lecture Exams

		n	Highest Grade (%)	Lowest Grade (%)	*M*	*Mdn*	*SD*
Lecture Exam 1	P02	33	86	38	65.2	68	12.74
	P03	27	92	38	65.8	68	14.73
	P05	29	82	28	55.6	58	14.55
	P18	20	85	40	63.3	65	15.35
	Control	33	92	38	68.7	72	15.44
Lecture Exam 2	P02	33	97	55	74.3	73	11.15
	P03	25	97	44	70.4	71	15.93
	P05	24	94	44	72.5	67	16.06
	P18	20	99	42	68.0	65	13.50
	Control	32	99	36	71.8	77.5	16.27
Lecture Exam 3	P02	32	98	38	68.3	69.5	13.67
	P03	24	95	47	71.5	71	14.72
	P05	25	96	45	67.8	66.5	13.90
	P18	12	91	59	70.2	67	12.16
	Control	27	97	34	71.9	74	15.75
Lecture Exam 4	P02	29	93	47	73.8	72	12.81
	P03	25	100	46	72.3	72	14.34
	P05	21	100	46	70.1	68	12.08
	P18	17	94	50	76.2	74	11.98
	Control	26	93	39	73.0	75	12.94

The percentage of participation, however, did not go below 86.6% as compared to the highest participation rate in the control group, which was 68%. Therefore, the increase in participation was at least 18.8%. The lowest difference in participation between the CPS experimental sections and the control section was 31% increase in participation for the experimental sections. The highest participation difference was 65% for the CPS experimental sections. The average participation difference was around 50% in the experimental sections. It can be concluded that the CPS increased participation in all the experimental sections studied as compared to the control section.

During all lectures, student attendance was at least 10% higher in the experimental sections than that of the control section. Attendance average in the experimental sections was 87.5%, while it was 78.5% in the control group. A paired-samples *t* test indicated significant increase in attendance in all sections used the CPS as compared to the control group.

Student achievement increased in the experimental sections as indicated by the results of pre/posttests and performance on the four lecture exams. As indicated by the pretests' averages, the control group was relatively more prepared for the course than the three of the experimental sections because of the higher scores on the pretest. This was further confirmed by the results on the first lecture exam (see Table 7). The students in the control group scored the highest average on the first lecture exam; it was 2.9% higher than the average scored by the experimental section P03 that had the highest average among the experimental sections. Moreover, performance on the pretests indicated that students had different levels of preparedness for the class because some sections scored higher than others. Accordingly, it was important to keep track of student performance to see if all would be brought to the same or closer levels of achievements on the posttest. On the posttests, all sections that used the CPS scored higher than the control group and had a higher rate of improvement; therefore, it can be concluded that the system had a positive effect on student achievement. The pre/posttests measured student understanding of the course materials and contained the 10 questions, which covered the course learning outcomes of the anatomy and physiology courses. Therefore, student performance on the pre/posttest gave an indication about student understanding, thus achievement in the course. As a result, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

By the time of the second lecture exam, which covered chapters three and four, students used the CPS during three lectures and were more familiar with it and its activities and group discussions. Students who studied with the CPS had higher rates of improvement from the first lecture exam as compared to the control group. The control group improved by 3.1%, while the experimental section P02 improved by 9.1%, the experimental section P03 by 4.6%, the experimental section P05 by 16.9%, and the experimental section P18 by 4.7%. The experimental section P05 scored the lowest average on the first lecture exam but the second highest on the second lecture exam after the experimental section P02 (see Table 13). However, the results on the third lecture exam, which covered more chapters, was scattered differently because the two experimental sections P03 and P18 improved by 1% to 2%, while the other two experimental sections P02 and P05 had lower average by 4% to 6%, and the control group did not improve from the second lecture exam. There was no clear reason behind these results, but it could be related to the heavier load and materials covered on the third lecture exam, which was more information-rich. However, further and in-depth research may be required to determine the reason that was behind the decrease in the two experimental sections P02 and P05. On the fourth lecture exam, all experimental sections improved by 1% to 6% from the third lecture exam, while the control group improved by 1% (see Table 7). Accordingly, it can be concluded from all lecture exam averages that students who studied under the CPS had an overall higher rates of achievement on the lecture exams as compared to the control group students who had improved during the semester, but at a lower rate. The experimental sections P02 and P05, however, had lower averages on the third exam, and this was the exception. From the averages on the first and fourth lecture exams, it can be concluded that the CPS helped students increase achievement rate although they started with a low level of preparedness and background information about the course materials. Together with pre-post test results, the lecture exams' results indicated that the CPS helped increase student overall achievements in the Anatomy and Physiology classes at South Texas College. Therefore, the findings of this study supported that of current literature on the effectiveness of the CPS in increasing student participation, attendance, and achievement. Additionally, the study gave more insights about the effectiveness of the CPS in a multicultural institution where the first spoken language is not English and in anatomy and physiology classes.

Implications and Recommendations

The effectiveness of the CPS is determined by the way an instructor uses it as indicated by current literature. The type of activities and questions prepared by the instructor would help in determining the effectiveness of the system. Further research might be needed to study the instructor's role in determining the CPS efficiency in education. To get the most out of the

CPS, instructors should prepare activities that promote active learning, critical thinking, and group discussions. This is in addition to straightforward CPS questions about the lectures that can be integrated to keep students alert and get instant perception about understanding of a certain concept. The role of the instructor is essential and a key factor when using this technology and any teaching strategy. For that reason, instructors should be computer and internet literate and should be well trained to use the CPS. The instructor needs to know how to use PowerPoint presentations and how to embed them in the CPS with some knowledge on how to browse, attach pictures and videos, convert Word documents to .pdf, enter data in Excel, and plug USB cables.

This study has added to the body of knowledge in the field of instructional technology in education. Specifically, the study added to the existing knowledge the importance of the CPS in increasing student participation, attendance, and achievement in multicultural anatomy and physiology classes. The results reached in this research can be used for further research in future and perhaps in other biology classes, other science classes, or other college-level classes in a multicultural institution. The CPS is in use in many institutions and in different courses, such as psychology, general education, physics, and others. However, very little literature was found in anatomy and physiology courses. For this reason, this study added to existing literature the effectiveness of the CPS as a teaching strategy in anatomy and physiology courses.

The effects of the CPS on other variables such as student retention, student perception, student engagement, and instructor perception may be also investigated in future research. Moreover, other methodological approaches, such as the qualitative phenomenological approach, can be employed to investigate student perception and the lived experience during the study. Also, the system can be studied for effectiveness in an institution where the first spoken language is English and in special education programs.

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