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Increasing Student Interactivity using a Think-Pair-Share model with a Web-based Student Response System in a Large Lecture Class in Guyana

Vineeta Persaud and Rita Persaud
University of Guyana, Guyana

ABSTRACT

This study investigated the feasibility of using a web-based Student Response Systems (SRS) to promote interaction in an undergraduate class of 239 students. The study was conducted at a tertiary institution in Guyana, a developing country, faced with technological challenges that made it impractical for every student in the class to respond individually using the SRS. The challenges were addressed by using the Think-Pair-Share model which uses peer discussions, in combination with the shared use of response devices, whereby the large class was subdivided into smaller groups of two to four students, with one student from each group posting the response using the SRS. The Interactivity construct was measured through aspects of learning which included involvement, engagement, participation, feedback and self-assessment. An independent samples t-test was conducted to compare student perceptions of their level of interactivity in class before and after the study. Results indicated that there was a significant difference in their average levels of interactivity before (1.7±0.536) and after the study (4.4±0.483); t = -53.6, p = 0.000 suggesting that the use of shared response devices to post responses in combination with the Think-Pair-Share model can increase individual student interactivity even in a large class.

Keywords*: Student Response System, Think-Pair-Share, Interactivity, Active learning, Peer discussions, large classes*

INTRODUCTION

Countries worldwide, especially developing countries, are seeing the link between education and the overall health, and socio-economic development of their citizens (Hahn & Truman, 2015; Munir et al., 2017). There is an increase in the number of persons seeking higher education, as they see a degree as the key to better job prospects. Goddard (2011) projects the number of students worldwide enrolling in higher education to more than double by the year 2025. He also notes that because of fewer economic resources for education in many low-income countries, there may be fewer institutions of higher learning available for students to attend. This can result in an increased intake of students without the corresponding resources to support their educational needs. The University may not have an adequate number of classrooms to support the class sizes, nor the financial resources to hire more instructors, resulting in the adoption of large class lecture style formats with a high student-instructor ratio (Abutu, 2018).

Numerous studies have shown that the lecture-based instruction format fails to motivate meaningful student engagement and promotes passive and superficial learning (Bransford, Brown & Cocking, 2000). Active learning on the other hand involves “engaging students in the process of learning through activities and/or discussions in class, as opposed to passively listening to an expert. It emphasizes higher order thinking and often involves group work” (Freeman et al. (2014). Interactivity is an important element of teaching and learning, and requires the active involvement of learners (Bannan-Ritland, 2002). Various pedagogical techniques for incorporating interactivity have been used in learning environments. These include the use of flipped classrooms, peer instruction, collaborative learning, Think-Pair-Share and Student Response Systems (SRS).

To date, there have been several studies conducted on the use of Student Response Systems in increasing student engagement, in situations where each student in the class had in their possession an SRS device such as a clicker, smart phone, tablet or laptop and was able to post individual responses (Heaslip et al., 2014; Campbell & Monk, 2015; Rana & Dwivedi, 2016). While the ability to post individual responses using an SRS would ensure participation at an individual level, this may not be possible due to the lack of resources. This was the situation in a large class at the University of Guyana, where the study was conducted. However, there is minimal research on the use of SRS in large classes where it is infeasible for every student in the class to post individual responses. Currently, research on SRS is limited to research designs where every student in the class is equipped with a response device. This study aims to investigate whether using a combination of shared response devices and the Think-Pair-Share model which involves the use of peer discussions, can introduce or increase interactivity at an individual level among students in a large lecture classroom when faced with the lack of adequate technological resources to permit individual responses. The study is important to both instructors and students in educational environments where the lack of resources may have prevented them from incorporating the benefits of the SRS technology into their classrooms.

The study was guided by the following research questions:

1. What is the level of individual student interactivity during a traditional lecture class?
2. What is the level of individual student interactivity during a class incorporating the Think-Pair-Share model and the SRS?
3. What is the perceived level of satisfaction of students with this teaching intervention?
4. What do students like and dislike about this teaching intervention?

Statement of the Problem

The University of Guyana is a financially-strapped institution in a low-income country in South America. Due to the physical space constraints and the availability of only one large classroom capable of handling approximately 300 students, many large introductory classes are scheduled for a three-hour long session per week in this classroom. Lecturers use a lecture style teaching format with electronic slideshows to impart course content resulting in a passive learning environment. Since each weekly session is three hours in duration, the majority of students tend to lose focus and start getting easily distracted after the first hour or so of class. In an effort to promote interactivity in a large introductory Information Systems course (class size = 239), the researchers decided to use a web-enabled response system to allow students to respond to questions posed by the lecturer. In a web-based response system, the student responds to the instructor's question using a portable computing device such as a laptop, tablet, or smartphone that is connected to the Internet. The researchers faced two main challenges in the introduction of the response system.

- The University provides free Wi-Fi to its academic community, but the bandwidth is insufficient to support the entire university population, resulting in extremely slow Internet access.
- Additionally, not all students had access to a portable computing device which meant that they could not post individual responses.

The researchers addressed these practical challenges by using a combination of shared web-enabled response devices and the Think-Pair-Share model which involved the use of peer discussions in groups of two to four students, and having one student from each group respond using the SRS. The class sessions were designed to stimulate participation from the students periodically during the lecture to prevent them from being a passive audience.

LITERATURE REVIEW

Several studies have demonstrated the ineffectiveness of the traditional lecture-style instructional format that utilizes a passive learning style in promoting student learning (Hrepic, Zollman, & Rebello, 2007; Deslauriers, Schelew, & Wieman, 2011). Research has consistently shown that active responding in the classroom is crucial to student achievement (Shin et al., 2000). Active learning instructional methods transform the classroom from a teaching-centered to a learning-centered environment and include a number of characteristics such as eliciting responses and ideas from students, engaging students in problem solving activities during class, providing rapid feedback, working together in small groups, encouraging conceptual thinking and the ability to express their reasoning clearly, and reflecting on their own learning (Meltzer and Thornton, 2012). Various forms of active responding, such as collaborative learning, guided notes and note taking, response cards and Student Response Systems have been used to introduce interactivity and promote active learning in a traditional lecture style classroom (Draper & Brown, 2004; Neef et al., 2006; Bruff, 2009). Several studies have found that active learning environments improve student success by improving student engagement and learning outcomes in large undergraduate introductory classes (Walker et al., 2008; Armbruster et al., 2009; Freeman et al., 2014; Downs & Wilson, 2015).

Interactivity has been described as the active involvement and participation of students in the classroom (Siau et al., 2016). Research has shown that student interactions among each other and between students and lecturers are important factors affecting student learning and success (Umbach & Wawrzynski, 2005, Blasco-Arcas et al., 2013). Interaction has been linked to three key theories of learning: behaviorist, cognitivist, and constructivist (Haseman, Polatoglu & Ramamurthy, 2002; Siau et al. 2006). From the behaviorist theory, stimulus response methods used to prompt a learner's response which is then reinforced by feedback and provides for self-assessment are forms of promoting interaction that can result in effective learning. The cognitive approach involves the efficient and effective transfer of knowledge to the learner through interactive methods such as encouraging and enabling students to ask questions and seek answers and clarifications, and providing them with informative feedback. The Constructivist Theory involves discovery-based learning requiring the learners to internally process and organize pieces of information into knowledge. Encouraging users to collaborate, participate and engage actively can increase interactivity (Haseman, Polatoglu & Ramamurthy, 2002). Thus, various elements of interactivity encompassing interactivity with the lecturer, and interactivity with students can be used to support the three learning theories.

Interactivity with the lecturer allows the lecturer to assess students' understanding of course material by eliciting responses from students and providing appropriate feedback to address gaps in knowledge, and well as having students ask questions of the instructor and providing answers (Trees & Jackson, 2007). Interaction with students (peers) results from group discussions and peer instructions enabling higher order thinking where students can assimilate, reflect and apply knowledge to new situations (Michaelson, Knight & Fink, 2004). Incorporating or increasing elements of interactivity in accordance with the learning theories into instructional design can result in active involvement of students in the classroom, provide feedback to both students and instructors and improve learning (Trees & Jackson, 2007). Siau et al., (2006) developed an instrument for measuring the interactivity construct by measuring student involvement in the class, student engagement in the class, student participation in the class, student feedback from instructor, and student self-assessment.

The Think-Pair-Share is a cooperative learning model proposed by Lyman in 1981, where students initially think for a few moments and formulate their thoughts about the question individually, then pair up with another student to discuss their solutions, and finally share their collective responses with the instructor and the class (Lightner & Tomaswick, 2017). This type of classroom activity creates an active learning environment by motivating students to interact with each other and the

instructor. It also engages the entire class and encourages the quiet students to participate. Studies using this model have reported increased student engagement and improved learning outcomes (Razak, 2016; Raba, 2017). However, there have been potential drawbacks identified with implementing peer discussions. These include limited knowledge of the topic among students in introductory courses that may result in the inability to adequately process the material and create meaning, both of which are elements crucial to active learning. This may also prompt students to feel that discussion groups were pointless and a waste of their time, not helpful or contributing to their learning (Walker et al., 2018). Additionally, group discussions may be dominated by a few individuals which may have a negative effect on the other students in the group (Lantz, 2010).

Web-based Student Response Systems and clickers allow for individual responses to be collected, analyzed, aggregated and displayed in real time. They have been widely used by instructors to promote cognitive and non-cognitive learning outcomes in the classroom. Studies have shown that the introduction of Student Response Systems, which can take the form of clickers or web-enabled devices, into traditional lecture settings can create an active learning environment and impact student perceptions and attitudes by promoting student engagement, increasing attention, increasing interaction between the student and instructor, and improving learning (Siau et al., 2006; Boscardin & Penuel, 2012; Heaslip et al., 2014; Hunsu et al., 2016). Students are engaged at a higher level of cognitive processing as they are required to be more attentive in class in anticipation of the lecturer asking questions, and need to mentally organize their response. However, there is inconclusive evidence as to whether the use of SRS actually improves student performance in quizzes and end of term exams (Galal et al., 2015).

Most of the research on the use of SRS has been conducted in developed countries where it is financially feasible for every student in the class to have access to a clicker or a web-enabled device. Unfortunately, there is a significant lack of research on the use of clickers and web-enabled response systems in large classes in developing countries. This lack of research could possibly be because unlike the developed world where electricity, facilities, and technology are taken for granted, low-income countries may lack the finances and basic infrastructure to support the implementation of SRS in educational institutions, especially for large class sizes.

This research uses a combination of the peer discussion technique of Think-Pair-Share with a web-based SRS technology to investigate the effect on interactivity in the learning environment.

METHODOLOGY

Participants

The participants in this research were first- and second-year University of Guyana students who were registered for an undergraduate Information Systems course (class size = 239) for the academic year 2016-2017. The class met once a week for three hours in a traditional classroom using lecture-based instruction. The course covered principles of Information Systems and the use of MS Excel for Data Analysis and Business Intelligence.

Procedure and Materials

A pre-test/post-test design method was used to ascertain the impact of the intervention on students' interactivity during the lectures.

A pre-test Interactivity questionnaire using the Individual Degree of Interactivity Scale (Siau et al., 2006) was administered in the last 10 minutes of class in week 4 of the semester. The Interactivity construct as developed by Siau et al. is based on a combination of the following factors: involvement, engagement, participation, feedback and self-assessment. This instrument was chosen by the researchers because unlike a number of ad hoc questionnaires used in most surveys

in the literature, this questionnaire has been fully validated by its authors. The Cronbach's alpha coefficients for individual interactivity in the pre-test and post-test were 0.86 and 0.91 respectively, indicating that the instruments are highly reliable (Siau et al., 2006). The questionnaire for this study consisted of 10 questions and used a five-point Likert scale with 5 = Strongly Agree to 1 = Strongly Disagree. Students' involvement in the class was measured through questions 1 and 2; engagement through questions 3 and 4; participation through questions 5 and 6; feedback through questions 7 and 8; and self-assessment through questions 9 and 10.

The Pre-test Interactivity questionnaire asked students to give their preferred response to the statements for typical lecture-based class sessions. It consisted of the following 10 questions.

1. I interact with the lecturer in class.
2. I am involved in learning in class.
3. I am focused for the majority of the class.
4. I reflect on the material taught in class.
5. I participate in class discussions.
6. I respond to questions from the lecturer during class.
7. I receive feedback in class on my understanding of the course materials.
8. I receive feedback from the lecturer during class.
9. I can gauge whether I am following the course materials during the class.
10. I can assess my understanding of the course materials with respect to other students during the class.

The mQlicker Student Response System was introduced in the fifth week of classes and used for four weeks. Each lecture class was divided into a series of three to four short sessions. Each session included a short quiz consisting of one or two multiple choice questions on the key concepts covered during the session. The students in the class were asked to form groups comprising of two to four students per group and were instructed on the process whereby, for each question posed by the lecturer, the students were given 2 to 3 minutes to individually formulate their answers (Think) after which they were given 5 minutes to discuss their answers among their group members (Pair) and then submit their collective response using the SRS (Share). Since the students did not need an mQlicker account to post their responses, it was not possible to associate individual students with their responses. It was stressed to the students that the responses collected would be anonymous, and that neither the lecturer nor the rest of the class would know who had submitted a particular response. This was done so that the students would feel comfortable participating.

Once all responses had been submitted, the lecturer displayed the graph from mQlicker showing a summary of the student responses generated in real time, and provided the correct answer. Based on the results for a given question, class wide discussions were encouraged to give students the opportunity to indicate their rationale for choosing their answer. The lecturer addressed the misconceptions. If more than half the groups got the answer incorrect, the lecturer revisited the topic and posed another question based on the same concept to reassess the students' understanding.

A post-test questionnaire was administered at the end of class in week 8 of the semester to investigate student perceptions towards the use of the SRS technology. Questions relating to Interactivity in this questionnaire were identical to the pre-test Interactivity questionnaire. Students were instructed that the statements pertained specifically to the four-week period during which the web-based SRS was used. In addition to the post-test interactivity questions, a Yes/No question was used to capture information about whether students would like to see the SRS implemented in other courses. Qualitative data was also collected using two open ended questions at the end of the study to elicit insight into what students liked and disliked about the use of the intervention.

RESULTS AND FINDINGS

Quantitative Data Analysis

The statistical software package SPSS v 24.0 was used to analyze the data. The interactivity questionnaires for this study used a five-point Likert scale with 5 = Strongly Agree to 1 = Strongly Disagree. 221 students filled out the pre-test interactivity questionnaire, while 217 students responded to the post-test questionnaire. 199 complete cases were used for the pre-test, while 211 complete cases were used for the post-test.

Descriptive statistics computed for the various factors comprising Interactivity for the pre- and post-test are shown in Table 1.

Table 1*. Comparison of Pre-test and Post-test Means for Factors comprising Student Interactivity*

Question	**Pre-test (N = 199) (M, SD)**	**Post-test (N = 211) (M, SD)**
I interact with the lecturer in class. (Involvement)	1.56 (.700)	3.32 (.731)
I am involved in learning in class. (Involvement)	1.51 (.567)	4.38 (.639)
I am focused for the majority of the class. (Engagement)	1.85 (.657)	4.27 (.448)
I reflect on the material taught in class. (Engagement)	1.61 (.776)	4.36 (.483)
I participate in class discussions. (Participation)	1.15 (.359)	4.36 (.483)
I respond to questions from the lecturer during class. (Participation)	1.79 (.585)	4.09 (.498)
I receive feedback in class on my understanding of the course materials. (Feedback)	1.72 (.570)	4.55 (.498)
I receive feedback from the lecturer during class. (Feedback)	1.81 (.523)	4.55 (.498)
I can gauge whether I am following the course materials during the class. (Self-Assessment)	2.59 (.900)	4.46 (.500)
I can assess my understanding of the course materials with respect to other students during the class. (Self-Assessment)	1.51 (.602)	4.36 (.483)

Descriptive statistics were also computed for the Likert scale construct Interactivity, for before and after the teaching intervention. The average level of interactivity before the study was computed as 1.7 (SD = 0.536), while the average level of interactivity at the end of the study was computed as 4.4 (SD = 0.483), indicating an increase in interactivity after the intervention. An independent samples t-test was used to test for statistical significance of the means for Interactivity. The results of the t-tests ($t = -53.6$, $p = .000$) indicate a significant difference between the means for the two groups. This is strong evidence that the intervention improves student interactivity, increasing average interactivity by almost three points.

Findings in relation to the research questions

Research Question 1: What is the level of individual student interactivity during a traditional lecture class?

The first research question sought to measure the level of interaction during a normal three-hour lecture session. This is the pre-test interactivity. As seen in Table 1, the means for all aspects of interactivity were quite low, lying between 1 and 2, except for the question 'I can gauge whether I am following the course materials during the class' which was 2.59. The average level of the pre-test Interactivity construct was 1.7±0.536 indicating a very passive audience. This corresponds to the low level of interaction observed during traditional lectures. The passive behavior is reflected in the low levels of Involvement (interaction with the lecturer (1.56) and involvement in learning (1.51)), Engagement (reflecting on course material in the class(1.61)), Participation (participating in class discussions involving fellow students (1.15) and responding to the lecturer (1.79)) and Feedback (receiving feedback on understanding of class materials (1.72)). The higher mean of 2.59 for the question 'I can gauge whether I am following the course materials during the class' can be supported by Felder and Brent's (2015) observation that when students are passive viewers or listeners, they imagine they understand all the material and hence may overestimate their understanding of course material.

Research Question 2: What is the level of individual student interactivity during a class incorporating the Think-Pair-Share model and the SRS?

The second research question was designed to measure the level of interactivity during the four weeks when the web-based SRS was used. This is the post-test interactivity. As seen in Table 1, the means for all interactivity measures were high, lying between 4 and 5, except for the question 'I Interact with the lecturer in class' which was 3.32. The average level of the Interactivity construct was 4.4±0.483 indicating a very active learning environment.

There was an increase in the means for all aspects of Interactivity. The students perceived themselves as being more involved in learning (4.38). This is consistent with their perception that they were more focused (4.27) and were given the opportunity to reflect on the course material in class (4.36). In addition, there was greater participation while responding to questions posed by the lecturer (4.09) and in class discussions (4.36). The feedback in response to the SRS enabled formative assessments allowed students to assess their understanding of the course material. The increase in the mean for feedback (4.55) suggests that students found it more helpful to their understanding of the material. Useful feedback that can assist in progress toward understanding can best be provided if students are able to reveal their understanding about a subject matter and ask questions. Since students showed higher levels of involvement, engagement and participation during the classes using the SRS, the lecturer was able to provide appropriate feedback to clarify their misconceptions. The students were therefore able to more accurately assess their understanding of the course materials (4.46). Though there was an increase in the levels of interaction with the lecturer as compared to pre-test, it was still rather low (3.32). The higher levels of participation however, suggest that some students though unwilling to interact with the lecturer by asking questions, were active participants in discussions with their group members (4.36) and also actively responded to questions posed by the lecturer (4.09).

The results of the t-tests for the pre-test and post-test Interactivity means ($t = -53.6$, $p = .000$) indicated a significant difference between the means for the two groups, indicating that the intervention increased the post-test interactivity.

Research Question 3: What is the perceived level of satisfaction of students with this teaching intervention?

The third research question sought to understand the level of perceived satisfaction of the participants toward the teaching intervention. In response to the Yes/No question "Do you think your learning experience at the University of Guyana would be positively affected if the SRS was used in all your courses?" 212 out of the 217 respondents (97.7%) indicated that they would want the SRS to be used in all their courses. This suggests that the vast majority of students were

satisfied that the use of the teaching intervention had helped them in their perceived understanding and learning of the course content and felt that it would benefit them if used similarly in other courses.

Research Question 4: What do students like and dislike about this teaching intervention?

The fourth research question sought to understand what participants in the study liked and disliked about the teaching intervention. This question was answered through the use of two open-ended questions which were analyzed qualitatively.

1. What did you like about using the SRS?
2. What did you dislike about using the SRS?

Not all students answered the open-ended questions. Of the 217 respondents to the post-test survey, 97 respondents provided responses for the open-ended questions. The researchers performed a content analysis of the responses submitted, and coded each response for the presence or absence of a set of content themes. Multiple themes were identified in some responses. For what they liked about using the SRS, a total of six themes were identified and two themes emerged for what they disliked about using the SRS.

Table 2 shows a summary of the emergent themes, their frequencies, and thematic exemplars.

Table 2: *Thematic analysis of Likes and Dislikes of using the teaching intervention (n = 97)*

Theme	**Frequency**	**Exemplar**
What did you like about using the Student Response System?		
Enjoyment of sessions	63	"It was cool seeing the graph with how many got correct and wrong" "It is really hard focusing for 3 hours. Group work is like taking breaks" "I enjoyed the sessions wish we could have it in every class" "made the class more interesting and fun"
Discussion with peers	21	"I liked that we could discuss with others before answering the question. It helped my understanding of the topic". "Talking and discussing with others is fun. It also helps me to remember". "We were so happy when our group's answer was correct"
Instant feedback from lecturer	13	"I like that Miss just doesn't give the answer but explains it". "Knowing whether I got the answer right or wrong right away allows me to be sure I understood the topic"
Perceived understanding and confidence	12	"When I got a question right, I knew that I had definitely understood the material." "I didnt get pivot tables but I think I finally understand it now"

Mutual awareness of responses	11	"It was interesting to see how the rest of the class answered the question" "I was proud when I was one of the few students that answered a question correctly"
Increased involvement in class	9	"I am shy and don't like answering in front of so many students. This was a fun way to participate" "I was more focused"
What did you dislike about using the Student Response System?		
Slow Internet connection	78	"UG offers free WiFi but it is so slow especially when we are all trying to connect to it at the same time" "UG needs to offer faster Internet". "It took ages to connect to the net" "The student response system is good, but only if students get fast access to the Net"
Dislike group discussions	7	"I prefer working alone" "I had the right answer, but others in my group would not listen to me" "I don't like group work. My group members did not contribute"

Among the positive comments, enjoyment of the sessions emerged as the most liked aspect of the SRS. Those who liked peer discussions felt that it contributed to their understanding and retention of the matter, in fact, finding it a welcome disruption from the boredom of the lecture. Students appreciated getting instant feedback from the lecturer and felt increased confidence in their understanding of the topic. Students generally looked forward to the histogram showing the responses for the entire class, and were excited when their group had the correct answer. A number of students in their responses to the open-ended questions admitted to being shy or afraid to speak up in class due to fear of their peers' reactions. They appreciated the anonymity of the SRS and the fact that they could participate and be involved in small groups that provided safe spaces, very likely comprised of their friends, with whom they could share their ideas without fear. The study found that students enjoyed discussing with each other and the classroom would be abuzz with the sounds of students communicating with each other. There was an additional major benefit derived from students working in groups. 21 students who responded to the open-ended questions claimed that peer discussion helped them with understanding the topic. Most students also felt that the teaching style used allowed them to reflect on the materials covered in class.

The main drawback to the successful use of the SRS listed was the slow Internet connection provided by the University. There were also some students who indicated that they preferred to work alone rather than as part of groups. It is possible that some of these might have included high-achieving students who preferred to work alone, or introverts who were reluctant to lose the anonymity of the large class and interact on learning content with others, or some who were too timid to defend their solution to the other more dominant members of their group.

DISCUSSION

In this study the researchers examined the effectiveness of the Think-Pair-Share model in combination with the use of web-based SRS technology to promote interactivity in a large lecture class, at a University ill-equipped to support students with the required technological resources for submitting individual responses through the SRS. Students used various web-enabled devices such as smart phones, laptops, and tablets to post responses. Due to resource constraints in terms of not every student having access to a response device and the lack of sufficient bandwidth, each group posted a collective response using one device per group.

This study contributes to the existing literature on whether Student Response Systems can promote student engagement in large classes. Mayer et al. (2006) identified Student Response Systems as a technology that could be integrated into instructional design to promote student-teacher interaction during learning. The findings from this research suggest that the use of the SRS effectively enhanced student-teacher interactivity in the classroom by enabling students to participate through responses to questions from the instructor, receive feedback from the instructor during the class regarding their understanding of the course materials, gauge whether they are following the course materials, and assess their understanding of the course materials with respect to the other students in the class, by viewing their classmates' responses. Results from this study confirm previous reports documenting the benefits of using SRS in promoting engagement, encouraging participation by allowing anonymous classroom participation, and providing instant feedback and self-assessment in addition to making the classes more enjoyable (Blasco-Arcas, 2013; Mork, 2014; Latham & Hill, 2014). The findings from this research are also consistent with studies that incorporate discussion groups into the learning environment to allow for collaborative learning. Peer discussions gave students the opportunity to interact with other students, receive peer instruction to help in understanding course material, and to process material more deeply. By combining the two unique active learning pedagogies of peer discussions and the SRS, it was possible to increase both student-teacher and student-student interactivity. Most studies conducted so far used research designs which involved the use of individualized response devices, even when combined with other active learning technologies. The new finding from this study is that increased levels of student interactivity can be achieved even by using shared devices and that it is not necessary to have individualized response devices.

Though students who are highly motivated will most likely perform well irrespective of the instructional approach employed, all students, especially the weaker students, will benefit from a pedagogical approach that uses a learning environment where they are engaged and are active responders. Peer discussion forces students to formulate their thoughts and then explain their thought process that they used to arrive at their answer and convince others of its correctness. According to Lantz (2010), "understanding the meaning of material is instrumental in memory and learning". Lantz stated that not only do students process deeply when attempting to respond to a question, but this processing is even deeper during peer discussion where "students will be able to consider points made by other students that they might not have considered". However, there were a few students who indicated that they preferred working alone or that their contribution was overlooked by others in their group. This is one of the drawbacks of group discussions, where it might be dominated by one or two members, making other group members feel slighted.

Using SRS in conjunction with peer discussion created interest, involved students, improved understanding and resulted in more interactive classes. It was also noted that students were more focused and were quite attentive for most of the class as compared to a normal lecture where their attention span tended to diminish after the first hour of class. The researchers attribute this to the incorporation of the short sessions of lecture and quiz activity as compared to the sustained three-hour long lectures. As stated by a student in response to the open-ended questions, "It is really hard focusing for 3 hours. Group work is like taking breaks".

In addition to promoting interaction between students, there was greater interaction between students and the lecturer as compared to traditional lectures. When the lecturer asked students to explain why they had chosen a particular answer, a number of students as compared to traditional lectures were quite animated in their responses. Interestingly, not only did more students speak out, but it also encouraged some of the usually quiet students to respond, especially when they realized that they had the correct answers. It is possible that the process of peer discussions provided them with increased confidence to express their responses openly. When the lecturer provided the correct answer to the lecture questions, there was usually great jubilation from the set of students who had answered the question correctly. Students appeared to look forward quite keenly to the lecturer providing the correct answer and in seeing how the questions were answered by their classmates. The students clearly enjoyed this part of the lecture as it added a sense of anticipation. The more questions students got correct, the more confident they seemed and responded with increased enthusiasm. It also seemed to the researchers that there was a certain amount of competition involved between the various groups. However, consideration must be paid to the fact that since the students worked in groups, it was impossible to use the SRS to assess the actual understanding and learning of individual students. Not all members of the various groups may have played an active part in the discussions or some groups may have been dominated by one or two persons.

The main issue encountered by the researchers in using the SRS was a slow Internet connection that resulted in more time than anticipated spent on students establishing the initial connection and sending their responses. Additional preparation was necessary by the lecturer in order to design questions for each lecture session to be used with the SRS. Also, administering these questions and addressing the solutions to these questions used up considerable class time, resulting in not all the anticipated material for the lecture being covered during that class. A possible solution would be to get the students to read ahead before coming to class, so that class time could be spent on the material that they might have found hard to understand.

CONCLUSION

Based on the results from the research, the Think-Pair-Share model in conjunction with the use of Student Response Systems was successful in promoting student interactivity in a large class of 239 students with limited technological resources. The SRS was useful in increasing student engagement by enabling students to post responses to the instructor stimulus, especially anonymously. However, benefits of higher order thinking were achieved through peer discussions. While integration of SRS into a classroom can foster student-instructor interactivity, the combined use of SRS and peer discussion develops student-student interactivity as well. Even though each student was not able to post individual responses, the results of the post-test survey suggest that the majority of the respondents were found to have been actively engaged in the classroom. The results of the t-tests ($t = -53.6$, $p = .000$) show a significant difference between the means for the pre-test and post-test groups indicating that the intervention improved student interactivity. It is thus possible to use student response systems successfully in large classes even when the resources for providing individual responses are unavailable. Overall, 212 out of the 217 respondents (97.7%) who took part in the post-test survey indicated that they would want the SRS to be used in all their courses.

However, since the study was conducted for a period of four weeks only, there is a possibility that the results might be different over a longer period of time. It is possible that the novelty of the technique gave rise to increased enthusiasm and interest. Further studies will need to be conducted in order to assess whether the high levels of involvement and interest can be sustained over the period of an entire semester. It is significant that class attendance remained stable over the course of the SRS study. This might be attributed to the students' self-professed enjoyment of the classes and their increased self-perceived understanding of the topics covered. Credé, Roch, &

Kieszczynka (2010) have shown attendance to be a strong predictor of academic success among undergraduate student populations. Further research would be needed to see if the use of the SRS can help maintain a high level of attendance through the semester.

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