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Using Technology as a Partner yo Encourage Action Learning in Class

Ina Louw, Department Mathematics and Statistics, Tshwane University of Technology, South Africa
Louwcj@tut.ac.za

ABSTRACT

Mathematics is a subject where action learning and active learning is needed to enable students to progress adequately. Large class groups make it difficult for lecturers to ensure active participation by all students. A Personal Response System (known as clickers) was used in this study to allow regular practice of newly taught principles. I collaborated with a colleague who is an instructional designer for the needed technical support in this project.

In this paper I will present work in progress and I will focus on the challenges faced when using technology to improve learning, but I will also share the triumphs for the students and me. The clickers were used to monitor class attendance, as well as to answer multiple choice questions presented regularly during lectures. The answers to these questions had to be calculated by students (or groups) during the lecture. Student responses were represented by bar graphs and I could establish the level of understanding, as well as the exact misconception that existed. This information shaped my presentation for the next day. I used the four moments of action research – plan, act, observe and reflect on a daily base. I used the knowledge from the previous lecture to inform my practice for the next lecture. The software associated with the package also keeps a record for each student and these marks could contribute to their progress mark, resulting in less administrative work for the lecturer.

Some advantages of this approach are that students are encouraged to attend lectures and do their homework more regularly. Their "time on task" is increased and their level of participation in class is also increased. The responses from students made their specific lack of knowledge evident without them having to ask questions for clarity.

I. INTRODUCTION

Mathematics performance in higher education is a global problem and many authors have alluded to that fact (Valverde 1984; Stevenson 1987; Gerardi 1990; Nongxa 1996). Lecturers have to cope with an ever-expanding list of demands when students arrive at higher education. In South Africa, as elsewhere in the world, students arrive at higher education with different schooling experiences; levels of prior knowledge; learning cultures; learning styles, meta-cognitive skills, backgrounds and motivational levels (Oliver 2007). In this paper I want to argue that if a lecturer uses technology appropriately, engages the students intellectually, acts as a role model and creates emotional rapport with the students, positive student progress is almost inevitable.

Abrahamson (2006:13) asserts that it is hard to model scientifically what it is that teachers do when teaching, but continue to say that an effective learning environment is learner centered, knowledge centered, assessment centered and community centered. Students should not expect that knowledge will be "transferred" to them; they have to construct the new knowledge for themselves (Goff, Terpenny and Wildman 2007).

Large lecture groups in higher education globally add other factors to the equation. Students experience a lack of individual attention, they engage less often and more superficially, they experience problems with learning resources and they do not have sufficient learning support and assistance (Oliver 2007). In South Africa, at a university of technology, it is very likely that the student is a first generation student and that the support and understanding they receive from their families to sustain their studies, is not adequate.

Audience response systems (clickers) are used for more than a decade now in other parts of the world, but mostly in interactive (online) classrooms. In my institution I do not have access to such a classroom and had to adapt the methodology a bit. I wanted to use clickers to monitor class attendance (Lowery 2005), to give immediate feedback and to enable the students to see and discuss their results immediately (Wrzesniewski 2008); to discover and remediate misconceptions sooner (Wrzesniewski 2008); to achieve more active participation (Lowery 2005); to strive for greater student satisfaction (Lowery 2005) for the Millennial learners (Vernaza 2007) in order to retain their attention.

I partnered with an instructional designer who is doing her PhD and she wants to investigate if clickers can enhance deep and active learning. She performed learning style questionnaires and investigated her issues, while I wanted to increase student activity in and outside the classroom, as well as time on task (Owsten, 2007) to determine if regular practice will improve their final mark in mathematics. I also wanted to draw on my previous knowledge about action learning and action research (Zuber-Skerritt 2003) and agreed with Revans (1998) in assuming that learning means to be more efficient economically, more truthful socially, and less pretentious personally.

II. PROCEDURE

Clickers are little remotes that are used by the students to log in their response to a multiple-choice question. The lecturer's laptop is connected to a radio frequency receiver that receives the responses and the results are immediately available in either a bar chart or pie chart. Possible misconceptions can be discussed and clarified by supplying additional explanation before continuing to the next topic. The software used is TurningPoint and it operates similarly to PowerPoint. In Figure 1 a slide with the question and the graph of the responses is shown.

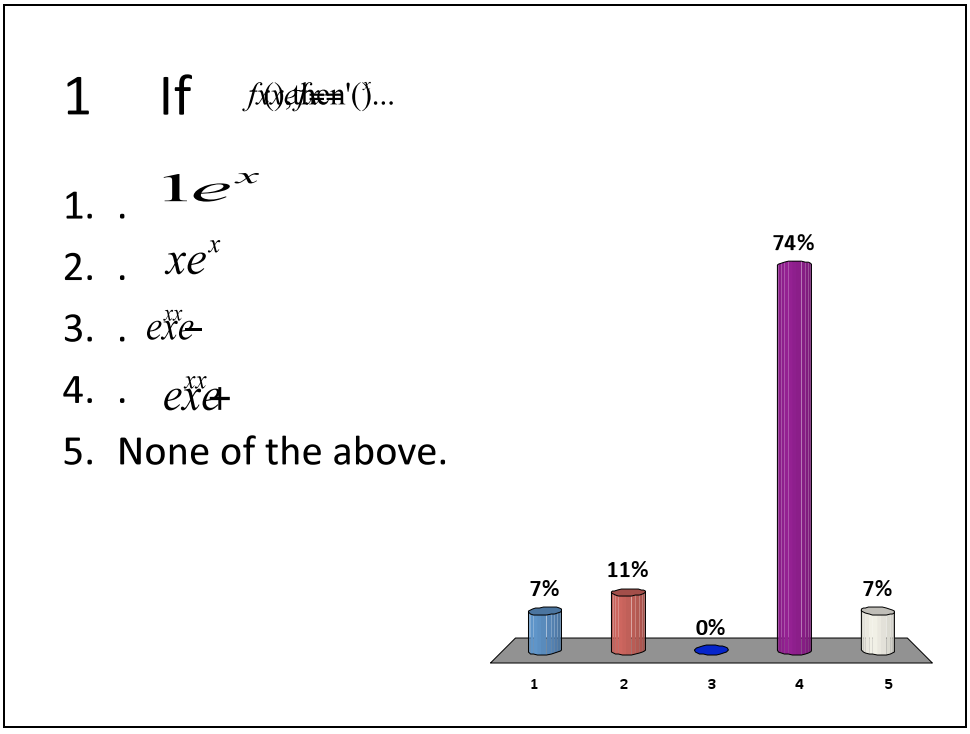

Figure 1. Bar chart of the responses for a clicker question

In this particular study, I didn't use clickers every day, since I see clickers as a "tool" and not a "solution" (Beatty, Leonard, Gerace & Dufresne 2006). I only used clickers when I wanted to assess students' understanding of concepts. I typically constructed four multiple-choice questions and displayed the questions without the distracters on the screen. Students then got the opportunity to solve the problems on paper for a predetermined timeframe and finally I would allow them an opportunity to look at the distracters and log in their answers on the TurningPoint system. A definite timeframe is adhered to again. At the end of all the clicking, we discussed the answers that were supplied and cleared up all possible confusion. Sometimes I allowed them to work in groups to formulate a consensus answer for the group in order to foster collaborative learning.

I quickly discovered that students were guessing the answers when they did not have one of the distracters on their paper, despite the option: "None of the above" that made out a possible option in every question. By that time I already had emotional rapport with the students and they knew they could trust me. They also knew that the "marks" for the clicker tests were not credit bearing. I therefore asked them to indicate when they have guessed the answers. A clicker "test" would typically consist of four mathematics questions (questions 1,3,5,7) and four identical questions asking: "Did you guess the answer to the previous question" (questions 2,4,6 and 8). These answers about the guessing were also logged into the system and the results were shown to students. I sometimes collected their rough work papers to investigate their "original" answers and could see exactly what they answered before they made their guess. This is, however, very time consuming.

During the very next lecture period I would follow on this session by letting them practice carefully selected problems during class and volunteers write their answers on the white board. I would put four questions on the board simultaneously and four students will complete them and then sit down. A class discussion will follow and I would use the opportunity to correct notational errors. Students know by then, that mistakes are learning opportunities and nobody experiences the session as stressful. As the semester continues I allow students to improve on the answers by using another colour ink. In that way we can still see the original attempt and can discuss the reasons for the incorrectness.

Ultimately I didn't include the marks of the clicker tests in the calculation of their progress mark due to the high rate of guessing. I didn't want them to enter into the examinations with an inflated year mark.

III. METHOD

This two-in-one-study has a mixed method design and my part is done with an action research approach. The doctoral student has a case study design and uses observations, questionnaires, focus group interviews, documents and pictures to collect data. She determines the learning style of each student at the beginning and end of the semester, using a standardized questionnaire. I haven't used the learning style results in this paper, but I have access to the data for future use. I also have the transcriptions of the focus group interviews and I worked through those to determine student attitude regarding the use of clickers.

For my part of the study, I have used observations, focus group interviews, the institutional lecturer's evaluation form and assessment documents to collect data during the first semester of 2010. Semester One of 2010 was the pilot study for the doctoral student and I didn't want to put her study at risk, thus my research aims were structured in such a way that it would not interfere with her study. I also had to play a supportive role in her study.

Every semester should be seen as an action research cycle consisting of many iterations of plan-act-observe-reflect. During the previous semester a typical mathematics lecture developed according to the following strategy. During the **plan** phase I planned:

- a structured and organized presentation based on the learning objectives;
- content to be shared and examples to be used that will be appropriate for the subject matter;

- the appropriate technology to be used;
- activities to be done in class and for homework; and
- class room assessment strategies (for example a clicker test).

During the **act** phase I facilitated student learning through an engaging presentation and by creating intellectual excitement (Lowman 1995). I had:

- clear written and verbal communication;
- a high degree of contact with students; and
- a variety of teaching aids where possible (Estes, McKune, Ressler, & Welch 2007).

Students participated in the act phase by performing the activities I planned for them. Students were willing to participate because I established interpersonal rapport with them early in the semester by being fair, available, approachable, caring and motivating (Lowman 1995).

In the **observe** phase I observed the dynamics in class. I established their levels of enthusiasm, participation, positive rapport with me and overall attitude towards the classroom activities.

The **reflect** phase consisted of me evaluating the outcomes of the classroom assessment. The different kinds of formative assessments were paper-based tests, clicker tests and working on the board during the lecture. My reflection on the results of these assessments enabled me to **plan** my next lecture by remediating the misconceptions that were present during the previous lecture.

During the current semester I will be making use of "one minute papers" and "muddiest point papers" (Angelo & Cross 1993) to collect more data about students' perceptions of the learning process. In a one-minute paper students are asked to summarise the main learning point and in muddiest point papers they have to identify the topic that needs the most clarification (Estes *et al*. 2007). Both these methods are forcing students to reflect on their learning during a particular lecture period. This reflection will enable me to **plan** my next lecture according to the needs that were expressed in the reflection papers and the misconceptions that were displayed on the bar graphs of the clicker test.

IV. RESULTS AND DISCUSSION

I am going to start with the academic results, then the issues about guessing and finally the students' perceptions from the evaluation questionnaire and focus group interviews.

The results given here are for the subject Mathematics I (MAT171T) of students who are studying the Diploma of Civil Engineering. The class group consisted of 32 students of whom 24 were admitted to the institution through the foundation programme. This programme is designed to allow access to students who do not completely comply with the necessary academic prerequisites for tertiary studies. They then do the first semester over a year period in an attempt to prepare them to join the main stream of students. All of these 32 students failed the subject previously and were repeating MAT171T. Traditionally repeater students do not perform well when repeating a subject, since they do not attend regularly and are of the opinion that they "have seen all of this before". Due to the very structured approach that was followed, and the regular monitoring of class attendance, absenteeism was lower than usually experienced.

There was only one student who didn't get admission to the examination (a minimum of 40% semester mark) and the final pass rate for this group was 81%. The combined pass rate for the entire MAT171T cohort (all diplomas) was 45%. It would be opportunistic to assume that the excellent pass rate for this Civil Engineering group can be linked entirely to the teaching approach, since there was not a proper experimental design done. I generally have the best or second best pass rate result for the entire cohort, and this could be seen as "normal". It is also possible that the Hawthorne effect (Cohen, Manion & Morrison 2002) could have partly been responsible for the good results. This research effect recognizes that

participants increase their efforts because they know they are part of a research study. I do however think that the clickers might have played a minor role in the success rate the students had.

Although the good pass rate can been seen as a triumph, there are many challenges that needs mentioning. The setting up of the laptop and data projector in the classroom takes a lot of time. The handing out and collecting of the clickers are even more time consuming, since each student has to get a particular (numbered) clicker. The biggest challenge, however, is for me personally to arrive at the venue with all of these equipment. I have to walk nearly 800m from my office to the lecture hall, where there is no elevator and I have to go to the second floor carrying my normal teaching equipment such as a text book, pens, a brush and lecture notes. Then I also have to carry the clickers, data projector, extension cord, a laptop and power cable.

Another challenge is the guessing done by students. An example of a paired question can be seen in Figures 2 and 3.

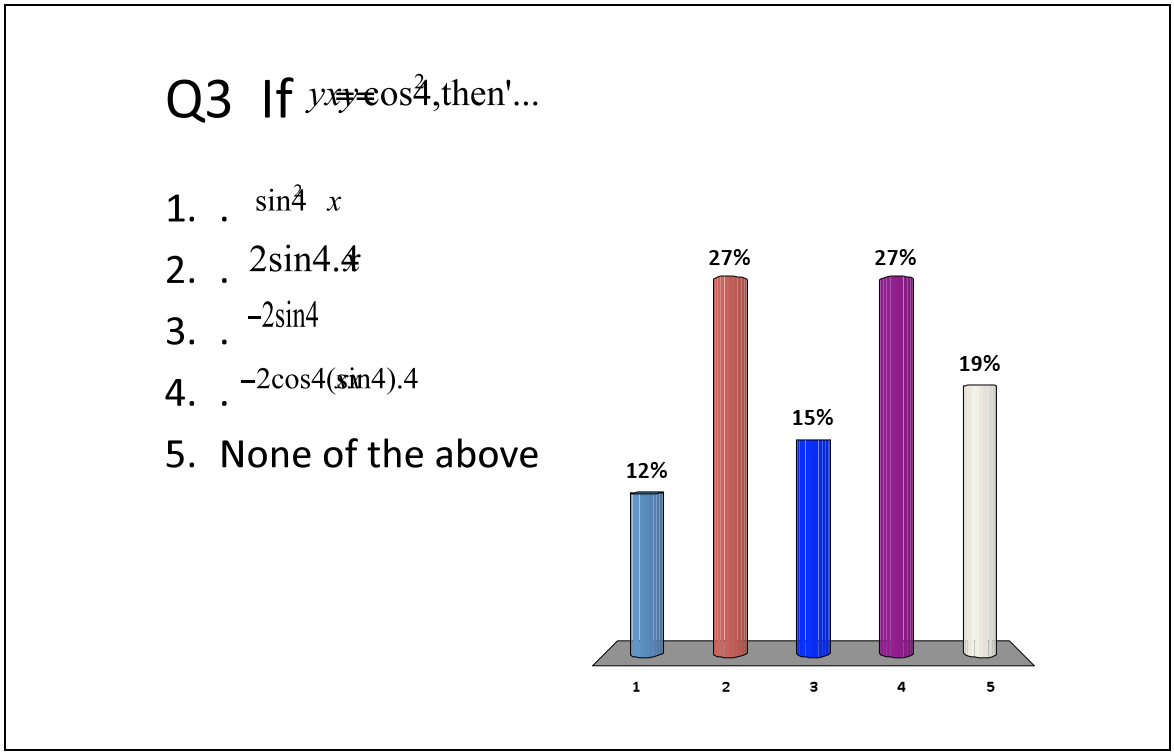

Figure 2. Bar graph of responses to a question

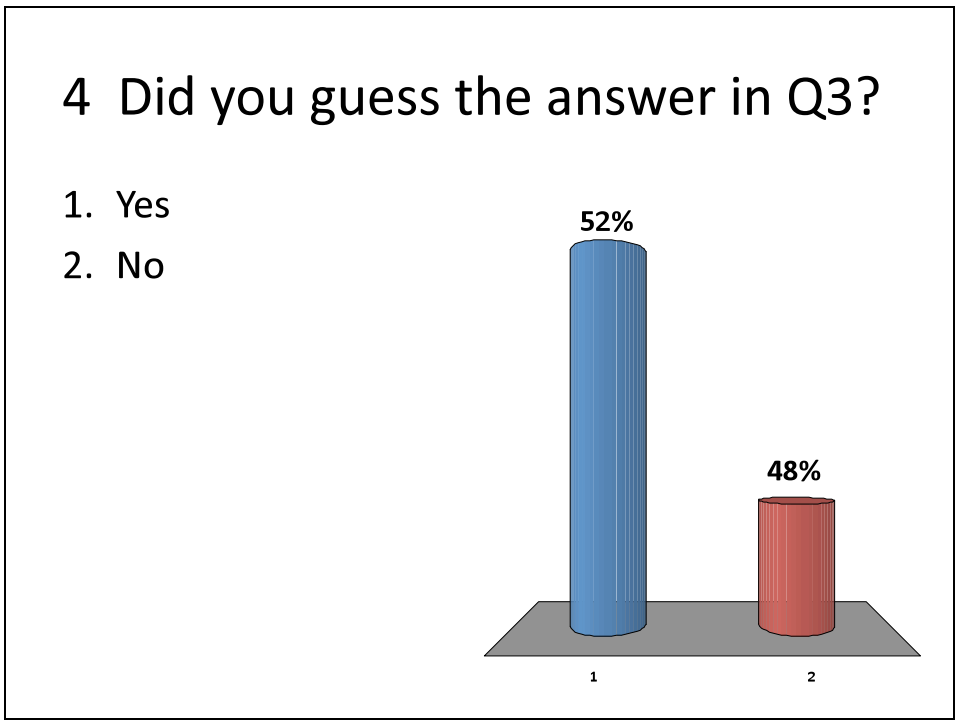

Figure 3. Bar graph indicating the guess factor

Option four was the correct answer, yet one can see that an equal percentage chose option 2. This question assessed a differentiation technique that needs practicing and the students' failure to even recognise the answer correctly, indicated their lack of practice. Further analysis of the responses revealed that in this particular question, when looking at their paper responses, the results would have looked differently if logged in truthfully. The results would have been:

Response 1:	11%
Response 2:	0%
Response 3:	0%
Response 4:	31% (The correct response)
Response 5:	58% (None of the above)

It is interesting to note that only 23% had this answer correct on their paper tests. The fact that guessing will probably never be eradicated when distracters are supplied, made me realise that I will probably continue to use these clicker tests only for remedial and formative purposes and not as credit bearing tests.

The reasons for not using the clicker tests as contributing to the semester mark are threefold. Firstly, it would inflate their semester mark and they would find the examination paper to be much harder to score in, since there are no multiple-choice questions in the examination paper. They would have a false sense of confidence entering the examination. Secondly, it would be seen as unfair by all the other students who are not exposed to clickers as a means to generate a good semester mark. Lastly, the matter of honesty amongst the students when clicking their results is a concern to me. This issue was raised during the focus group interview. The lecturer is occupied with the technology while the students are clicking; the students have to look at the screen to make a final choice and that opens up opportunities for students to see what their neighbours are choosing.

From the data of the focus group interview it became clear that students perceive the clicking part of the process to be too fast, yet they admit that when using clickers they were all forced to think and make a decision about the response to the question. They also emphasized the fact that they prefer the style of getting all the questions at once and being able to solve the problems in any order which they liked and

then having to log in their answers afterwards. They thought the lecturer was doing a good job by asking about their guessing, because that is also useful information in the remedial process. When asked whether they were of the opinion that clickers motivated them to engage in the work mentally, one respondent's answer was the following:

> I will tell you, it did not motivate me to improve on mathematics. It actually taught me just to think a little bit, but a bit faster, faster. The time allocated is less than in a conventional test. (Respondent 8)

Students were also asked to reflect on the two styles that were used in class to practice concepts, i.e. the clickers and working on the board. Surprisingly students preferred to work on the board and they claim that they learn more that way and they follow better and generally leave the class with a feeling of satisfaction that many of their "problems" were solved.

Students were not positive about the group work that I tried at two different occasions. The students were randomly grouped in groups of four to five students and the process unfolded as such:

All the questions were given up front with no distracters. Every student had to calculate his/her own answers. Then they had to go into a group discussion and communicate and collaborate to formulate a single consensus answer for the group. I collected all these paper responses afterwards. It was clear that in a situation where students are still practicing new concepts, they tend to confuse each other more than helping each other to better understanding. Two groups (11 students in total) had all the answers wrong, and nine students had 50% of the answers wrong in the group settings.

From the lecturer's evaluation form, that was administered by an administrative staff member and analysed by the Directorate Student Support and Development, the following data became available. The questionnaire consists of Likert-type questions and students agreed or disagreed with the statements. The values on the questionnaire were given as follows: 0=strongly disagree; 1=disagree, 2=agree, 3=strongly agree. The results were analysed with a software package and each lecturer received a printout with graphical and numerical data. There are four sections in the questionnaire, i.e. interpersonal relationships, communication and presentation style, assessment and study material. The field interpersonal relationships is made up by eight sub-fields and in that field I obtained an average of 93% with the highest score in the sub-field "She is easy to approach for help" (98%) and the lowest for "She expects students to work independently" (87%). In Figure 4 all eight the sub-fields for interpersonal relationship can be seen. The graphs show the average for each sub-field out of 3.

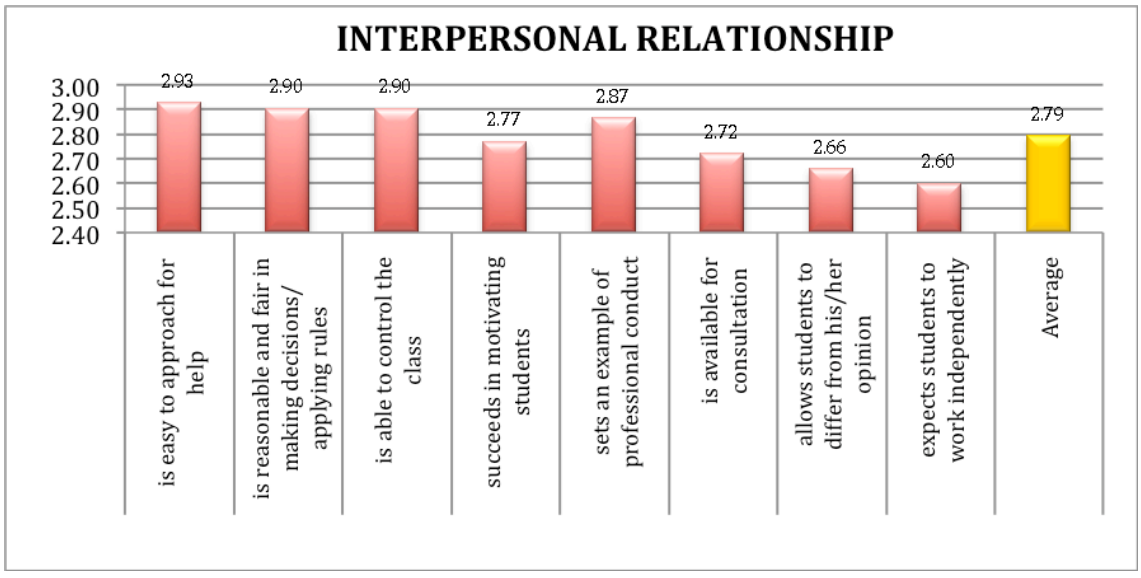

Figure 4. Graphical representation of data for interpersonal relationship

In the section about communication and presentation style I obtained an average of 93% as well. Here my lowest score was for "she applies a wide range of teaching strategies" (82%) and the highest for "She is prepared for lectures" (100%). In Figure 5 the 15 subfields for communication and presentation styles are shown.

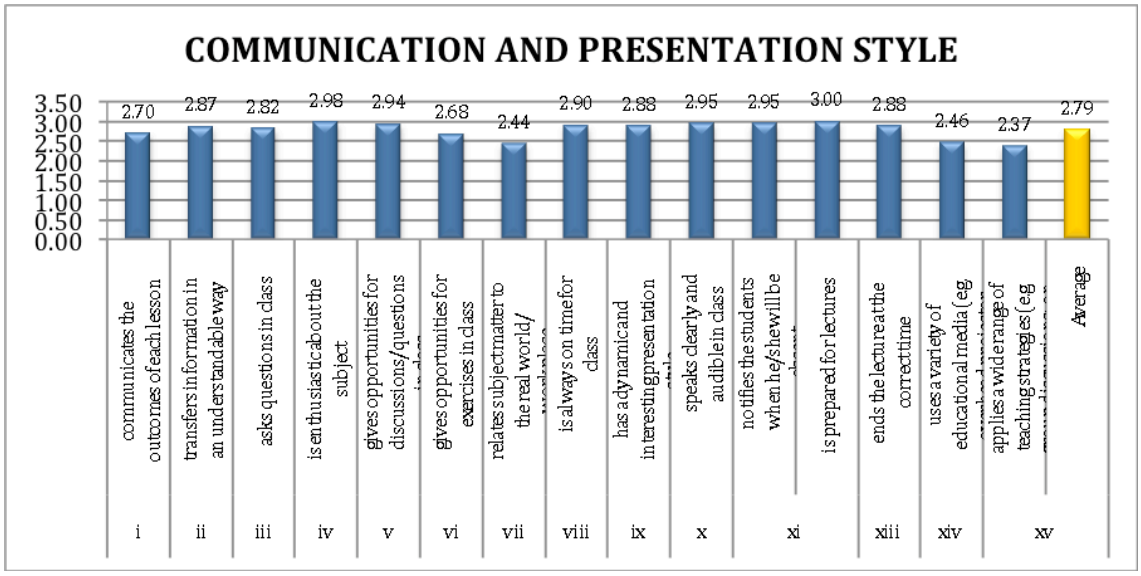

Figure 5. Graphical representation of data for communication and presentation style

In the assessment section I scored a high of 98% for two sub-sections, i.e. "She returns marked scripts within two weeks" and "she discusses the memorandum in detail". The average mark for this section was 97%. It is important to note that the institution expects lecturers to return marked assessments within two weeks, but I return my paper based tests, during the very next lecture, because otherwise one looses out on the remedial effect it could potentially have. Students can still remember what they did and their misconceptions can be rectified in time.

The data from the lecturer's evaluation form paints a gratifying picture and although the faculty does not particularly pay attention to these evaluations, it is pleasing for me to know that students acknowledge and appreciate the extra efforts made by me towards their mathematical progress.

V. CONCLUSION

I want to conclude that the success rate in Mat171T for this Civil Engineering group of repeating students can be ascribed to a variety of factors, and not only to the use of technology. Technology was used in a very specific and dedicated way by means of clickers. It was used to enhance the face-to-face situation by supporting, deepening and enhancing the students' learning through greater interaction (Abrahamson 2008). Students could gauge their personal progress without losing face in the lecture room, which is another triumph for us.

The use of clickers transforms the classroom environment to be student centered. If the distracters are carefully selected, the lecturer can identify the particular lack of prior knowledge and accommodate a variety of learning styles. The learning environment is also knowledge centered; meaning that knowledge is not merely the collection of ideas. Students should be guided to realise that information is raw material of useful knowledge (Beatty, *et al*. 2006). Lastly the classroom becomes assessment centered. The clickers provide immediate feedback and students can be assisted to change their misconception to better understanding. It also guides the lecturer to design the next lecture in such a way as to address the identified lack of prior knowledge.

The fact that there were only 32 students in the group was also a contributing factor. I reach out to struggling students and try to motivate and assist them. In a class of 80 students I can firstly, not identify the struggling students so easily and secondly, I do not have enough time to spend with individuals to bring about a sustainable change.

In this paper I showed how I used technology appropriately as a tool and not as a solution. I succeeded in engaging students intellectually, because they all had to select answers after calculating a personal attempt on paper. I also engaged them in well-prepared lectures, and during these lectures they spent "time on task". I acted as a role model by being enthusiastic, dedicated and task oriented. They knew that their paper tests would be returned at the next lecture, yet they were still always impressed that I could maintain that good practice. I created emotional rapport with the students because I care. Students can very effectively determine if a lecturer honestly cares or only makes the right noises. Maybe these were the only factors contributing to the success of my Civil Engineering students, but maybe there are others as well. I will not stop seeking ways to make mathematics more accessible to the masses. Africa needs her children to be academically, technologically and emotionally ready to lead the new generation into a sustainable future and I want to play my part in it.

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