Team-based approach using Student Response Systems in Mathematics Tutorials

Patrick Tobin, Con Lozanovski, Carole Haeusler

Team-based approach using Student Response Systems in Mathematics Tutorials

P. Tobin, C. Lozanovski
Faculty of Arts & Sciences, Australian Catholic University, Australia
Patrick.Tobin@acu.edu.au, Con.Lozanovski@acu.edu.au

and C. Haeusler
Faculty of Business, Law, Arts and Education, University of Southern Queensland, Australia
Carole.Haeusler@usq.edu.au

Student Response Systems (SRS) have been used widely in higher education as part of active learning and teaching initiatives within lectures. The technology also shows potential in enhancing the student experience in tutorials, in addition to many other benefits. In this study we combine the technology with a team-based approach as part of traditional Mathematics education courses. The focus is on implementing this technologically endowed pedagogy within a tutorial environment. The pedagogical approach developed here is founded on a two tier student response method based on group discussion. The first tier involves individual student responses while the second hinges on group responses. Students receive invaluable, multifaceted, feedback throughout the tutorial from the technology itself through displayed results, the tutor and peer-feedback from team members. An analysis of the data reveals a remarkable polarization of group responses to the correct answer in most cases. To explain this phenomenon we briefly explore a connection between group dynamics and the use of technology that allows for individual anonymity (such as SRS). Finally, we also speculate on the impact of absentees and individuals rejecting the technologically driven pedagogy.

Keywords: Student Response Systems; Clickers; Tutorial

Introduction

Student response systems (SRS) [1] involve students responding directly in class to short questions posed to determine conceptual understanding. These questions allow the lecturer or tutor to gauge the effectiveness of learning transfer in a class. Commonly students use small input keypad devices ('clickers'; 'zappers') to signal support for an option among those presented to them with a question stem. Multi-choice and true false questions are usually posed – sometimes mixed together – and displayed by prepared PowerPoint slide. The responses are automatically collected and the results displayed in the form of bar-charts for further discussion by the class. The idea has been around for many years (Horowitz, 2006) but only recently have systems been sufficiently affordable and reliable to be widely used. Changes to technology also made systems compact, portable, wireless and easy to use. Even the wireless systems have undergone changes from infrared use to radio frequencies to increase efficiency and reduce

[1] Also known as Audience Response Systems or Personal Response Systems.

collection errors. Increasingly Smart Phones can be used with associated software replacing the need for dedicated hardware.

The use of SRS has gained widespread acceptance across broad disciplines at tertiary level. In Mathematics, teaching staff view this technology as an opportunity to instil the practice of active teaching and learning – much needed in modern day Mathematics lectures (Larsen, 2006). This promotes feedback, for staff and students, which is an essential aspect of Mathematics pedagogy. The overall approval by students and their positive perception of the technology in supporting meta-learning has fuelled the development of this technology (see, for example, Kay and LeSage (2009) and Caldwell (2007)). This has been reinforced by the recent surveys carried out on pre-service primary Mathematics education courses by Haeusler and Lozanovski, (2010) and Lozanovski et al (2011). The majority of these students agreed that the technology, implemented in a particular way, is helpful and engaging. The technology is well suited and compliments pedagogy in the mathematical sciences (Retkute, 2009). The use of SRS can be adapted to most classroom situations, from large lectures to small groups within tutorials. In fact by 2006 it was estimated that some use of SRS existed in almost every university in the USA (Titman and Lancaster, 2011).

A broader use of SRS is in team-based learning (Haeusler and Lozanovski, 2010) within tutorials. In this application the students form small teams which remain unchanged throughout a course. They respond to questions as individuals and as a team where there exist and opportunity to reflect on the results and review individual opinions. Feedback, in the form of bar-charts and discussions with teaching staff, plays an important role in this process. Team-based approaches by definition relinquish one of the key advantages of SRS, that of anonymity (Stowell et al., 2010). However, this is done within a small team which serves to inform through group discussion among team mates as opposed to the entire class. It is the focus on use in tutorial teams which is our aim here.

In this study we show that an analysis of the data collected from the SRS software reveals a remarkable polarization of group responses to the correct answer in most cases. To explain this phenomenon we briefly explore a connection between group dynamics and the use of technology that allows for individual anonymity (such as SRS). These results promote the two tier approach, as applied in this study, to be a viable learning and teaching, technologically driven, pedagogy. Finally, we also speculate on the impact of absentees and individuals rejecting the technologically driven pedagogy.

Methodology, Implementation and Practicalities

This study draws from a course in Mathematics education offered in the faculty of education USQ Springfield Campus. The education course is compulsory for all students enrolled in the education degree, either taken in first year or the second year. However, it is important to note that the cohorts are made up from a mixture of students from various year levels, for example, due to part time enrolments or failing the course on previous attempts. The data presented here was collated from the first year cohorts in semester 1 of 2011. There were three (repeat) Mathematics tutorials and students were asked to attend one. In all courses in the faculty students are required to attend practicum over a three week interval during semester[2]. This has the effect of significantly reducing the student numbers over this period and, consequently, this has been screened from the data sample by simply selecting a week where all students were present. Clearly, a more comprehensive analysis would require data obtained from a longitudinal study. However, the sample obtained is sufficient for our study.

In this course students attended a traditional on hour lecture and a two hour tutorial. Clickers were used throughout the course; however, the method and implementation fundamentally differed between the lectures and tutorials. This study focuses on the tutorial scenario and complements a recent investigation implementing clickers in lectures (see Lozanovski et al, 2011, for more details). In lectures students were instructed to pick up their "clicker" upon entry for use in class – each student was assigned a clicker number for the entire semesters work[3]. Students would then be asked (as individuals) three (3) multiple-choice and/or true-false questions per one hour lecture. The lecturer would first read the question to the class and the possible answers (in the case of multiple-choice questions). Students would then respond to the question by depressing a number on their key-pad corresponding to the choice they determined was correct. Then the overall response to a question was displayed on a bar-chart for the entire class to review. Finally, a classroom discussion would then address any misconceptions. In the event that such discussions did not clarify the issues and concerns of the students the lecturer would inform the teaching team to focused and resolve these problems during the tutorial.

In tutorials students were also instructed to pick up their "clicker" for use in class. However, the similarity with the lecture scenario ends there since the important issues when implementing the "clickers" in lectures, e.g. time constraints (see Lozanovski et al, 2011), were not an issue in tutorials. In fact, the technology was seamlessly incorporated into the tutorial setting with ample time for reflection and discussion. The pedagogical approach developed for the tutorials is founded on a two tier student response method based on group discussion. The first tier involves individual student responses while the second hinges on group responses. Ten "clicker" tutorial questions were presented over the two hour tutorial (see Appendix). Each question was presented in a multiple choice format using PowerPoint[4] with TurningPoint2008 as an add-in. Primarily, the multiple-choice options were used to gauge understanding and provoke discussion, both within groups and the whole class. Initially, as individuals, students responded by depressing the corresponding number they assumed was the correct answer on their keypad. The result, in the form of a histogram, was then presented to the entire class and students were instructed to initiate discussions within their groups. The (same) question with its multiple-choice options was then reset and each group was instructed to submit their results. This was done collectively. Finally, the group results were displayed, again using a histogram and a class discussion followed. It should be noted that it was observed that the majority of students had no issues using the

---

[2] This was further complicated since the timing of each three week internal differed with respect to the year level of the student.
[3] Clicker numbers were not recorded, however, served as a useful means of facilitating the logistics of distributing the clickers each week.
[4] This required Window PowerPoint together with the, third party, proprietary software by *TurningPoint 2008©.*

technology at the first tutorial after having encountered them during the first lecture of the course.

The size and number of groups per tutorial was neither fixed nor predetermined[5]. Students were instructed to form a group no larger than eight in number and no fewer than three. However, the group numbers varied throughout the semester due to absentees and inter-movement of students from one tutorial class to another (for example, due to personal timetable clashes). Recall, our sample was taken for a select week where the total number of students was maximised for the semester. Interestingly, it was generally observed that students formed groups with others already seated in close proximity[6].

Analysis

In accordance with the pedagogical approach reported in this study a correct individual response is defined to be an individual (student) who chose the correct response to the multiple-choice/true-false question. In the first instant (responding as individuals), their decisions were assumed not to be influenced by the group or any other member of the tutorial. A correct group response is defined as a (student) group who chose the correct response to the multiple-choice/true-false question after engaging in group discussion. The group response was agreed to by its members but not enforced; individuals could decide to reject the agreed response in favour of their own choice without having to inform either the group or tutor. Interestingly, it was observed that even if students were aware that the process of using “clickers” carried no penalty they generally did not just guess randomly.

The percentage of correct responses by individuals increased from 41.2% to 69.8%. From a bar graph of the correct responses to all 10 questions based on groups it is clear that some group pressure substantially affected the responses in the correct direction, see Figure 1. The chance of an individual response being right was quite low *ab initio* but after discussion this settled to a reasonably high success rate. From a group dynamics perspective the minority who originally held the correct response here clearly were seen by their peers as persuasive and these students must have had firmer resolve.

It is important to note that the multi-choice questions with one correct response had four distractor responses. Hence the probability of an individual purely guessing a correct response is 0.2. For a group of five students acting independently (initial response situation) the probability of 3 or more getting this response correct is about 0.057. When students discussed the available choices in their groups, we can assume persuasion would influence decisions. In Figure 2 we see that initial correct responses for the ten questions the whole cohort varied from 28% to 48%. This was better than chance but not very good. Following the group discussion, we saw for nine of the ten questions students were able to respond correctly between 55% and 95% of the time. The difference in overall response from initial to final was clearly significant.

---

[5] This is in total contrast to methods such as Jigsaw (Aronson, 1978).

[6] Initially, students had the freedom of choosing where to sit in the tutorial room and with whom to sit next to.

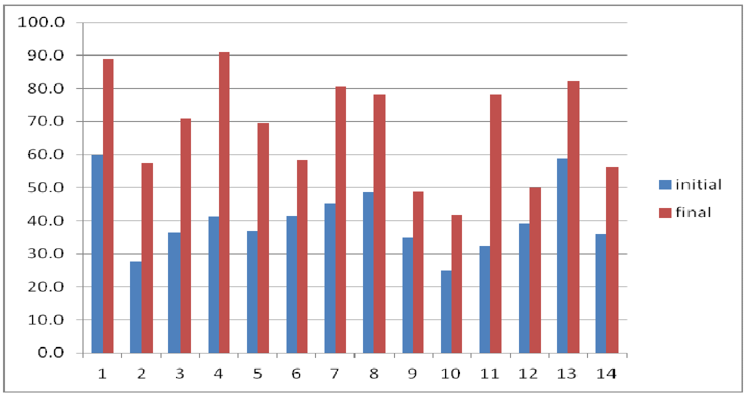

Figure 1: Percentage correct responses for all questions based on each group

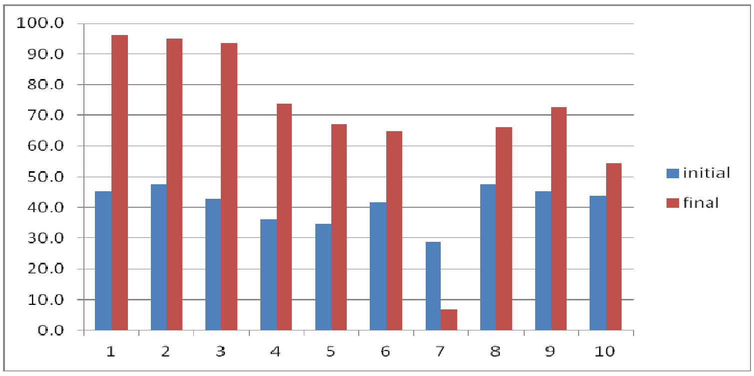

Figure 2: Percentage correct responses for the whole cohort for each question

On the remaining question (7), students' performance declined and it was clear that incorrect explanations or misconceptions were reinforced in the group discussions. These situations provide tutors with a chance to identify and address major problems. It is clear from the individual group response shown in Figure 1 and observations in class that stronger students tend to associate with stronger and weaker with weaker which may be a natural group dynamic.

Group Dynamics, Student Perception and Benefits of Group Work

Small group problem-solving within a tutorial setting can improve student learning, student motivation, and be used as a tool to help manage large class numbers (Webb, 1989). The concept of small group learning has been a around for a long time (Wagner, 1982) but only recently has this been supplemented with technology such as student response systems (Titman and Lancaster, 2011). There have been numerous studies of the types of interactions among students that assist or hinder learning and the factors that lead to these types of interactions (see, for example, Webb and Cullian (1983)). It appears that small group learning success is dependent on good assistance from teaching staff more than just topic knowledge (Silver and Wilkerson, 1991).

Students have different abilities and backgrounds in Mathematics. In this study it was observed that group leaders naturally arose though students were not given specific roles as would be the case in peer tutoring. It was observed that group leaders were decisive and capable students who usually steered the group in the right direction. This was confirmed from an analysis of the data showing substantial increases in correct responses submitted per group. This increased from 41.2% initially to 69.8% for the final submission.

By definition and implementation, student response systems require all information and teaching materials to be shared by all members of the group. Therefore, the method used in this study is not of the Jigsaw type (Aronson, 1978). SRS minimise the phenomena of "free-riders" as all group members must submit responses as individuals at the first stage of each tutorial question. All students in each group are encouraged to master the material by the two tier process described above. However, the results of the analysis of the data from the student response system show that not all students achieve this standard. For example, question 7 was worrying as there was a decrease in correct responses from an initial 28.8% to only 6.8% for the final submission.

The feedback to groups is immediate (Lozanovski and Tobin, 2013) and this, in turn, has some influence on the dynamics of the group members in subconsciously electing a leader. There are a number of factors to consider when analysing how a (generic) group of people elect a leader. Dominance, both academically and non-academically, could have a profound influence (Bass et al, 1953). In this study it was found that group members would more likely follow the lead of a student with the highest correct responses to the SRS questions with the fewest changes. For example, groups 1, 8 and 13 show a total of 50% or greater correct initial responses and even greater percentage of final submissions. On the other hand, group 10 present low initial correct responses with marginally higher final submissions. Note that this approach is quite distinct to methods that require only submissions of final group reports (Sharan & Sharan, 1976).

Discussion and Conclusion

In this brief study we introduced a two tier student response method facilitated by SRS technology and based on group discussion. We focused on the tutorial setting where students formed small groups and responded to set SRS questions. The first tier involves individual student responses while the second tier requires group responses. An analysis of the data obtained from the SRS software reveals a remarkable polarization of group responses to the correct answer. This was a vast improvement over individual responses. To explain this phenomenon we briefly explored a connection between group dynamics and the use of technology such as SRS. Clearly, it appears that students perform better in a group setting and there is sufficient reason to believe that group dynamics plays an important role in this success.

The results presented here certainly motivate a more in-depth study. However, there would be severe technical obstacles encountered by any methodology implementing a longitudinal investigation. On one hand, one would have to deal with the impact of absentees. This is an ever increasing issue in modern undergraduate education given that the average hours of external work that students engage in during semester exceeds

20 hours. Absentees will have a profound impact on the group dynamic especially if key members, such as group leaders, are absent. Another issue, for the investigated Mathematics course in particular, was the timing of the practicum which takes place over a three week period and is a distinct period for each year-level. Since the co-hort investigated in the study was made up of all possible year-levels this would certainly proved challenging with respect to gathering data.

Appendix

A typical question used in this study is displayed below in both versions[7]. The first is for tier 1 of the process and the other for tier 2. In the first case only individuals are required to respond and the total (class) outcome is displayed in the form of a histogram. However, the correct answer is not shown at this stage. Then the students are instructed to converse with group members and reach a consensus on their group's response. The question is then re-posed, as denoted by a red capital R next to the question. Students then collectively submit their group results. The total (class) outcome is displayed in the form of another histogram and the correct answer shown.

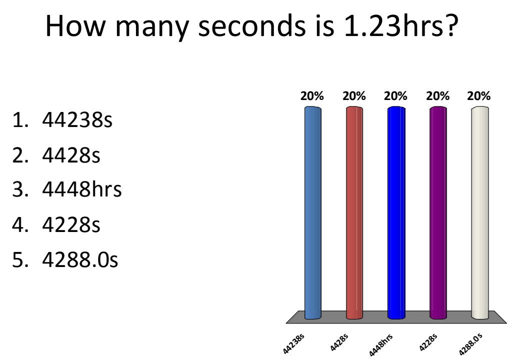

Figure 3: Example of SRS question for tier 1 where individual students' responded

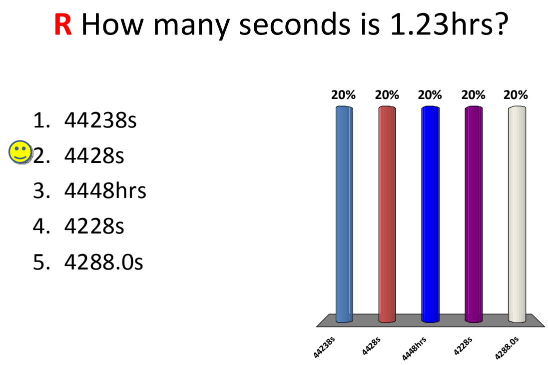

Figure 4: Example of SRS question for tier 2 (denoted with red R) where groups responded.

[7] Recall, ten questions were used in this study during a week when the student numbers were maximised for the cohort.

References

Silver M, Wilkerson L. (1991). Effects of tutors with subject expertise on the problem-based tutorial process. *Acad Med*, 66, 298–300.

Kyprianidou, M., Demetriadis, S., Tsiatsos, T., & Pombortsis, A. (2012). Group formation based on learning styles: can it improve students' teamwork? *Education Tech Research Dev*, 60, 83-100.

Webb, N. M. (1989). Peer Interaction and Learning in Small Groups. *International Journal of Educational Research*.Vol. 13, pp. 21-39.

Wagner, L. (l982). Peer Teaching: Historical Perspective. Contributions to the Study of Education Series. Westport, CT: Greenwood Press.

Titman, A and Lancaster, G (2011). Personal Response Systems For Teaching Postgraduate Statistics To Small Groups *Journal of Statistics Education* 19 (2), 1-20

Webb, N. M., and Cullian, L. K. (1983) Group Interaction and Achievement in Small Groups: Stability Over Time. American Educational Research Journal September 21, 20: 411-423

Aronson, E. (1978). The Jigsaw Classroom. Beverly Hills, CA: Sage.

Lozanovski, C. and Tobin, P. (2013). Optimising Student Response Systems for Feedback and Higher-order Thinking in Mathematics. http://telearn.archives-ouvertes.fr/hal-00866662, 1-10.

Sharan, S.. & Sharan. Y. (1976). Small-group teaching. Englewood Cliffs, NJ: *Educational Technology* Publications.

Bass, B. M., McGehee, C. R., Hawkins, W. C., Young, P. C., & Gebel, A. S. (1953). Personality variables related to leaderless group discussion behavior. *Journal of Abnormal and Social Psychology*, 48, 120-129.

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *Life Sciences Education,* 6(1), 9-20. http://www.lifescied.org/cgi/reprint/6/1/9.pdf

Horowitz, H. M. (2006). ARS evolution: Reflections and recommendations. In D. A. Banks (Ed.), *Audience response systems in higher education* (pp. 53-63). Hershey, PA: Information Science Publishing.

Kay, R. H. & LeSage, A. (2009). A strategic assessment of audience response systems used in higher education. *Australasian Journal of Educational Technology*, 25(2), 235-249. http://www.ascilite.org.au/ajet/ajet25/kay.html

Retkute, R. (2009). Exploring Technology-Based Continuous Assessment via Electronic Voting Systems in Mathematics and Statistics, *MSOR Connections,* Vol 9, No 1, 24-28.

Lozanovski, C., Haeusler, C. and Tobin, P. (2011). Incorporating Student Response Systems in Mathematics Classes., In J. Hannah and M. Thomas (Eds) *Delta Communications*, University of Canterbury and University of Auckland, 238-247.

Haeusler, C. and Lozanovski, C. (2010). Student perception of clicker technology in Science and Mathematics education. In: CETL 2010: Enhancing Learning Experiences in Higher Education, 2-3 Dec 2010, Hong Kong.

Larsen, M. D. (2006). Advice for New and Student Lecturers on Probability and Statistics *Journal of Statistics Education* 14 (1).
http://www.amstat.org/publications/jse/v14n1/larsen.html

Stowell, J. R, Oldham, T., and Bennett, D. (2010). Using Student Response Systems to Combat Conformity and Shyness *Teaching of Psychology* 37 (2) 135-140