An Evaluation of the Effectiveness of the use of Multimedia and Wiley Plus Web-Based Homework System in Enhancing Learning in The Chemical Engineering Extended Curriculum Program Physics Course

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Abstract: Today's 21st century students are regarded as 'digital natives', who are influenced by digital environments for acquisition of information, communication and interaction. With the emergence of new technologies, educators are encouraged to find meaningful ways of incorporating these technologies into their classrooms. The practice currently in South African classrooms is still the traditional lecture method, which poses limitations on students' learning due to its frequent lack of interaction and communication between students and educators. As a result, there is a need for educators to adjust their teaching methods and create learning environments that stimulate dialogue and engagement in and outside the classroom. This paper presents results of an evaluation of the effectiveness of the use of Facebook social media as communicative media, Clicker technology as an interactive medium, and Wiley Plus web-based homework system as an adaptive medium for enhancing learning through interaction and dialogue activities in and outside the first year Physics classroom as described in Laurilland's framework. Both quantitative and qualitative methods of collecting data were used in this study. A student feedback questionnaire and focus group interviews were carried out to elicit students' opinions on the effectiveness of the use of these technologies in the first year introductory Engineering Physics course. Quantitative data on student performance was analysed using descriptive and inferential statistics, while qualitative data was analysed using inductive strategy. Results showed that the use of Clickers and Facebook facilitated interactions between students and their teacher, in and outside the classroom, which resulted in deep and meaningful collaborative learning of the subject content. This resulted in better student performance in the homework and assignments done on the Wiley Plus web-based homework system, which may have contributed to the good performance of the students in both mid-term Examination and Final integrated Summative Assessment (FISA).

Keywords: Clicker technology, Facebook, and Wiley Plus, Web-based homework

1. Introduction

The inclusion of technology in the classroom has revolutionized the education environment and impacted on the way students learn and access educational materials (Cobcroft et al., 2006). Most of the learners populating today's classroom in South African universities and colleges use different digital technologies to support their learning (Jaffer, 2007). In the classroom, technology encourages inquiry, enhances communication, production of learning materials, and helps students express themselves better (Baek et al., 2008). In Engineering and Sciences classrooms, the use of technology helps students to participate in classroom activities and understand content faster (Ivala & Gachago, 2012). Furthermore, technology also helps educators to provide timeous feedback to the learners (Laurillard, 1997, 2013).

The social network site (SNS) Facebook enjoys high popularity among university students, who use the technology to create a platform for community of practice outside the classroom as described by Bosch (2009). Facebook as an SNS promotes active participation, connectivity, collaboration, community and sharing of knowledge and ideas amongst its users (Ivala & Gachago, 2012).

The inclusion of Clicker technology in classroom instruction has been reported by many researchers to improve educator-learner interaction and provide a space for active participation by all students. In South Africa, the use of technology such as Clicker combined with interactive media to enhance learner active participation, collaboration and engagement is still in its infancy, with little research published in the field (Gachago et al., 2011).

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The use of web-based homework (WBH) online systems has rapidly been growing in the education sector, especially in the developed countries (Bonham *et al.* 2003). College researchers in the area of mathematics, physics and science related courses recognize the importance of homework assessment, provision of instant individual feedback to students and its impact on students' academic performance (Bonham et al*.,* 2003). However, providing individualized instant feedback to students is nearly impossible and time consuming. Hence, there is a need for designing ways of providing instant feedback to students. As a result, this has led to the development of Adaptive software packages such as Wiley Plus online media, which allow students to complete homework assignments online.

This study used Laurilland's conversational framework to evaluate the effectiveness of Clicker technology as an interactive medium, Facebook SNS media as communicative medium supporting the "discursive activities" and Wiley Plus web-based homework system as an adaptive medium to enhance learner dialogue, learner and educator interactions, active participation and collaborative learning in and outside the classroom.

The main aim of the study was to evaluate the effectiveness of the use of a combination of multimedia such as Facebook, Clickers and Web-based homework system Wiley Plus, in supporting different learning outcome using Laurilland's conversation teaching and learning framework. **This study was guided by three main objectives:**

1. To evaluate the impact of Facebook SNS as a communicative medium on students' performance in a first year ECP Physics course. Analysis of students' academic learning activities on Facebook outside the classroom were conducted.

2. To evaluate students' experiences on the implementation (piloting) of the Clicker technology as an interactive medium in an ECP first year Physics course.

3. To evaluate the impact of Wiley Plus web-based online system as an adaptive medium for promoting learning through experiential tasks such as Web-based Homework (WBH) and assignments.

   In line with the above objectives, this paper will present findings based on research questions adapted from a similar study done by Jones et al. (2008) at the California State University, who used the Wiley Plus web-based system in an introductory first year accounting course. See Appendix A for research questions.

   The following sections were used to organize the paper: (a) The context of the study, brief information about the participants of the study and where the study was conducted; (b) The theoretical framework that underpins the study; (c) Literature review on the three technologies used in the study; (d) Methodology used to collect data for the study; (e) The findings and discussion of the study; (f) Conclusion and recommendation;(g) References and (h) Appendix A, on research questions used on web based homework section of the study.

2. Context of the study

The study was carried out at the Faculty of Engineering, Department of Chemical Engineering at a University of Technology in South Africa. The participants of the study were 34 out of 47 students who were enrolled for the ECP Chemical Engineering program in 2014 and working towards a national diploma.

3. Theoretical framework

This study was informed by Laurilland's conversational framework for teaching and learning (Laurillard, 1997). The theory advocates that teaching and learning is a dialogic activity in which learners attempt to reconstruct the mental model of the course content (Laurillard, 2013) as shown in Figure 1 below. This framework is composed of five media forms, which are (a) narrative, (b) interactive, (c) communicative, (d) adaptive, and (e) productive. Each media form supports different types of learning experiences. Narrative media tell or show the learner something (e.g. text, image). Interactive media respond in a limited way to what the learner does (e.g. search engines, multiple choice tests, simple models, and in the case of this study the Clicker technology). Communicative media facilitate exchanges between people (e.g. email, discussion forums, and in the case of

this study a Facebook closed group). Adaptive media are changed by what the user does (e.g. some simulations, virtual worlds) and supports: (a) experimenting, (b) practising, and (c) clarifying internal relations. Automated grading of homework assignments such as WBH is a form of adaptive media which facilitates interaction by helping students move from initial conceptual understanding to experiential knowledge that closely approximates the teacher's mental model of the course material (Jones, 2008).

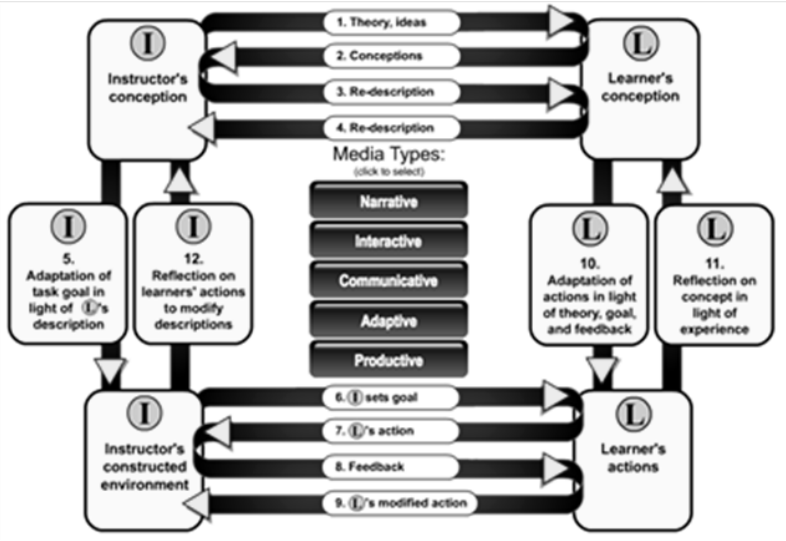

Figure 1: Laurillard educational media framework (Laurillard, 2013)

The learning process in this framework is supposed to support an iterative exchange between teacher and students, which occurs at two distinct levels. The first level is referred to as "discursive activities", whereby the teacher presents the conceptual knowledge, idea, principle, and theory to be learned. Then learners are supposed to engage with the course content through dialogue, asking questions and receiving responses from the teacher. Through this dialogue between the teacher and the learners, the teacher clarifies or elaborates on the course material. The second level is the "interactive or experiential activities", whereby the learner puts the theory into practice, application and action through experiential tasks such as homework exercises, laboratory experiments, or even field trips. The teacher continually monitors the learners' experiential progression and provides feedback, which enables learners to improve their understanding of the course material (Laurillard, 1997, 2013). Learners at the same time are expected to reflect on their experiential learning and "adapt" their actions, as a way of blending the theory and practice. The model argues that interaction is central to "deep" learning (Laurillard, 2013).

4. Literature Review

4.1 Communicative media, Facebook a Social Network Site (SNS)

Literature on the value of using Facebook for teaching and learning is quite convincing and on the rise in universities and colleges (Basitere & Ivala, 2014; Ivala & Gachago, 2012). Basitere and Ivala et al. (2014) reported the effectiveness of the use of Facebook outside the classroom to bridge first year students' Mathematical knowledge gap between high school and university. Additionally, Badge et al. (2012) reported that encouraging engagement with social media, students develop connections with their peers, establish a virtual community of learners and ultimately increase their overall learning. Furthermore, social network sites provide an opportunity to enrich student-teacher relationships, which results in positive learning experiences for both parties (Mazur et al., 2010). Hence, social networking services such as Facebook, Twitter and Myspace have gained huge popularity among university and college students globally over the past few years. This study will evaluate the effectiveness of Facebook SNS as a communicative medium outside the physics classroom.

4.2 Interactive medium, Clicker software Technology

Clickers are interactive technology that enables instructors to pose questions to students and immediately collect and view the response of the entire class. Research has shown that Clicker technology increases active participation and students' engagement level in the classroom (Gachago et al., 2011). Kay and Lesage (2009) reported the benefits of using Clicker technology for:

(a) Overall improved students' attitudes towards the course,
(b) Learning benefits such as improved student interaction, discussion, and peer learning,
(c) Improved students' class attendance, students' active participation and engagement, and
(d) Improved on the provision of instant feedback on formative assessment and also teacher reflection on the students' understanding of the course material, which helps the teacher to modify the teaching, based on students' feedback.

Additionally, most of the researchers have reported Clickers' benefit in large classrooms and little research has been reported on the use of Clicker technology in small classes (fewer than 60 students)(Kay and Lesage, 2009).

4.3 Adaptive medium, web-based homework system

In the literature, web-based homework has been used for formative assessment 1) to provide feedback for the teacher to modify learning activities and experience, 2) to identify and remediate individual student deficiency; 3) to improve student learning and build student confidence, and 4) to improve students' metacognitive awareness of how they learn (Bonham et al., 2001; Bonham et al., 2003; Jang, 2009). However, the main goal for which many universities use web-based homework is to provide instant individualised feedback to students, which is often time consuming in paper-based homework and beyond the resources available in the universities (Tang et al., 2002; Bonham et al., 2003; Demirci, 2007; Jones, 2008). With the lack of experienced tutors and teaching assistants, many universities around the world are abandoning time intensive approaches of collecting and grading paper-based homework (Mestre et al., 2002).

There are several studies comparing the impact of WBH on paper-based homework (PBH) reported in the literature. For instance, Bonham et al. (2003) reported on a college physics study that there was no statistical difference in exam score between students who used Web Assign WBH and those using PBH system. These results were also in agreement with results obtained in a study conducted in 19 college-algebra classes (Mestre et al., 2002; Hauk et al., 2005using the Web Work online system. However, results from studies by Mestre et al. (2002), Hauk et al. (2005) and Bonham et al. (2003) were in agreement that WBH was as effective as PBH. A study conducted by Jones (2008) using commercial web application Wiley Plus to automate grading of multi-part accounting exercises on a first year introductory accounting course for students majoring in business, showed that the web-based homework system enhanced learning but did not increase student interaction. Furthermore, the study found that immediate feedback and allowing for multiple attempts encourage students to practice with the course material.

Additionally, a study conducted by Mestre et al. (2002) using Online Web-based learning (OWL) at a large U.S. public university found that offering WBH led to an improved overall exam performance in a physics course. Findings indicated that students who used OWL to submit assignments for grading scored significantly higher in examinations compared to those who submitted PBH. The mean difference between WBH and PBH was found to be about one-third typical exam standard deviation. These results were in agreement with results from a study by Tang et al. (2002) using Web Assign on college physics and calculus courses. The study findings showed that using Web Assign to deliver and grade WBH increased the level of interaction with faculty peers, increased time spent on course work and students' collaboration outside the classroom, and enabled faculty to provide instant individualised student feedback on homework assignments.

For the findings reported in this paper, Wiley Plus WBH was used to provide, submit, and grade exercises and to monitor at-risk students on weekly homework assignments. Students were given 96 hours to submit the web-based homework assignment, which was based on the sections of the chapter being taught in the classroom. Students' performance marks on the WBH were compared to students' marks on the paper-based tutorial mock test, mid-term test and FISA. When working on Wiley Plus, students received individual feedback on the completed portions of the physics exercise each time they clicked the <Submit Answer> button. After one attempt of the homework assignments, students received a publisher-provided hint in questions to which they had given a wrong answer. On the second attempt, all parts of the exercise were graded and the scores were recorded on the grade book. Students were given the option to view the solutions. Students could also view the online grade book in Wiley Plus to see the total score for the web-portion of the assignment along with class averages.

5. Methodology

Both quantitative and qualitative methods of collecting data were used in this study in order to ensure triangulation of data and to enhance the significance of the findings by integrating different ways of knowing (Caracelli et al., 1997).

5.1 Context and participants

The study was conducted in the 2014 academic year at the Department of Chemical Engineering at a University of Technology in South Africa. The participants of the study were first year National Diploma Extended Curriculum Program (ECP) students. The ECP program has been designed to support students who are enrolled in a Chemical Engineering program with ≤50 percent pass rate in high school (matric) Mathematics and Physical Sciences. To ensure that the ECP students succeed in their studies, the students take half a workload compared to mainstream students (mainstream students are those who enter the Chemical Engineering National Diploma program with matric marks above 50 percent and who take six subjects per semester). As part of providing learning support to these students, the lecturer responsible for teaching Physics with support from the department piloted Clicker technology to enhance discussion and engagement in the classroom, a Facebook closed group as a communicative medium platform outside the classroom and Wiley Plus online system to provide online homework assignments with an aim of ensuring that students receive immediate rich feedback. The online system not only provided online assignments but also video, animation, PowerPoint presentations and a prescribed e-book, which were supposed to be beneficial to both the teacher and the students.

5.2 Data collection methods

Facebook data on students' participation was extracted using a PHP script, which makes use of the Facebook application interface (API) written and self-hosted by Mr Dzumbuluwani Mmbara (IT specialist) of Musuku Africa Pty (Ltd), South Africa. The Data extracted showed how the ECP Chemical Engineering students participated on the Facebook close group to support learning activities. Student participation on Facebook in this study was defined by 1) the number of academic posts posted by individual students, 2) students' post comments on the academic posts posted by other students, and 3) the number of students who liked the posts. Students' posts in this study were in terms of asking questions on the course content, which encouraged informal academic interaction and indicated to other students that their opinion on the subject of the post is required or it mattered. A survey was administered at the end of the term, followed by focus group interviews with students, to solicit student comments in order to obtain deeper feedback on their perception, opinions and attitude towards the use of Clicker, Facebook and web-based homework. Students' scores on the WBH were extracted for comparison to students' scores on the paper-based tutorial mock test, mid-term test and FISA, which were gathered and recorded by the lecturer and saved on his computer at work.

5.3 Data Analysis

Quantitative data was analysed using descriptive and inferential statistics, while qualitative data was analysed using an inductive strategy. Focus group interview data was recorded on tape and transcribed verbatim. The interviews were analysed focusing on the identification of conceptual themes and issues emerging from the data, using techniques such as clustering, and making contrasts and comparisons (Miles & Huberman, 1994). The researchers were especially interested in moments in the study that could be construed as the focal points for the benefits of the use of Facebook, Clicker technology and the Wiley Plus web-based system for enhancing student learning. The inferential statistics were calculated using the Pearson product moment correlation coefficient (PPMC) to evaluate the strength of the correlation between WBH and tutorial mock test, mid-test and FISA. A t-test was used to determine the significance of the correlation coefficients of the WBH compared to tutorial mock test, mid-test and FISA. Descriptive statistics such as frequencies were used to understand students' participation in the Facebook closed group.

5.4 Ethics Approval

The participants' consent to participate in the study was sought and the purpose of the study was explained to the students. Interview transcripts and student scripts were available for the students to scrutinize. Anonymity and confidentiality were adhered to as promised to the students. The Fundani Centre for Higher Education and Development ethics committee gave ethical clearance for the study.

Findings and discussion are presented in the subsequent section using themes, which emerged from the data analysis.

6. Findings and Discussion

This paper reports on an evaluation of the effectiveness of Clicker technology as an interactive medium, Facebook SNS media as communicative medium supporting the "discursive activities" and Wiley Plus web-based homework system as an adaptive medium to enhance learner dialogue, learner and lecturer interactions, active participation and collaborative learning in and outside the classroom. Findings and discussion are presented under the following categories derived from themes emerging from data analysis:

- The use of Clicker software technology to improve students' participation and interaction with the course content and lecturers' reflection on their teaching practice;
- The use of a Facebook closed group for students' interaction with the course content and peers;
- The use of Wiley Plus Web-based homework for enhancing student learning beyond the classroom.

6.1 The use of Clicker software technology to improve students' participation and interaction with the course content, peers and lecturer, and lecturers' reflections on their teaching practice

Students were provided with a Clicker technology remote to choose a correct answer on given conceptual questions. Students were given 120 seconds (2 minutes) to make their vote/choice. After polling was closed, the Clicker technology gave the polling results on how students voted in percentages (see Figure 2) on what students thought was the right answer to the question asked:

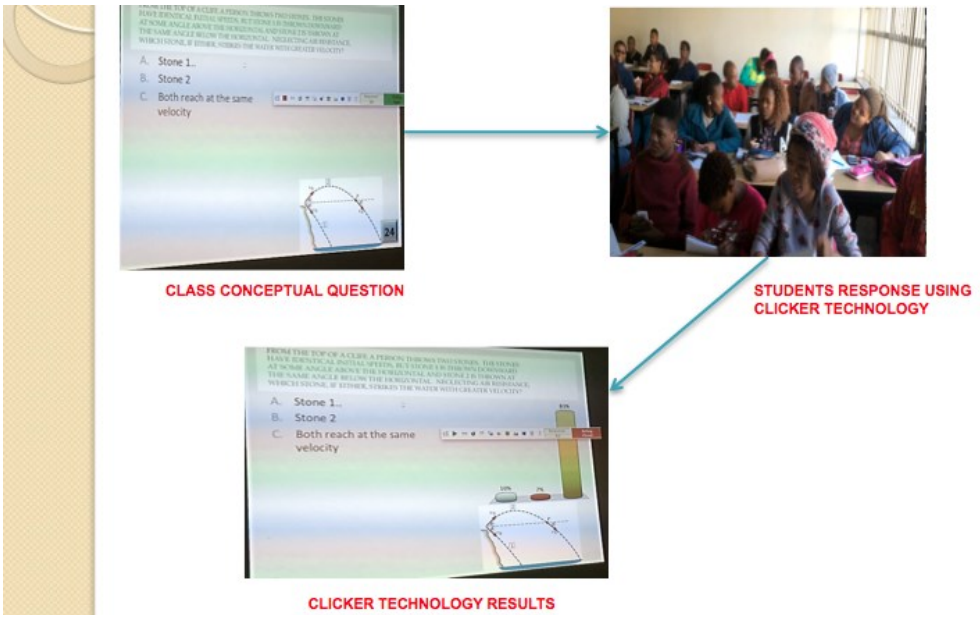

Figure 2: How Clicker technology was used by students to respond to conceptual questions

After the polling, a case of two strong opposing views on the correct answer arose as reflected in the polling results in Figure 3. This was followed by students' discussion of why their choice of answer was correct. After the discussion, the lecturer opened the polling again to see if students had changed their choice based on peer discussion. The lecturer facilitated engagement between the students and only got involved when the second polling still indicated two strong opposing views, showing some students had misconceptions of the content and compelled the lecturer to reflect on his teaching and come up with a way of teaching the particular content in ways that enhanced student understanding as advocated by Laurillard's conversational teaching and learning framework.

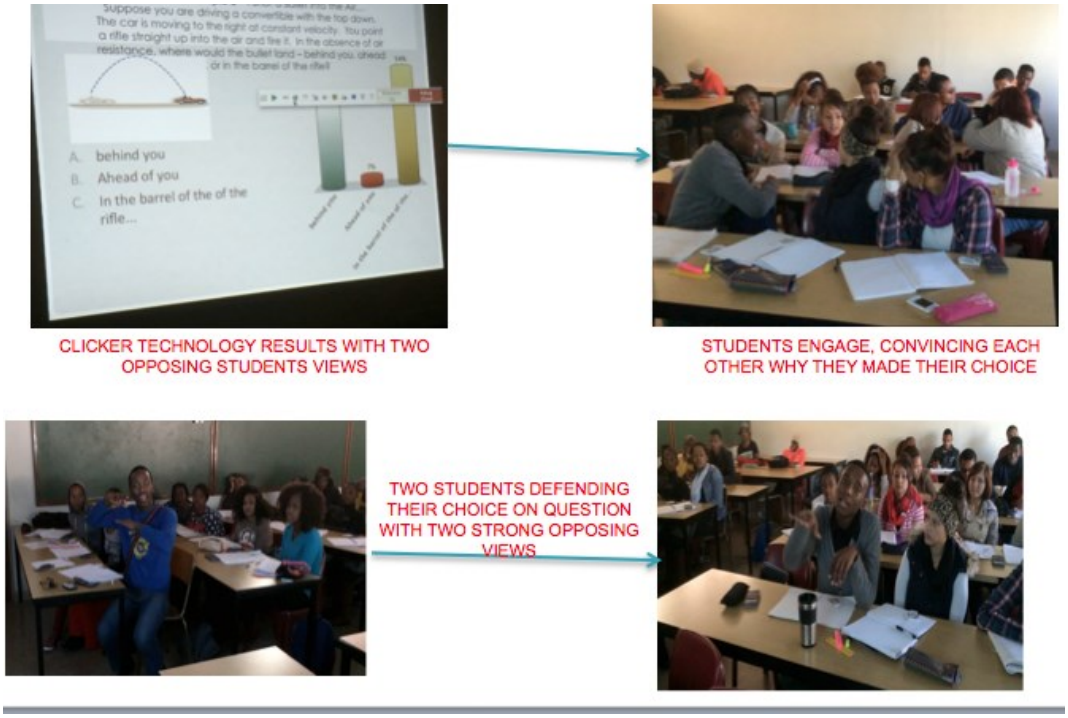

Figure 3: Students engaging with each other after two strong opposing views on the conceptual question

Students indicated that Clickers encouraged passive students to participate in class discussions as all students responded to the Clicker questions, as evidenced in the following quote from one of the students:

> ***Student A:****….. for me it's good that in class we actually get a tough question then everyone has got a chance to engage. So some of the students like me, I'm shy of raising up my hand and actually asking what's happening there but if you use Clickers, everyone will just click, click what you think. Then the next thing the percentage is shown on the board. Obviously, then if we've got more or less 50% on the answers then we're all going to engage. Why do you say this, why do you say this then afterwards the lecturer then clarifies everything. So even the person at the back who's shy, wasn't able to ask the question then gets the clarity of which the question is going to come in the exams maybe, or the skill is going to help you to tackle another question in the exam. So it's easy for everyone to learn in that way. So, I really enjoyed and liked the Clickers. [sic].*

Students who are shy in class felt that Clickers encouraged them to participate in class discussions as the Clicker technology displayed students' responses anonymously. Furthermore, the above results show that the use of Clickers enabled students to engage more deeply with the course material, peer interactions and student-lecture interactions during their discussions on their choice of answers, which enhanced their understanding. Students also reported that the use of the Clicker technology enabled the lecturer to pick out whether students understood the course content/concepts:

> ***Student C****:….. I think that it was an advantage to the lecturer and also to the students because he used it as a recap of the lecture because he, like when he's done teaching, lecturing he can actually see like how many students do understand the concept that he taught. [sic].*

Hence the use of the Clicker technology helped the lecturer in reflecting on the students' actions or understanding of the content and used this knowledge to modify the way he taught the content in order to improve students' understanding.

6.2 The use of a Facebook closed group for students' interaction with the course content and peers

Findings from analysis of students' Facebook activity showed that students posted a total of 107 academic posts (see Table 1) during the second semester (July to December 2014). The academic post generated 267 comments and some students responded to the posts by liking the academic posts or comments and discussions (168 likes).

Table 1: Students' Facebook activity in a closed group for Physics

Facebook activities	Total
Academic posts	107
Comment discussions on academic posts	267
Like on academic post or comments	168

Students' posts were in terms of asking questions, which encouraged informal academic interaction and indicated to other students that their opinion on the subject of the post was required or it matters. Some students responded to the academic posts by use of post comments, which are comments generated in response to the academic post. Other students liked the post, which is a way of letting the students who posted the post know that they engaged with the content and enjoyed the comment or post.

Figure 4 (a) and (b) showed a screenshot example of how students participated in a closed Facebook group by posting academic posts, which generate discussions and comments, or students respond by liking the academic post or the comments. The use of smart phone cameras to upload questions or responding to an academic post was one of the most commonly used methods by students in sharing information with each other. The lecturer's presence on the closed Facebook was also appreciated by the students in giving clarity and guidance on questions that students are battling with. This also gave a chance for the lecturer to reflect on the learner actions based on the academic post or comments and discussions to modify the description of the missing knowledge concepts on the section currently being taught in the classroom as supported by Laurillard's conversational framework for teaching and learning (Laurillard's, 2007). Student mentorship through Facebook was also visible in this study in Figure (4b) by a second year ECP student responding to a question posed by the first year student (response "Mandilakhe Facebhuk", a second year ECP student). This was also supported by the quote as exemplified below;

> ***Male Student A:*** *…"I just interact with people and I also have like mentors there. So when I have a problem I just chat with them and they help me sometimes". [sic].*

This also supported the study by Badge et al. (2012), who reported that encouraging students' engagement with social media helps students to develop connections with their peers, hence establishing a virtual community of learners, which ultimately increases their overall learning of the course material.

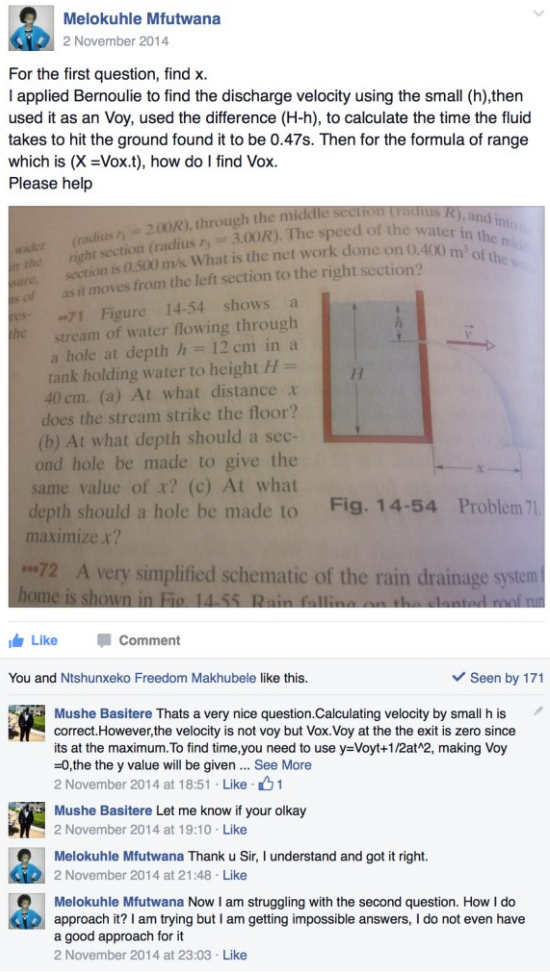

Figure 4 (a): Example of academic post on a closed Facebok group

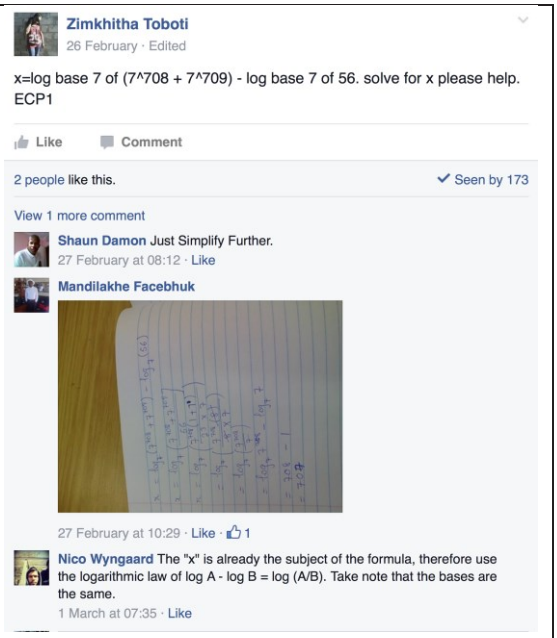

Figure4 (b): Example of academic post on a closed Facebook

Time series closed group Face book Data

There was a steady rise in academic posts (35), academic comments (86) and likes on comment or post (53) in the months of July and August 2014 (see Figure 5). Furthermore, the number of posts dropped from August to October to below ten resulting in a drop of academic comments, as comments and discussions are based on academic posts posted by the students. This might have been partly due to the introduction of the Wiley Plus adaptive media online platform for supporting the web-based homework assignment in August 2014, as students spent most of their time and mostly support on the online platform, which guides students on how to respond to questions through video and hints. This was confirmed during the focus group interview:

> ***Student E:*** *…"Like first semester when we were doing Mathematics Facebook was amazing because questions were popping up now and then in second semester we were focusing more in Wiley Plus adaptive media and then Facebook was kind of left aside, so ja". [sic].*

A semester break during the month of September could also have contributed to the low participation. However, results show that there was increased student activity between the months of October and November, which are the examination period (see Figure 5). The same trend was observed in a study conducted by Vivian et al. (2014).

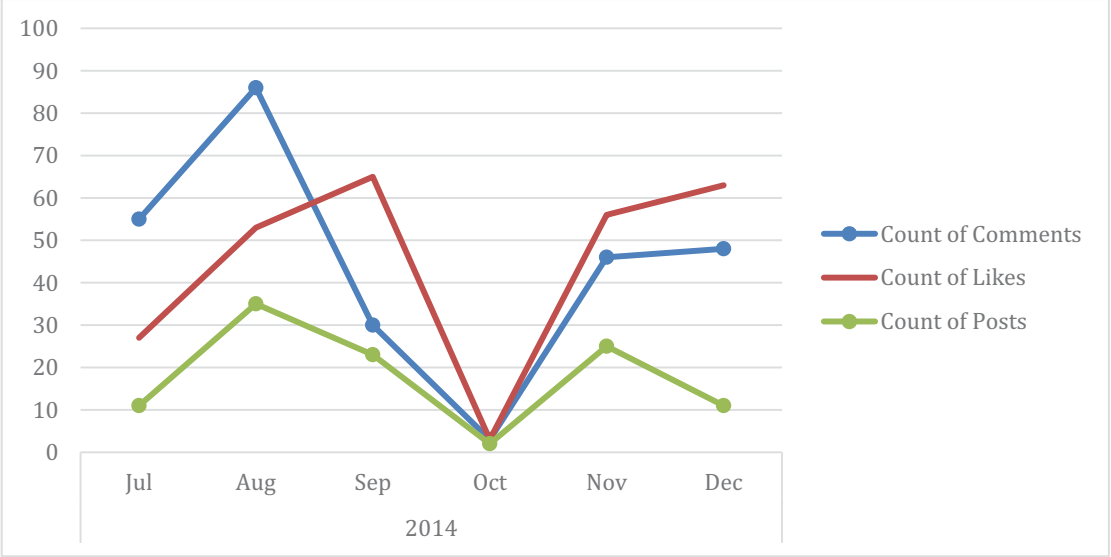

Figure 5: Facebook time series in Physics class first semester Correlation

6.3 Web-based homework as an adaptive medium

The survey results showed that 73% (34 out of 46) of ECP students responded to the survey and participated in the focus group interviews. Fifty-six (56%) percent (N=19) of the students were female. Eighteen percent (18%) of the respondents were between the age of 17 and 18 years, 59% between 19 and 20 years and 24% between ages 20 and 25 years. Twenty-four (24%) percent of the respondents achieved high school Physical Science marks at level 3 (40-49%), 65% achieved at level 4 (50-59%) and 12% achieved at level 5 (60-69%). The rest of the findings are presented by using questions, which guided this study.

Research Question 1: If homework is not collected and graded, would students spend less time practising course concepts?

Over eighty (80%) percent of learners (53%-strongly agreed; 35% agreed) indicated that they spent less time practising course concepts when homework was not collected and graded. This was confirmed during student focus group interviews:

> ***STUDENT B****: …I actually think that some of the questions on Wiley should be for marks because what we're actually seen like when we first used Wiley Plus, Mr Moses said that the first two tests are not for marks. And if you actually check on that, not a lot of people attempted it. But when he started saying okay, guys, these are for marks, that's when you could see that people are on the IT centre. They are doing the questions and all that. So I think in a way it should also be for marks, ja. [sic].*

The above findings support the findings of Jones (2008) and Tang et al. (2002) in which 71% of accounting students and 58% of physics and calculus students respectively claimed they would study less if homework was not collected and graded. Additionally, the results can be interpreted as students' endorsement of the web-based homework assignment (Tang et al., 2002) as it motivated students to study and practise course concepts.

Research Question 2: Do students prefer paper-based homework with no individual feedback to web-based homework with individual feedback?

More than 60% (50% disagreed; 15% strongly disagreed) of learners indicated that they preferred web-based homework with individual feedback, 15% percent pointed out that they preferred paper-based homework with no individual feedback compared to web-based homework with feedback and 21% neither agreed nor disagreed. These results confirm Jones's (2008) findings, which showed that over 70% of accounting students overwhelmingly preferred WBH with individual feedback compared to paper-based homework with no feedback. Wiley Plus web based online system allowed students more than one attempt for each online

homework assignment submission, which students saw as an advantage over the paper-based homework. Also the instant feedback provided after each attempt was said to be an advantage for the WBH compared to PBH.

Research Question 3: Where do students access the web to complete online assignments?

Fifty-nine percent (59%) of the students reported that they completed their homework assignment at home, 16% accessed the assignment using a cellphone, while 41% accessed using their laptops and 41% using the university Information Technology (IT) centre computers. These results are in contrast with Jones's (2008) findings in which 84.1% of the accounting students completed their homework at home and 12.2% completed their assignments at university. Although students receive free Internet data to use at this university where the current study took place, university Internet is slow at times, which makes it difficult for students to access online assessments. Hence, students who use their cellphones and laptops at home have to pay for their own data to access the web outside the university.

Some of the students indicated that they could not afford Internet data to access Wiley Plus at home as indicated in the quote below and as a result they used the printed version of the Wiley Plus text book from the library to read and prepare for the assignment at home and complete the online assignment at the university as free data was provided for each student to use on campus.

> ***STUDENT E***:*…The disadvantage of this is that at home, I don't have Internet at home and therefore the Wiley Plus was a problem for me and that's why I took the book out and the book was also wow. So I prefer if you can give the Wiley book to some of the students who don't have Internet at home.*

Research Question 4: Do students believe technical issues with computers, the web, or the WBH systems affect their course performance?

Fifty-five percent (55%) of the students (26%-strongly agreed; 29%-agreed) reported that technical difficulties with computers, the web or web-based homework affected their course performance, with 26% neither agreeing nor disagreeing. A little less than 20% (18%) disagreed that web-based and technical difficulties were a concern. Students also elaborated on this during the focus group interviews by indicating that the Internet was slow at the university. However, this only happen for a short period of time when students were still getting used to the introduction of the web-based homework system as indicated by the student below:

> ***STUDENT C***:*... What I didn't like about Wiley at first it was a bit problematic. I don't know if you guys all remember the Internet problems and stuff. But then as time goes by it was just easy and nice.[sic]*

This finding is in contrast with findings from Jones's (2008) study, whereby most of the students (67.5%) reported that technical difficulties did not affect their course performance; with 19.3% neither agreeing nor disagreeing, and 13% indicating that technical difficulties with web-based homework were a concern.

Research Question 5: Do students perceive automated homework grading as a form of course interactivity?

Over sixty percent (60%) of the students (24%-strongly agreed and 41%-agreed) were of the opinion that WBH promoted course interaction and peer learning (student collaboration), and 35% of the students neither agreed nor disagreed. The promotion of peer learning was also reported during the focus group interviews:

> ***STUDENT D***:*...If you still don't understand we could discuss amongst ourselves. It actually promoted a lot of group work because we would go to IT centre and then try to get these things done, get your answers and ask other people.*

As the Wiley Plus web-based online platform is an adaptive medium, which has the capability to change its state due to user response as defined in Laurillard's conversational framework, there was no student-teacher interaction but student collaboration and computer-student interaction did occur. Computer-student interaction by nature is interactive but does not promote teacher-student interaction (Jones 2008). Computer-student interaction was beneficial as it promoted student-content interactions as students received more

exercises with instant individual feedback, multiple attempts, access to video and animation from the web-based online system as indicated in the following quote:

> ***STUDENT E**: …it helped with video thing, everything. I think we got more work in Wiley, than we could in class because we would get feedback right there and there and then you know that I'm wrong here. [sic]*

Research Question 6: How many hours per week do students spend on web-based exercises?

Most students (56%) spend 2-4 hours per week completing web-based homework and other Wiley Plus activities such as reading the e-book, watching videos and animations, while 29% of students spend 0-2 hours and 9% spend between 4-6 hours.

> ***STUDENT F:**… Okay, ja it helped me with my marks because sometimes I would spend like four hours in Wiley sometimes like – let me say most of the time when I'm at IT Centre then I'd be like, let me just open Wiley and do some questions or read. Wiley, I have the book as well. So sometimes I do not need to go to the IT Centre, I would just stay in my room and then do some questions and then read. [sic].*

The above results confirm Jones's (2008) findings in which students in an accounting course indicated that 49.4% of them spent between 2-4 hours per week completing web-based homework, which was over and above time spent on any paper-based homework required for the class.

Students also indicated that they used Wiley Plus online system to catch up with the work if they missed a class:

> ***STUDENT G:**… Like some of the topics that we did example, like I think it was Heat Transfer, I was not in class that time and then I sat down with my Wiley Plus e-book in my room and then I studied. And then I found it easy…[sic]*

Research Question 7: Do students believe web-based homework enhances learning?

Over 75% (32% strongly agreed; 44%-agreed) of the students reported that Wiley Plus web-based homework enhanced their learning of the physics course content. Only 9% of students disagreed, while 15% neither agreed nor disagreed. These results corroborated Jones's (2008) findings, which showed that 71.1% of the accounting students reported that using Wiley Plus enhanced their learning of the course content. Additionally, Tang et al. (2002) reported similar findings (over 64% agreed) in a calculus and a physics course using Web Assign online system. The researchers in the current study are in agreement with Jones (2008) in suggesting that irrespective of which online system used, online homework based systems seem to be perceived by most students to enhance learning of the course material.

Research Question 8: What is the ideal number of attempts students should be allowed before assignment submission?

On this question, students were asked to indicate the number of attempts at exercises they preferred before submitting web-based homework for final grading. Results showed two opposing views among students, with 53% of the students preferring 1-2 attempts and 47% preferring 2-3 attempts. The students who preferred 1-2 attempts felt that too many attempts encouraged a trial and error approach to the homework completion, while those who advocated more than two attempts indicated that it helped them in learning and trying different ways of solving problems:

> ***STUDENT I:** ……The reason why we have more than one attempt is because we need to learn, you can't just do it once and get the answer. You have to try different ways of getting that answer. So I don't think that they have to reduce the number of attempts.*

However, the idea of multiple attempts was said by some of the students to have also promoted cheating collaboration among students on completion of assignments especially in the multiple choice type questions. In this regard, students sat in groups of three and each made a choice until one got the correct answer on the first attempt. Those students who got the wrong answer on their first attempt could use their second chance to answer the question based on their peers' correct answer:

> ***STUDENT J***:*… Because if you sit as she said, three, then if I click A, and she clicks B, she clicks C then the second time we're going to click D, then obviously D's the right answer.*

The above results may explain why some of the students performed lower than 50% in the paper-based tutorial mock and mid-test, while in the Wiley Plus web-based homework assignment system they scored higher marks (see Figures 6 and 7).

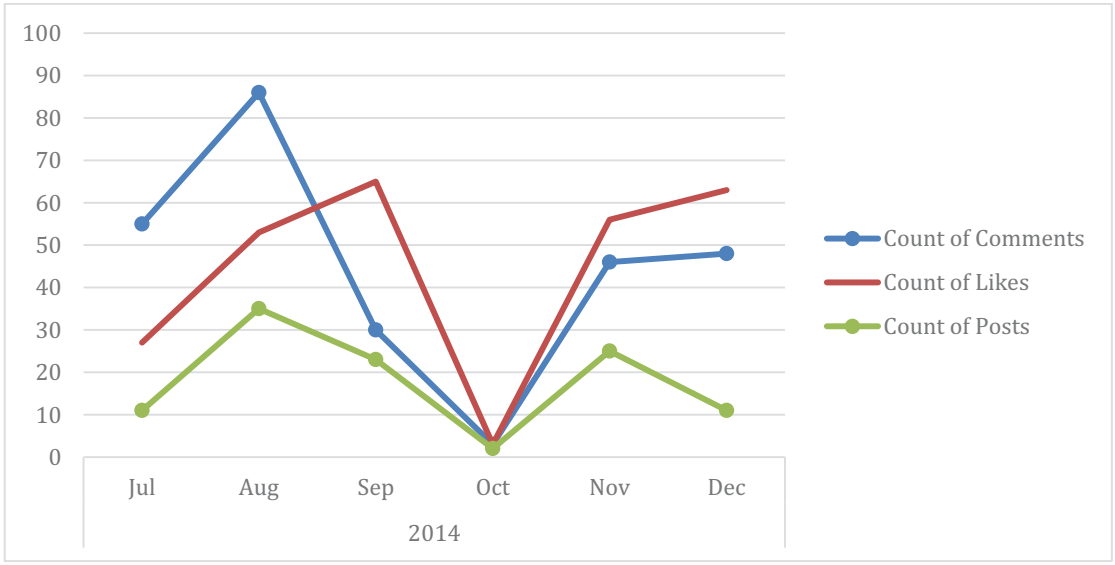

Figure 5: Correlation of Facebook time series in a Physics class in the first semester

6.4 Web-based homework as an adaptive medium

The survey results showed that 73% (34 out of 46) of the ECP students responded to the survey questions and participated in the focus group interviews. These results also indicate that some of the students did not understand the purpose of web-based homework as a formative assessment.

Research Question 9: Are exercise hints and links to electronic and online animation helpful in clarifying what is required?

Over 90% (50% strongly agreed; 47% agreed of the students indicated that Wiley Plus online exercise hints were helpful in giving them clues on how to solve a problem and hence enabled their understanding of concepts. The usefulness of hints was also confirmed during students' focus group interview:

> ***STUDENT H***:*… Like for me, ma'am, I liked it very much in the sense that it provided more time to actually do the questions and then if you went wrong it gives you a hint on how to tackle it. Then if you went wrong the second time then, maybe it pops the answer so that you can read how the answer should be done.*

The above results are contrary to what Jones (2008) found in a study using Wiley Plus WBH in an accounting course, whereby only 43.3% of the students found hints provided by the Wiley Plus system to be helpful, with 25.3% of the students neither agreeing nor disagreeing and 31.4% of the students indicating that the hints were not useful. Students also appreciated the availability of hyperlinks to other media texts such as video, animations and an electronic e-book version of the Wiley Plus WBH.

> ***STUDENT I***:… *What I liked about the Wiley Plus it's the thing, the videos and the hints like after reading you study, you do some questions and then if the questions, they are not clear, like sometimes you do not understand the questions clearly. So we view the thing – the clips, we watch the videos and then they explain how it's done and stuff like that and then after that if still you don't understand still, they give you a hint and then you do it and then you get it correct.*

The provision of hyperlinks to other texts also resulted in students taking full control of their learning, independent learning, and promoted a learner-centred approach to learning.

Research Question 10: Is there a correlation in student performance on WBH compared to the paper based tutorial mock test, mid-term averaged test and FISA?

A series of paired sample t-tests was done to compare the average marks students scored on the Wiley Plus WBH with the marks obtained in the tutorial mock test, mid-test and FISA. The first paired sample analysis was run to determine if there was a correlation between the WBH and paper-based tutorial mock test. Findings indicated a significant strong positive correlation between the WBH and paper-based Tutorial test with a correlation coefficient (r=0.5068) and t-test value of 3,9436 at a critical value of 2,014 (α=0,05), suggesting that students who scored high on the WBH tended to score high on the paper-based tutorial test. Likewise students who performed low on WBH also tended to perform low on the paper-based tutorial mock test (see Figure 6). Figure 6 below clearly shows that 52% of the students with high scores of (≥50%) in WBH scored high (≥ 50%) on paper-based tutorial mock test. Likewise, 11% of the students who scored low score on WBH (≤ 50%) scored low on paper-based tutorial mock test.

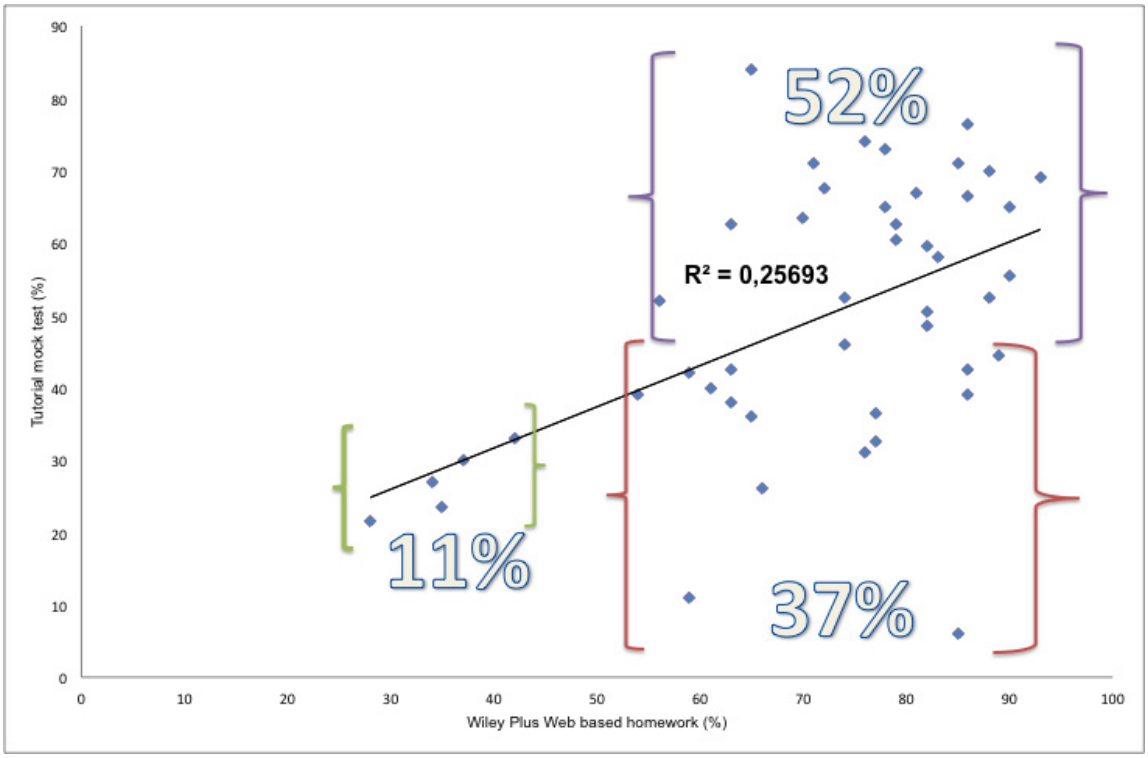

Figure 6: Correlation between Wiley Plus marks compared with paper-based tutorial mock test

However, 37% of the students who scored high on Wiley Plus scored low on the tutorial mock test. This may be due to students' cheating collaboration as indicated in *Research Question 6*. Additionally, the mean score on WBH was also high at 70% compared to 49% on the tutorial mock test.

The second paired-sample analysis was run to determine if a correlation existed between WBH and the mid-term test. Results showed that a positive correlation existed between the WBH and mid-test marks, with a correlation coefficient of r=0.4805 and t-test value of 3,6753, with a critical value 2,014 (α= 0,05). These results showed that students who scored high on WBH also score high on mid-test, while students who scored low on

the WBH also scored low on the mid-term test (see Figure 7). Figure 7 illustrates that 52% of the students with high scores on WBH performed well on the mid-term test, while 37% of the students who scored high on Wiley Plus WBH did not score high in the mid-term test. Although the results showed a coincidence of the same percentage (52% and 37%) score as in the first paired sample analysis, the percentages do not represent the same group of students as in the first paired analysis but a mix, as some of the students who scored 50% and above on the paper-based mock test scored lower than 50% on the mid-test. The mean score of 70% for WBH was still high compared to that of the mid-term test, which was 48%.

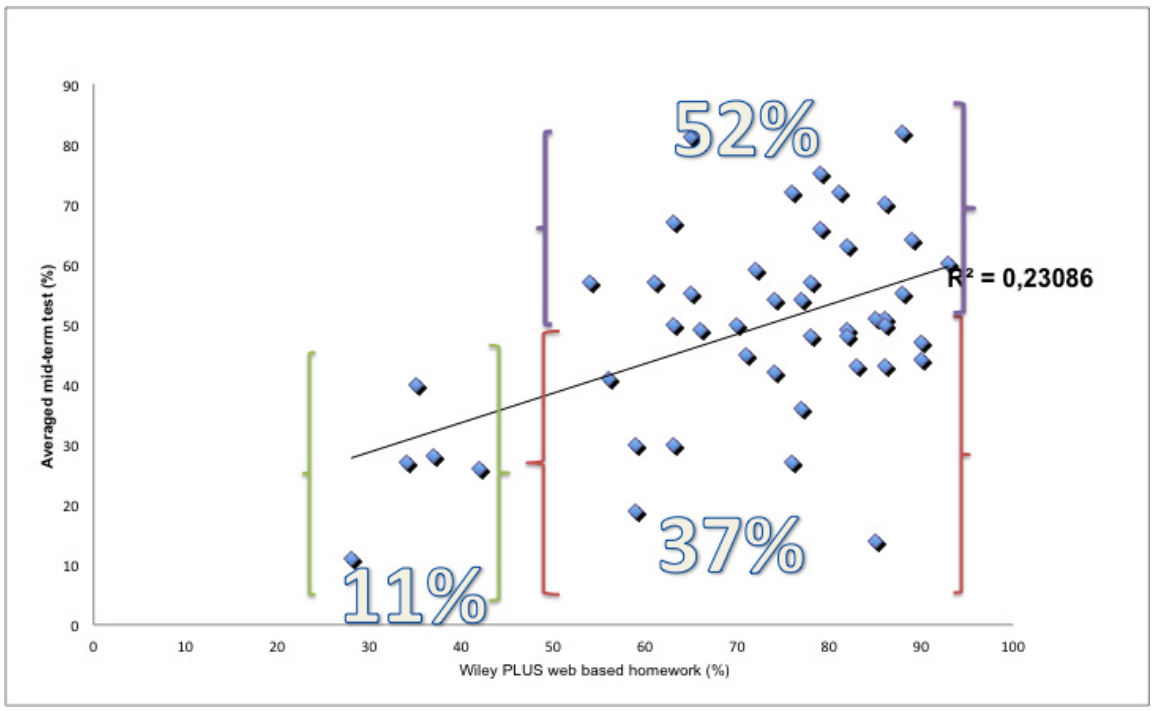

Figure 7: Correlation between Wiley Plus marks compared with averaged mid-term tests

A third paired-sample analysis was run to determine if a correlation existed between WBH and FISA marks (FISA covers all sections in Physics 1 and it is done at the end of the semester). Results showed a significant positive correlation between WBH and FISA marks, with a correlation coefficient r=0,6532 (see figure 8) and t-test value of 4,9948 at a critical value of 2,014 (α=0,05). These results suggest that students who scored 50% and above on WBH had a higher chance of scoring 50% and above on the FISA. The FISA mean score was 52%, which was slightly higher, compared to the one on the paper-based tutorial mock test and mid-term test.

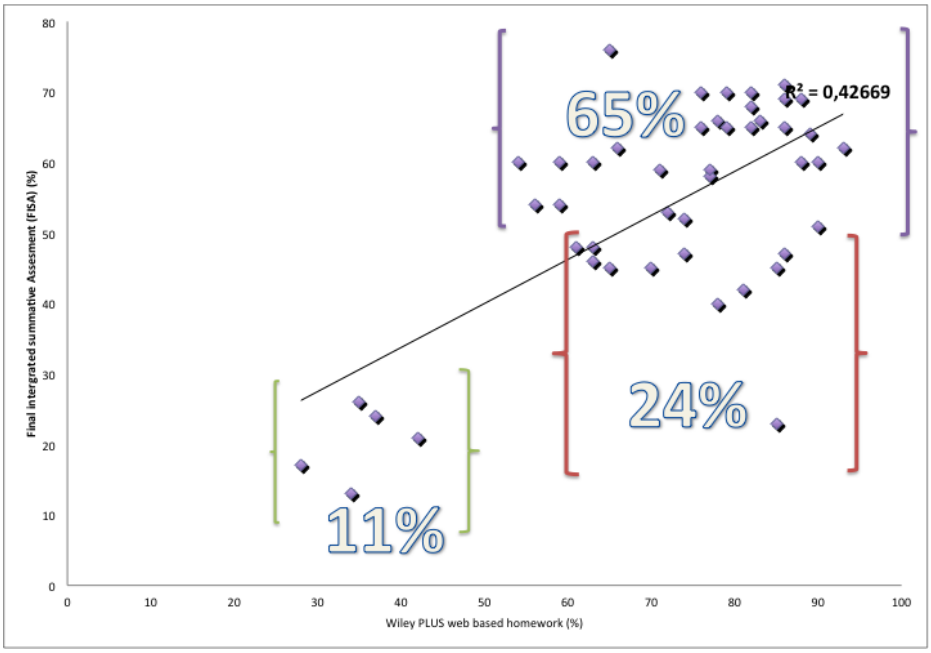

Figure 8: Correlation between Wiley Plus marks compared with Final Integrated Summative Assessment (FISA)

Furthermore, results shown in Figure 8 indicate that 65% of the students who scored 50% and above on WBH also scored 50% and above on the FISA. The same 11% of the students who had low scores on the paper-based mock test and the mid-term test also obtained low scores on the FISA and the 20% of students who scored high scores on WBH consistently obtained higher scores in the paper-based tutorial mock test, mid-term test and the FISA.

Overall findings in this study clearly reveal that a combination of the use of the Wiley Plus WBH, a Facebook closed group and the Clicker technology created a learning environment, which was conducive for students' deep and meaningful learning (Anderson 2003). The Clicker technology increased students' participation in class, student-student interactions, student-content interactions and student-lecturer interactions during the lecture time, while the Facebook closed group facilitated student-content interactions, student-student interactions and student-lecturer interactions beyond the classroom. Wiley Plus WBH facilitated aspects promoted by the Facebook group with the exception of student-lecturer interactions.

7. Conclusion and recommendation

Findings show that multimedia in the form of Clicker technology, a Facebook closed group and Wiley Plus WBH were used in this study. The Clicker technology was used to increase student participation and interaction with the course content during the lecture time. Facebook and Wiley Plus WBH were used to extend learning outside the classroom and improving collaborative learning and engagement with their peers.

Results indicated that the Clicker technology increased students' participation in class, student-student interactions, student-content interactions and student-lecturer interactions during the lecture time, while the Facebook closed group facilitated student-content interactions, student-student interactions and student-lecturer interactions beyond the classroom. Wiley Plus WBH facilitated aspects promoted by the Facebook group with the exception of student-lecturer interactions. These are all characteristics which, according to Anderson (2003) promote meaningful and deep student learning.

Furthermore, students indicated that they preferred web-based homework with individualised feedback compared to ungraded paper-based homework as it enhanced their learning. There was overwhelming agreement amongst the students that if homework was not collected and graded, they would spend less time practising course concepts. Thus, they emphasised the fact that graded assignments encourage students to engage more with the course content. Additionally, results showed that some students cheated in their engagement with the online homework by practising what the researchers in this study call and define as cheating collaboratively, which perhaps hindered their understanding of the course contents. To solve this

problem, the researchers are of the opinion that randomised questions and also reduced mark allocation if students get the answer on their second attempt may be a solution. Also, the researchers suggest that the instructor should explain clearly to the students the purpose of the online-based homework (which is for formative assessment) so as to ensure that students use the resource to enhance their understanding of the course contents instead of just doing it for marks, which promoted collaborative cheating and students' lack of deep understanding of the course contents as evidenced in some of the students' scores on the WBH, Mid-test and FISA.

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APPENDIX A: Research questions for Wiley Plus web-based homework.

(a)If homework is not collected and graded, would students spend less time practising course concepts?
(b)Do students prefer paper-based homework with no individual feedback to web-based homework with individual feedback?
(c)Where do students access the web to complete online assignments?
(d)Do students believe technical issues with computers, the web, or the WBH systems affect their course performance?
(e)Do students perceive automated homework grading as a form of course interactivity?
(f)How many hours per week do students spend on web-based exercises?
(g)Do students believe web-based homework enhances learning?
(h)What is the ideal number of attempts students should be allowed before assignment submission?
(i)Are exercise hints and links to electronic and online animation helpful in clarifying what is required?
(j)Is there a correlation in student performance on WBH compared to the paper based tutorial mock test, mid-term averaged test and FISA?

In addition to the above questions borrowed from Jones et al. (2008), the researchers added the following additional question;
(k) Does the use of Facebook and Clicker technology in combination with the Wiley Plus web-based homework online system enhance students' interaction with the course content, students and their lecturers?