Mitigating the Mathematical Knowledge gap Between High School and First Year University Chemical Engineering Mathematics Course

Moses Basitere and Eunice Ivala
Cape Peninsula University of Technology, South Africa
Basiterem@cput.ac.za
Ivalae@cput.ac.za

Abstract: This paper reports on a study carried out at a University of Technology, South Africa, aimed at identifying the existence of the mathematical knowledge gap and evaluating the intervention designed to bridge the knowledge gap amongst students studying first year mathematics at the Chemical Engineering Extended Curriculum Program (ECP). In this study, a pre-test was used as a diagnostic test to test incoming Chemical Engineering students, with the aim of identifying the mathematical knowledge gap, and to provide students with support in their starting level of mathematical knowledge and skills. After the diagnostic test, an intervention called the autumn school was organized to provide support to bridge the mathematical knowledge gap identified. A closed Facebook group served as a platform for providing student support after school hours. After the autumn school, a post-test was administered to measure whether there was an improvement in the knowledge gap. Both quantitative and qualitative methods of collecting data were used in this study. A pre-test was used to identify the mathematical knowledge gap, while a post-test was employed to measure whether there was a decrease in the knowledge gap after the intervention. Focus group interviews were carried out with the students to elicit their opinions on whether the intervention was of any help for them. Students' participation on Facebook in terms of student post, post comments and likes and an evaluation of students' academic performance in comparison to their Facebook individual participation was also conducted. Quantitative data was analysed using descriptive statistics, while qualitative data was analysed using inductive strategy. Results showed that all the students in this study had the mathematical knowledge gap as no student in the class scored 50% on the overall pre-test. Findings further revealed that the intervention played a major role in alleviating the mathematical knowledge gap from some of the students (with 1/3 of the students scoring 50% and above in the post-test) and no positive correlation between students' academic performance on the post-test and students' participation in the Facebook group was noted. We hope that insights generated in this study will be of help to other institutions looking into designing interventions for bridging the knowledge gap. Reasons for lack of improvement in the knowledge gap of 2/3 of the students in this class will be highlighted.

Keywords: knowledge gap, extended curriculum program, descriptive statistics, inductive strategy, diagnostic test, autumn school, Facebook closed group

1. Introduction

In South Africa, Engineering programs require at least two years of university mathematics. The student selection into these courses is based on one's marks achieved in the final school leaving examination – the National Senior Certificate (NSC) (Van der Flier, Thijs & Zaaiman 2003). Over the years, students entering university engineering courses struggle to succeed in the first year mathematics (Moyo 2013; Wolmarans et al. 2010). As a result, the South African higher education (HE) sector is faced with the challenge of the mathematical knowledge gap. Mathematical knowledge gap is defined as the lack of smooth transition from high school mathematics to university first year mathematics for students majoring in science, mathematics and engineering due to the shortcoming of both the high school and the first year university mathematics programs) between the knowledge possessed by school leavers and the knowledge required for first year entry into mathematics courses (Wolmarans et al. 2010). Research shows that some institutions have taken steps to bridge this knowledge gap, while others have continued to ignore the problem leading to high dropout rates (Moyo 2013). This paper reports on a study carried out at a University of Technology, South Africa, aimed at identifying the existence of the mathematical knowledge gap and evaluating the intervention designed to bridge the knowledge gap amongst students studying first year mathematics at the Chemical Engineering Extended Curriculum Program (ECP). The Extended Curriculum Program gives access to higher education to students from disadvantaged backgrounds who have only met the minimum requirements for entry to university and assists them in developing academic foundations by offering instructions in small classes over an extended period of time, and with more dedicated support.) In this study, a pre-test was used as a diagnostic test to test incoming Chemical Engineering students, with the aim of identifying the mathematical knowledge gap and to provide students with support in their starting level of mathematical

Reference this paper as Basitere M and Ivala E "Problem Based Learning and Authentic Assessment in Digital Pedagogy: Embracing the Role of Collaborative Communities" *The Electronic Journal of e-Learning Volume 13 Issue 2 2015*, (pp68-83) available online at www.ejel.org

knowledge and skills. After the diagnostic test, an intervention called the autumn school was organized to provide support on the knowledge gap identified. A closed Facebook group served as a platform for providing student support after school hours. After the autumn school, a post-test was administered to measure whether there was an improvement in the knowledge gap. Students' participation on Facebook in terms of student post, post comments and likes and an evaluation of students' academic performance in comparison to their Facebook individual participation was also conducted.

Using both quantitative and qualitative methods of collecting data, findings of the study showed that all the students in this study had the mathematical knowledge gap as no student in the class scored 50% on the overall pre-test. Findings further revealed that the intervention played a major role in alleviating the knowledge gap from some of the students (with 1/3 of the students scoring 50% and above in the post- test) and no positive correlation between students' academic performance on the post-test and students' participation in the Facebook group was noted. We hope that insights generated in this study will be of help to other institutions looking into designing interventions for bridging the knowledge gap. To investigate the matter under study, the researchers were guided by the following objectives:

- To investigate the existence of the mathematical knowledge gap
- To evaluate the impact of the intervention designed (the autumn school and the closed Facebook group) to bridge the knowledge gap

2. Literature

2.1 The transition between schooling and first year entry into mathematics courses

According to 2005 HEMIS (The Higher Education Management and Information System), the "pool" from which suitable science and engineering students are selected is small. For instance, 20 percent of the 2008 National Senior Certificate (NSC) candidates achieved a pass that allowed them access to admission to degree studies at higher education institutions, and only 7.9 percent of the candidates achieved more than 60 percent in the 2008 NSC mathematics examination – a requirement to enter Engineering programs (Department of Education 2008). Research suggests that many students in the South African schooling system are underprepared for success in higher education (HE), and especially in mathematics and Science disciplines (Badat 2010). Research shows that students entering university engineering courses struggle to succeed in the first year mathematics (Moyo 2013; Wolmarans et al. 2010). This is partly attributed to the mathematical knowledge gap possessed by school leavers and the knowledge required for first year entry into mathematics courses (Wolmarans et al. 2010).

The knowledge gap includes: a serious lack of essential technical facility – the ability to undertake numerical and algebraic calculations with efficiency and accuracy; a marked decline in analytical powers when faced with simple problems requiring more than one step; and most students entering HE no longer understand that mathematics is a precise discipline in which exact, reliable calculations, logical exposition and proof play an essential role (Clark & Lovric 2009). The matric topics that are said to be problematic and not taught in a way that minds the gap are: functions, sequences and series, differential calculus, euclidean geometry, analytical geometry, vectors, complex numbers and statistics. This mathematical knowledge gap encountered by first year engineering students in mathematics courses is not unique to the South African context (Moyo 2013; Wolmarans et al. 2010). These authors indicate that similar patterns have emerged in the United States, amongst others. However, the situation in South Africa in respect of mathematics is regarded as being more pronounced than elsewhere (Wolmarans et al. 2010). The effects of the knowledge gap in South Africa are that students drop out affecting the throughput rates and some students are discouraged from taking mathematics and physical sciences because they are perceived as cognitively difficult. This may have a long-term impact on the skills available in these areas in the country. As a result, it is imperative that institutions of higher education find educational strategies that would impact student success (Scott et al. 2007). Hence, many universities in South Africa in response to the fact that schools do not adequately prepare students for what is expected of them when they enter first year mathematics are designing interventions aimed at helping address this deficit (Human et al. 2010). Thus, this paper reports on a study carried out at a University of Technology in South Africa, aimed at identifying the existence of the mathematical knowledge gap and evaluating the intervention designed to bridge the knowledge gap amongst students studying first year mathematics at the Chemical Engineering Extended Curriculum Program. Facebook, a social media application, was used as part of the intervention.

2.2 Facebook for teaching and learning

Social media can be defined as a group of internet-based applications built on the ideology and technology of Web 2.0, which allows for the creation and exchange of user generated content (Kaplan & Haenlein 2010). Social media emphasizes active participation, connectivity, collaboration, community and sharing of knowledge and ideas amongst users (Correa 2013). This technology exists in different forms such as internet forums, web-logs, social-blogs, micro-blogging, wikis, podcasting, social bookmarking and social networks (Mazer, Murphy & Simonds 2007). The case for use of social media for teaching and learning is quite convincing (Badge et al. 2012;Ivala & Gachago 2012; Leece & Campbell 2011; Muňoz & Strotmeyer 2010). Badge et al. (2012) contend that by encouraging engagement with social media, students develop connections with peers, establish a virtual community of learners and ultimately increase their overall learning. By participating in a community of learners, students become more engaged with the course content, which increases the achievement of popular learning outcomes such as critical thinking. Similarly Junco (2012) reports a positive relationship between the use of social networking websites and student engagement adding that frequent users of social networking websites participated more often and spend more time in campus organisations than less frequent users. Mazur et al. (2007) also indicated that social networks offer opportunities to cultivate the student-teacher relationship, which creates a positive learning experience for both parties. Hence social networking services such as Facebook, Twitter and MySpace have gained huge popularity and widespread use in HE globally over the past few years.

The reasons for using Facebook in this study was because Facebook is ranked the top social networking site (SNS) in the world with an estimated 1 billion monthly active users and 552 million daily active users on average (Facebook newsroom statistics 2012). Studies by Hargittai (2008), Jones and Fox (2009) and Junco (2012), also indicated that Facebook is the most popular social media website for college students. Given that Facebook continues to be popular amongst college students, and that universities are interested in engaging and retaining students, Junco (2012) advises that those working in HE need to familiarize themselves with Facebook (and other such technologies) and to design and support interventions that meet students where they are in order to help them get to where they are going. Reporting on an experiment with Facebook as a teaching and learning tool, Esteves (2012: 6) revealed that: students asked questions related to the course topics by posting on the group's wall and received answers through "comments" from other members of the class; students shared new media like videos, websites, comic strips, podcast related to web design and publishing, distance education and Facebook as used for learning; and students used the "Chat" feature to discuss class-rated topics or simply chat casually with their classmates and faculty-in-charge. Facebook offers educators an additional venue for connecting with diverse cohorts of students, as well as a different forum for exchange with students in a less hierarchically structured manner. By "meeting students where they are" (e.g.Facebook) educators can capitalize on the existing incentive of participation in personal networks much like the commercial interests take advantage of their potential clients' presence in those spaces. In terms of creating a "community of learners", the use of a tool that students embrace in their daily lives, may improve discussion thread postings on course material, while supporting interactivity with students in these informal spaces.

However, caution needs to be exercised as literature shows that social network services might also negatively affect learning. For example, Welch and Bonnan-White (2012) found that many students had difficulty with the technology due to lack of familiarity and that some students were reluctant to adapt to unfamiliar technology and classroom expectations. Social media can also cause miscommunications, often because of the limited context available in digital communication and "since the lack of face-to-face contact involved in using social technologies leads to limited context, it is incredibly easy, and takes very little ego investment to propagate rumors and harassing content quickly and easily across the Internet". Other disadvantages of using Facebook for teaching are privacy concerns and issues of self-disclosure and identity management (Correa 2013).

2.3 The context of the study

The study was conducted in the 2013 academic year at the Department of Chemical Engineering at a University of Technology, in South Africa. The participants of the study were 41 ECP Chemical Engineering students. The

ECP programme has been designed to support students who are enrolled in a Chemical Engineering course with a minimum of 50 percent pass rate in mathematics and physical sciences. As part of the support system, the ECP students take half a workload compared to mainstream students (mainstream students are those whose matric marks are above 50 percent and who take six subjects per semester). The ECP programme takes two years in which students are provided with the necessary support to acquire the necessary skills and competences they need to succeed in their studies. The ECP programme is supposed to play a role in filling in the mathematical knowledge gap but in practice that does not happen often.

Therefore, in this university, the lecturer responsible for teaching mathematics with support from the department decided to administer a diagnostic test to incoming Chemical Engineering students to measure the mathematical competence of students upon arrival at university and to provide prompt and effective support to students on mathematical knowledge gap. The approach of diagnosing and providing support is based on the trust that incoming students are in principle quite capable of overcoming the initial difficulties and can attain the desired level in a rather short term. The lecturer's administration of the diagnostic test and designing of the intervention was driven by the concern that students may lack certain conceptual understanding as well as dispositions that are essential in the practice of mathematics and applied mathematics and the fact that the possibilities for genuine education depend on the knowledge and experience already existing within students (level of development) as well as on the students' potential to learn (Vygotsky 1986). The diagnostic pre-test consisted of open-ended questions, while the post-test consisted of open-ended questions with a few multiple-choice questions. The areas covered by both the pre-test and post-test were: trigonometry; analytical geometry, fractions and simplifying exponents and calculus.

On establishing the existence of the mathematical knowledge gap, the lecturer designed an autumn school, with a closed Facebook group (the intervention) being used to extend learning out of the classroom. The intervention was run for one week and it was aimed at: filling gaps in mathematical knowledge and skills, reviewing essential facts and brushing up on calculations and developing appropriate attitudes. The reason for this lecturer's caring about the knowledge gap was to improve student learning; to increase and/or maintain their motivation to study mathematics and to consider a career in a mathematics related field and to use resources effectively. Additionally, the lecturer cared about the transition because he has a responsibility towards his students, as they strive to achieve their university goals, to offer resources that are most effective for students' success so that students who fail in their studies will then know that it was not due to poorly designed transition and initial university offerings (Clark & Lovric 2009). On the social economic level, there is a tendency for greater proportions of the population to become engineers and scientists. As a result, engineering and science study programs are needed to take students who may in the past not have been considered as suitable for such studies, and then need to educate them to the right level. Secondly, the school system in South Africa is currently struggling to produce a sufficient number of students who are well prepared for engineering and sciences course. As a result, university courses need to adapt, and many engineering and science undergraduate programs in South Africa are already presenting support subjects in addition to "core" mathematics, science and engineering subjects (Human et al. 2010). In the next sections, the methodology and the results of this study will be presented.

3. 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 & Greene 1997).

3.1 Context and participants

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 41 students enrolled for ECP Chemical Engineering in 2013 and working towards a national diploma. A purposive sampling was used to select the participants in this study (Patton 1990). The students were selected because it was felt that they had rich information gained through their experiences in the intervention (Patton 1990).

3.2 Data collection

Both quantitative and qualitative methods of collecting data were used and the data consisted of recordings of three focus group interviews with the students, which were carried out to draw out their perceptions of the benefit of the intervention (autumn school and the use of the Facebook group). Quantitative data was gathered through the use of a diagnostic test as pre-test, used to identify whether students had the mathematical knowledge gap and a post-test was administered after the intervention to measure whether the intervention had any impact on addressing the mathematical knowledge gap students possessed. The pre-test question paper consisted of open-ended questions, while the post-test question paper comprised of open-ended and multiple-choice questions. An analysis of Students' participation on Facebook in terms of student post, post comments and likes and an evaluation of students' academic performance in comparison to their Facebook individual participation was also conducted.

3.3 Data analysis

Quantitative data was analysed using descriptive and inferential statistics, while qualitative data was analysed using inductive strategy. Frequencies were calculated to determine whether the students had mathematical knowledge gap and to measure whether the intervention had any impact in addressing the mathematical knowledge gap. A paired sample one tailed P-test was executed to test for significant differences in the pre- and post-tests marks. Facebook data was extracted using a PHP script (which makes use of the Facebook application interface (API) written and self-hosted by Mr Nzumbuluwani Mmbara (IT specialist) of Musuku Africa Pty (Ltd), South Africa. 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 contrast and comparisons (Miles & Huberman 1994). The researchers were especially interested in moments in the project that could be construed as the focal points for the benefits of the intervention.

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 faculty of engineering ethics committee gave ethical clearance.

4. Findings and discussion

The study aimed at identifying the existence of the mathematical knowledge gap and evaluating the impact of the intervention designed to bridge the knowledge gap amongst students studying first year mathematics at the Chemical Engineering Extended Curriculum Program (ECP), at a University of Technology in South Africa. Findings are presented under the following categories:

- Identification of the existence of the mathematical knowledge gap
- Impact of the intervention in addressing the mathematical knowledge gap

4.1 Identification of the existence of the mathematical knowledge gap

Findings of the study showed that students had the mathematical knowledge gap in the four areas assessed (that is, trigonometry; analytical geometry, fractions and simplifying exponents and calculus), as no student in the class scored 50% on the overall pre-test (see figure 1).

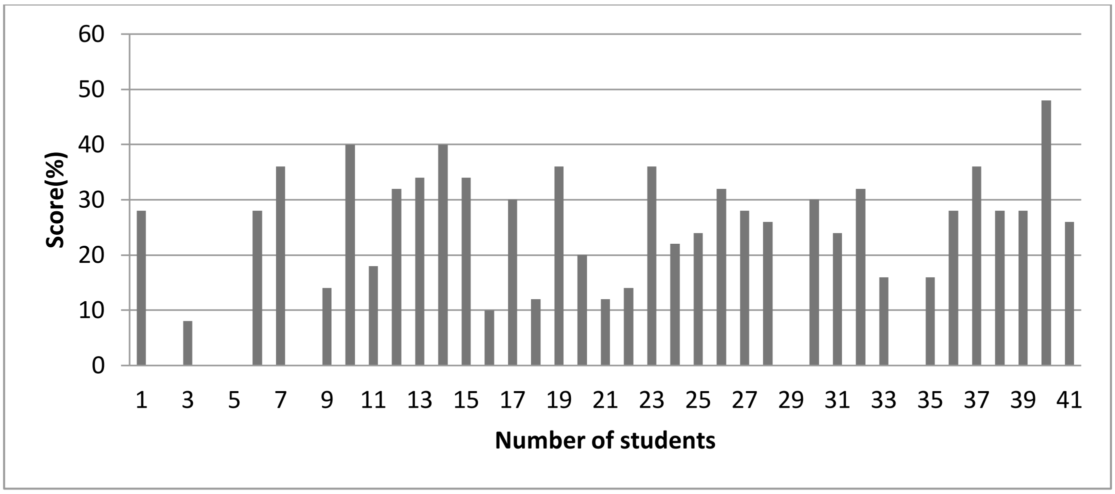

Figure 1: Pre-test results

The above results confirm the existence of the mathematical knowledge gap amongst the incoming first year Chemical Engineering students. These results are in agreement with findings by Wolmarans et al. (2010) and Moyo (2013) who reported that the mathematical knowledge gap existed amongst first year engineering students in mathematics courses in South Africa and elsewhere in the world.

4.2 Impact of the intervention in addressing the mathematical knowledge gap

After establishing that the incoming first year engineering students had the mathematical knowledge gap, the lecturer designed and implemented an autumn school to teach the four areas tested in the pre-test. A closed Facebook group was opened to extend learning beyond the classroom. After the autumn school, a post-test was administered on the first day of the new university term, which commenced after the autumn school. Findings of the post-test showed that the intervention played a major role in alleviating the mathematical knowledge gap from some of the students (with 1/3 of the students scoring 50% and above in the post-test and 2/3 scoring less than 50) (see figure 2), with Facebook playing a crucial role of extending learning beyond the classroom time. Further, the pre-test results showed a zero pass rate, with average results of 23%, which indicates that students lacked understanding of some of the basic mathematical concepts needed to be mastered before they start their first year engineering mathematics. The results of the post-test indicated an improvement on student performance with a pass rate of 39%, with an average student mark of 48% (see table 1). To determine whether the pre- and post-test marks were comparable, a p-test was performed on the pairs of pre-test and post-test data. A p-value smaller and equal to 0.05 ($p \leq 0.05$) is interpreted as significant as it indicates a probability of 5% or less difference between the pre-test and post-test data sets. The p-test showed a p-value of 2.22E-11, which is less than 0.05 indicating significant difference between pre-test and post-test (see table 1).

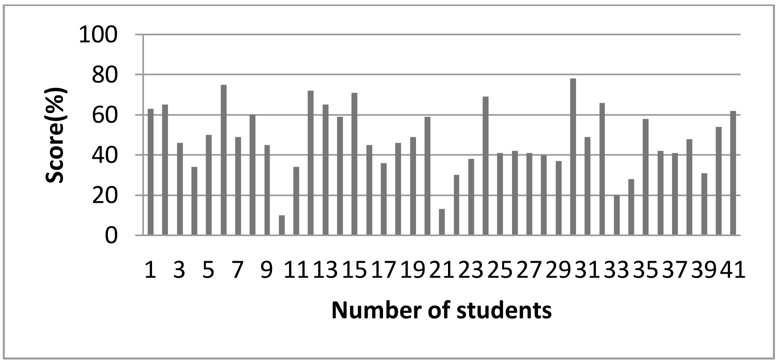

Figure 2: Post- test results

The progress of individual students between the pre-test and post-test is represented in the scatter diagram below (see figure 3). Each dot represents the score of a student in the pre-test and post-test.

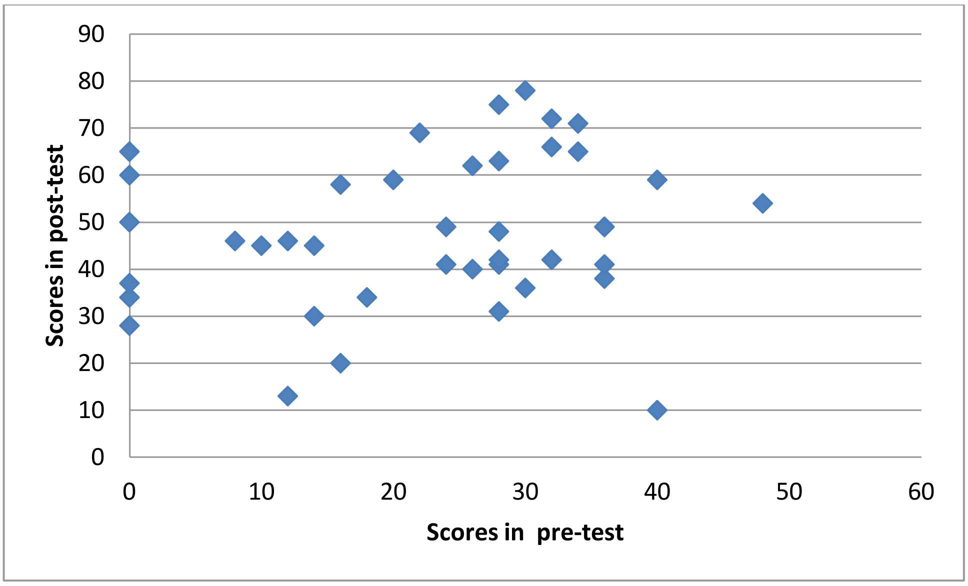

Figure 3: Scatter diagram of students' scores in pre-test and post-test

Even though 2/3 of the students did not score 50 percent and above, results show that there was increased understanding in knowledge as their marks had improved compared to what they had scored in the pre-test (see figures 2 and 3). However, it is disconcerting that only a third of the student population entering Chemical Engineering ECP reached a desirable level of mathematical competence (scoring>50%).

Table 1: Comparison of students' pre-test and post-test marks

	Pre-test	Post-test	End term results
Sample size	41	41	41
No of passes	0	16	31
Pass rate	0	39	76
Mean	23	48	54
Standard deviation	13	16	10
Coefficient of variation	57	33	9
P-test	2.22E-11		

Furthermore, figure 4 below shows a time series graph indicating student academic participation on the closed Facebook group. Facebook participation in this study was defined by the number of academic posts posted by individual students, students' post comments on the academic posts posted by the lecturer or other students and the number of students who liked the posts. Students' posts in this study were in terms of asking questions, which encouraged interaction and told the other students that their opinions on the subject of the post 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 student who posted the post knows that they engaged with the content and enjoyed it. In this study, the total number of academic posts were 96 (see table 2), 171 post comments (see table 3) and 41 likes as shown on Table 4 below;

Table 2: Individual and total students' posts on the Facebook group

Year	2013
Month	(Multiple Items)
Students	**Posts**
Abongile Ta Levie Nomfombo	2
Avela Manqina	4
Dale Lethling	3
Dimph Matshiya	4
Easton Chad Carolissen	3
Grant Marthinus	2
Kamva Mbalentle Dolz Landzela	5
Leigh Boo-thang Kruczynsky	8
Litha Martin Dyani	5
Lloyd Talmarkes	2
Malema Rendie Rendie	4
Matodzi Thalitha Makhado	1
Meagan Saul	1
Noxolo Shabangu	2
Nqobile Mamogobo	11
Pohotona Matome Thabang	1
Prudence Qhamisa Shuba	5
Sihle Isipho Samazima Kratshana	2
Sihle Ntsikelelo Zenani	1
Simbongile Kopana	1
Sinazo Nkuku	3
Siphokazi Favour Tomela	5
Thami Tha King	2
Themba-Elihle Sopazi	12
Yonelisa OlwAm Sitshinga	2
Zingisa Fani	1
Zulfah Samuels	4
Grand Total	**96**

Table 3: Individual and total students' posts comments on the Facebook group

Year	2013
Month	(Multiple Items)
Students	**Comment**
Abongile Ta Levie Nomfombo	1
Aphelele Piriri Mxabanisi	1
Aphiwe Mhlonyane	9
Avela Manqina	2
Dale Lethling	1
Dimph Matshiya	6
Easton Chad Carolissen	2
Grant Marthinus	1
Kamva Mbalentle Dolz Landzela	7
Leigh Boo-thang Kruczynsky	19
Litha Martin Dyani	7
Lloyd Talmarkes	4
Lulo Asa Kazi	3
Malema Rendie Rendie	4
Matodzi Thalitha Makhado	3
Meagan Saul	4
Noxolo Shabangu	4
Nqobile Mamogobo	10
Prudence Qhamisa Shuba	12
Rabs Vhafuwi	1
Sihle Isipho Samazima Kratshana	3
Sihle Ntsikelelo Zenani	4
Simbongile Kopana	3
Sinazo Nkuku	1
Siphokazi Favour Tomela	10
Thami Tha King	9
Thanyani Pandelani	3
Themba-Elihle Sopazi	22

Yonelisa OlwAm Sitshinga	1
Zulfah Samuels	14
Grand Total	**171**

Table 4: Individual and total students' likes of the posts on the Facebook group

Students	**Likes**
Avela Manqina	2
Dale Lethling	3
Easton Chad Carolissen	1
Kamva Mbalentle Dolz Landzela	2
Leigh Boo-thang Kruczynsky	1
Litha Martin Dyani	2
Lulo Asa Kazi	3
Matodzi Thalitha Makhado	4
Moloto Maleka	3
Pohotona Matome Thabang	2
Prudence Qhamisa Shuba	4
Sihle Ntsikelelo Zenani	4
Simbongile Kopana	1
Thanyani Pandelani	1
Themba-Elihle Sopazi	5
Zulfah Samuels	3
Grand Total	**41**

According to results presented in figure 4, the highest number of post was in the month of May during FISA examination with 38 academic posts, 70 post comments and 19 likes. The most post comments or discussion took place during the month of February, whereby more than 100 post comments were posted. Mathematics Autumn School was conducted between the months of March and April and a slight increase (8%) in the number of academic posts was visible with a 23% drop in post comments and a 64% drop in the number of likes. The drop in students' participation on the Facebook group between the months of May and June was due to the end of the term and the mathematics FISA was written at the end of May when students were no longer participating on the Facebook group.

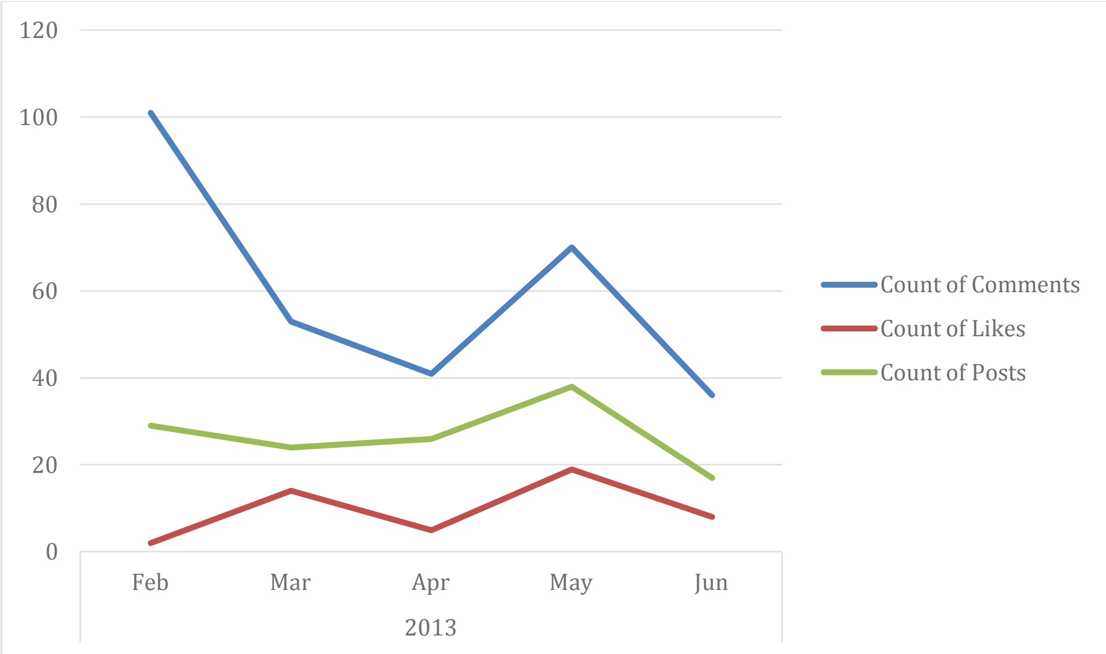

Figure 4: Facebook group students' participation data

The above post engagements (likes, post comments, share, etc.) show that the Facebook group allowed students to engage more with the subject matter outside the classroom, which may have led to deeper understanding of the subject matter. The figure 5 below shows an example of how students engaged on the Facebook group.

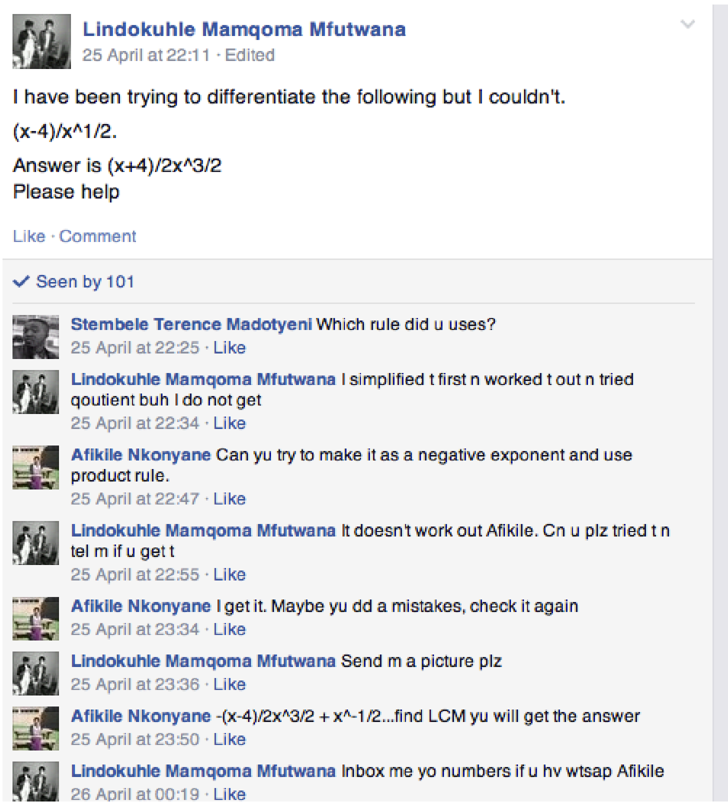

Figure 5: A screenshot showing an example of how students participated in the Facebook group

Moreover, the relationship between students' participation in the Facebook group and their academic performance in autumn post-test was analysed. A correlation coefficient (this was only calculated for the students who participated in the Facebook group) for academic posting (0,17558) (see figure 6), post comments (0,03) (see figure 7) and likes (0,083) (see figure 8) were obtained and showed no association between academic student performance in the autumn school post-test with Facebook participation.

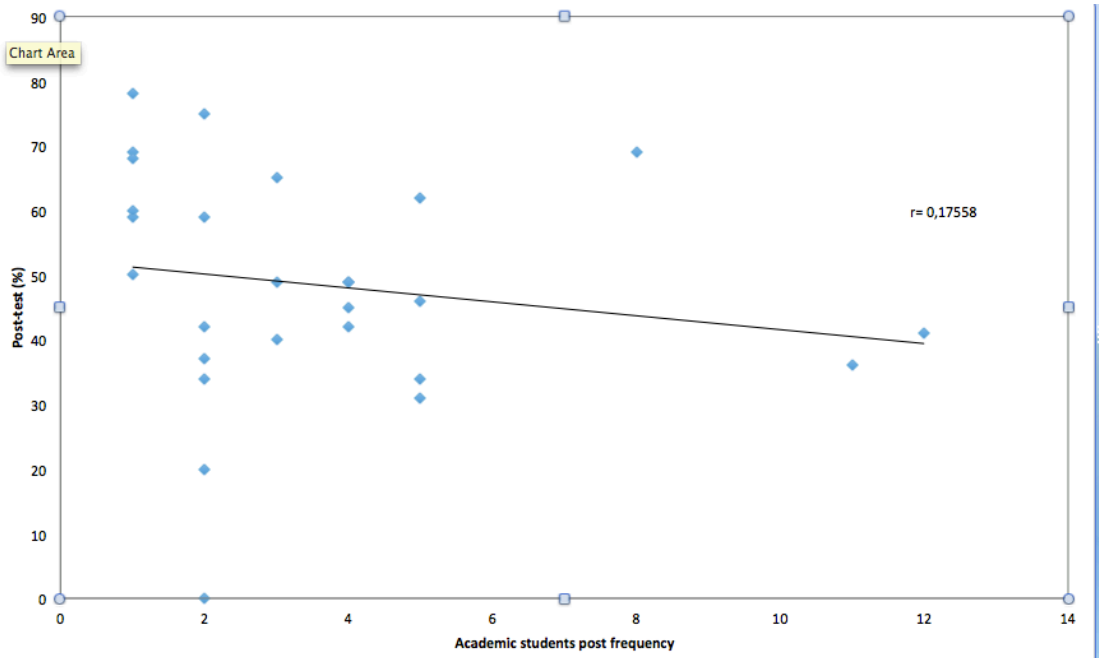

Figure 6: Correlation between student's post-test marks against Facebook academic post

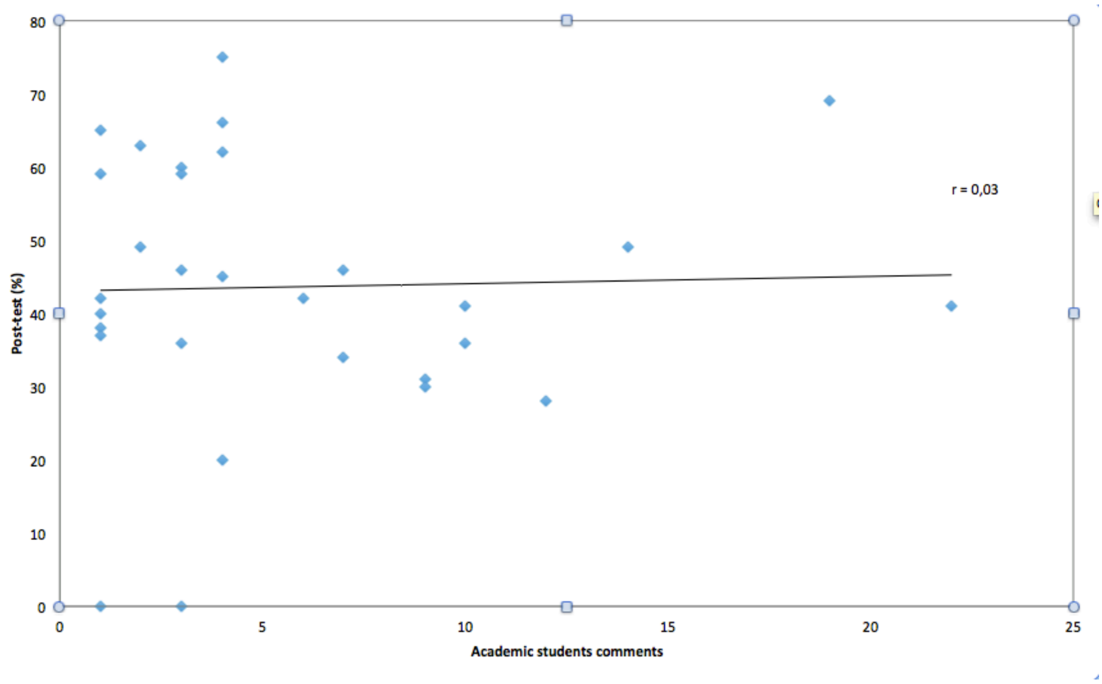

Figure 7: Correlation between student's post-test marks against students' post comment

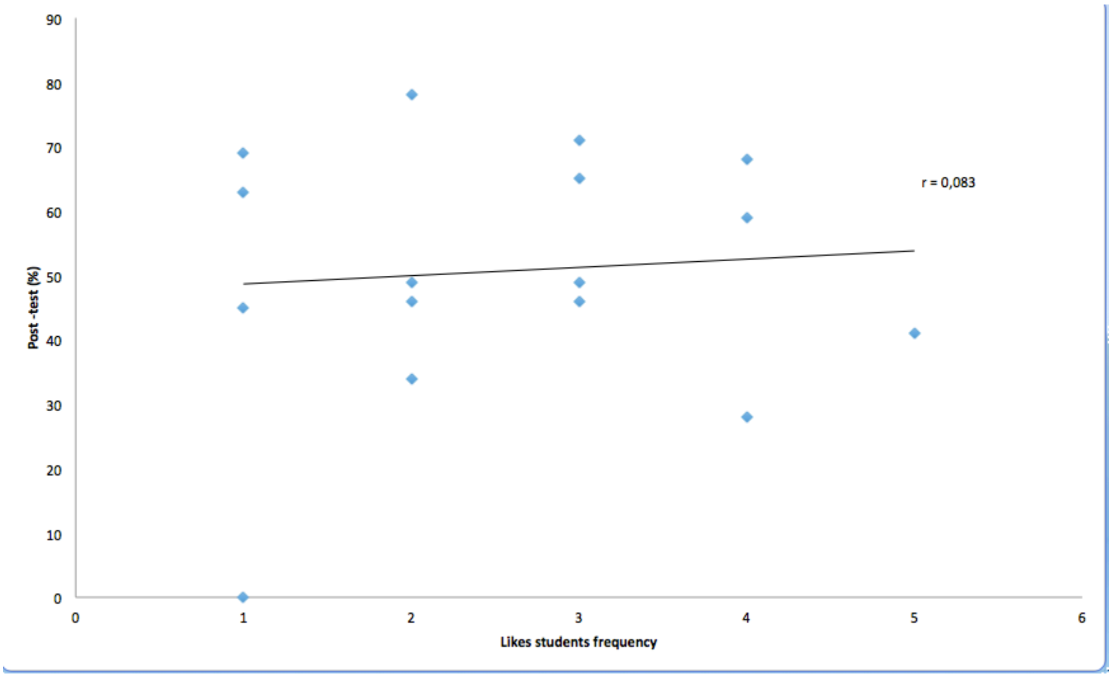

Figure 8: Correlation between students' post-test marks against students' likes of the Facebook posts

This finding indicates that academic performance in the autumn school post-test was not only as a result of the number of academic post students posted, post comments or likes, but could have been as a result of many other factors such as the autumn school. However, these results demonstrate that by students participating and collaborating in learning in the Facebook group, they collectively contributed to intelligence/[knowledge creation] and drew upon and contributed to distributed expertise and mentorship (Lankshear & Knobel 2011) which enhanced the understanding of the subject matter.

Quantitative data does not provide the reasons why two thirds of the students did not score 50 percent in the pre-test. But reasons are important in order to make informed decisions regarding the impact of the intervention. Therefore, three focus group interviews, each comprising of ten students, were carried out with the students to elicit further comments on the impact of the intervention. Analysis from the focus group interviews showed that all the students found the autumn school of benefit to them as it introduced them to things they did not learn in high school, helped them revise high school work and gave them the basic competences and skills needed to cope with university work, as exemplified in the following quotes:

> **Student C**: I think it helped a lot with some of the things we did in school, …we did not do in school.. .like we did not cover most of the things like trigonometry in NCS…So his intervention actually help when it comes to trigonometry.[sic]

> **Student E**: It was fine… because at first we didn't know the basics of things we were introduced to like here at university. So the bridging the gap thing gave us the basics so that we can cope well on like doing… the university work.[sic]

The teaching methods of the lecturer and the use of a closed Facebook group were given by the majority of the students as some of the aspects of the intervention, which enhanced its usefulness. On the lecturers' teaching methods, students said:

> **Student D:** It was his teaching method during that time. He had patience…we could bring like any queries that we had to him, especially the difficulties we had during matric…so we had an understanding to that, which helped us step up to be introduced into the university work. [sic]

The Facebook closed group was said to have been helpful in extended learning outside of the class. For example, students indicated that they used Facebook to:

Student F: I use Facebook to get notes, my notes, like most of the notes I get it from Facebook and if I want to know what is happening here [on campus] like if we are about to write a test and I am not sure about a thing…then that's when I use Facebook…[sic]

Facebook was also used extensively by students to post questions and get answers from their peers and the lecturer, which enhanced their learning as evidenced in the following:

Student A: When you do tutorials like Mr Moses gave us or things on the book then you go and ask question on the page and then you get answers and then they also show you steps on how you do it and then you get more understanding like that. You don't have to wait on something until the following day you just ask on Facebook and then they help you out, then you'll understand it, then you can do it… Mr Moses can help us and also the tutors and also my classmates. [sic]

Student B: It definitely improved my academic life because as I said, if you study a day before the test you can post like in the group a question and they help you with that question and if the question… comes in the test and then you score marks with that question. [sic]

Some of the students indicated that Facebook enabled shy students who would hardly ask questions in class to post questions on the Facebook group:

Student G: You know sometimes its difficult when you're sitting in class and you want to ask a question but you are ashamed to ask it because you know …maybe they're going to laugh at you. But the Facebook is giving you a platform where you ask a question then there's no one who's going to laugh at you but you are going to ask a question which you're going to help the second person who was going to ask that question and if they answer that question everyone is gaining not only you who's is gaining…which is good. [sic]

The above results show that students felt that Facebook was of benefit to them because they learned from each other's posts. This is vital because participating in someone's else's learning contributes to the growth of that person, one's experience as peers' tutor becomes a significant component of his/her education process and the best way to test whether we have leant something is to teach it to someone else (Clark & Lovric 2009). Despite the above benefits of the intervention, 2/3 of the students scored less than 50 percent in the post-test. Students gave varied reasons for their failure. Some of the reasons given were: forgetting what they learned, being lazy to study, lack of time management; being nervous during exams and struggling with university work. Some of the students echoed the following student's sentiment:

Student E: It is not the lecturers problem… he is doing his job and he is giving extra, but we also have like reach out like put more effort in, the time …we have the responsibility like she says, like we do the certain work, Thursday, we have to go and revise it that day…[sic]

The above results show that students appreciate the effort the lecturer was putting into teaching them and acknowledged that they needed to take responsibility for their studies. The researchers suggest that balance has to be struck between being too helpful, a short-term fix, and encouraging students to overcome their own deficiencies and problems (Clark & Lovric 2008), as a well-intended initiative at helping students, if lecturers go too far (babying students), can certainly disempower students as learners. Another reason given for failure was that students did not have time to study as they had to travel home and at home they had to do household chores or for some the environment was not conducive:

Student B: …Like me I get up at home 8 o'clock, [leave] from here about 4:30 pm because I am using the train from Belville to here [home] from here [Campus] to Kuils River, from Kuils River I take another train. So I don't have enough time to study…[sic]

Student C: … like most of the people here are staying in Res [residence] and you have to cook when you get home…you have to do like a lot of things when you get into your home before you study.So some of the things that we do like cooking, washing dishes and everything actually consumes our time of studying…[sic]

> **Student D:** Where I live I'm surrounded by taverns … So it is always noisy all the time and I'm living with too many people…there are a lot of disturbances…the environment is not conducive for me to study.[sic]

The above results highlight issues, which were not elicited by the diagnostic test but are crucial in impacting student success. The researchers suggest that student background information, their attitude towards mathematics and their learning styles should be included in the diagnostic test in order to enable the lecturer to design a relevant intervention for the students.

5. Conclusion and recommendations

Findings of this study showed that the incoming first year Chemical Engineering Extended Curriculum Program (ECP) students at a University of Technology in South Africa had the mathematical knowledge gap and hence the need for this University to come up with effective strategies for strengthening incoming students' level of mathematics knowledge and skills in order to enable them to cope and succeed in their university studies. The intervention designed by the lecturer in this study was perceived by all the students as beneficial for their studies. In particular, the lecturer teaching methods and the use of a Facebook group was applauded by the students, although there was no association shown between students' participation in the Facebook group and their performance in the post-test. The researchers argue that the lack of association between students' participation in the Facebook group and their performance in the pre-test indicates that alleviating the mathematical knowledge gap should not only be attributed to students' participation in the Facebook group, but that other factors may have contributed (e.g. the autumn school).

However, due to 2/3 of the students not scoring 50 percent in the post-test, the researchers agree with Clark and Lovric (2009) in suggesting that an effective diagnostics tool must inquire besides obvious information on mathematics background knowledge and skills, students' attitudes towards mathematics and learning mathematics, their motivation, intelligence, learning styles, and their social development in order to enable lecturers to design a relevant and effective intervention. The researchers further suggest that the university needs to find ways of assisting students living out of residence in order to enable them to have enough time for their studies. Further research will be conducted to establish exactly what aspects of the mathematical topics students found cognitively difficult to understand and ways of enhancing their understanding will be devised.

Acknowledgement

The researchers would like to acknowledge the Research in Innovation in Teaching and Learning grant that funded this study, the students who took part in this project and Mr Nzumbuluwani Mmbara, from Musuku Africa Pty (Ltd) for analysing the Facebook posts. This paper was first presented at the 9th International Conference on e-Learning, Chile June 2014. Feedback from the audience and the reviewers helped to reshape this paper for publication in this journal.

References

Badat, S. (2010) "The challenges of transformation in higher education and training institutions in South Africa," Paper commissioned by Development Bank of South Africa, [Online], http://www.dbsa.org/Research/Higher%20Education%20and%20Training/The%20challenges%20of%20transformation%20in%20higher%20education%20and%20training%20institutions%20in%20South%20Africa%20by%20Saleem%20Badat.pdf. Accessed 16 April 2012.

Badge, J.L., Saunders, N.F.W. & Can, N. (2012) " AJ beyond marks: new tools to visualize student engagement via social networks", *Research in Learning Technology*, Vol. 20, No.1, DOI: 10.3402/rlt.v20i0/16283pp1-14.

Caracelli, V. J. and Greene, J. C. (1997) "Crafting mixed-option evaluation design", In J. C. Greene & V. J. Caracelli (eds.), Advances in mixed-option evaluation: The challenges and benefits of integrating diverse paradigms. New Directions for Program Evaluation, No. 74, pp. 19-32.460, Jossey-Bass, San Francisco, CA.

Clark, M. & Lovric, M. (2008) "Suggestion for a theoretical model for secondary-tertiary transition in mathematics", *Math. Educ.Res. J*, Vol 20, No. 2, 25-37.

Clark, M. and Lovric, M. (2009) " Understanding secondary –tertiary transition in mathematics," *International Journal of Mathematical Education in Science and Technology*, Vol. 40, No. 6, 755-776.

Correa, E. (2013) "Social media in online course construction", In: R.M. Kersner (Ed.), The online university: Building viable learning experiences for higher education, World University Forum book series, USA, Common Ground Publishing LLC.

Department of Education (2008) "Abridged report 2008 National Senior Certificate Examination Results",[Online], http://edulibpretoria.files.wordpress.ocm/2009/01/abridgedreport2008nscexams.pdf. Accessed 1 January 2014.

Esteves, K.K. (2012) "Exploring Facebook to enhance learning and student engagement: a case from the University of Philippines (UP) Open University", *Malaysian Journal of Distance Education*, Vol.14, No. 1, 1-15.

Human, C., Hofmeyr, A. Human, P., Makae, N. & Van Koersveld, P. (2010) "Strategic and conceptual challenges experienced by first-year students while attempting to solve problems that require mathematical modelling", Paper presented at the ASSAF 'mind the gap' forum, 21 October 2010, Cape Town, South Africa.

Ivala, E. and Gachago, D. (2012) "Social media for enhancing student engagement: The use of Facebook and blogs at a University of Technology", *South African Journal for Higher Education* Vol. 26, No. 1.

Junco, R. (2012) "The relationship between frequency of Facebook use, participation in Facebook activities and student engagement", *Computers and Education*, Vol. 58, No. 1, 162-171.

Kaplan, A.M., & Haenlein, M. (2010) "Users of the world, united! The challenges and opportunities of social media", *Business Horizons*, Vol.53, No. 1, 59-68.

Lankshear, C. & Knobel, M. (2011) *New Literacies: Everyday practices and social learning* (third edition). UK: McGrawhill and Open University Press.

Leece, R. and Campbell, E. (2011) "Engaging students through social media", *Journal of the Australia and New Zealand Student Services Association*, Vo.38, 10-15.

Mazer, J.P.,Murphy, R. E. & Simods, C.J. (2007) "I'll see you on "Facebook": The effects of computer mediated teacher self-disclosure on student motivation, affective learning, and classroom climate, *Communication Education*, Vol. 56, No. 1, 1-17.

Miles, M.B. & Huberman, A. M. (1994) *Qualitative data analysis* (2nd ed.). Thousand Oaks: Sage.

Moyo, S. (2013). "A study of the possible existence, causes and effects of the mathematical knowledge gap between high school and first year University mathematics programmes and possible remedies for the situation at UNIVEN: A case study", [online], http://www.assaf.co.za/wp-content/uploads/2010/10/Mathematical-gap.pdf. Accessed 1 February 2014.

Muňoz, F.M. and Strotmeyer, K.C. (2010) "Demystifying social media", *Journal of Student Affairs Research and Practice*, Vol. 47, 123-127.

Patton, M. Q. (1990) *Qualitative evaluation and research methods*, 2rd edn, Newbury Park, California: sage Publication.

Scott, I. Yeld, N., & Hendry, J. (2007) "A case for improving teaching and learning in South African higher education", Research paper prepared for the Council on Higher Education.

Van der Flier, H., Thijs, G.D. & Zaaiman, H. (2003) "Selecting students for a South African mathematics and Science foundation programme: the effectiveness and fairness of school-leaving examinations and aptitude tests" , *International Journal of Education Development*, Vol. 23, 399-409.

Vivian, R., Barnes, A., Geer, R. & Wood, D. (2014) "The academic journey of university students on Facebook: an analysis of informal academic-related activity over a semester". The Journal of the Association for Learning Technology, Vol. 22, [Online] http://www.researchinlearningtechnology.net/index.php/rlt/article/view/24681. Accessed 11 March 2015.

Vygotsky, L. (1986) "*Thought and Language"*, Cambridge, MA: MIT Press.

Welch, B.K. & Bonnan-White, J. (2012) "Twittering to increase student engagement in the university classroom", *Knowledge Management and E-learning: an International Journal*, Vol. 4, No. 3, 325-345.

Wolmarans, N., Smit, R., Collier-Reed, B. and Leather, H. (2010) "Addressing concerns with the NSC: An analysis of first-year student performance in mathematics and physics", Paper presented at the 18th Conference of the South Africa Association for Research in Mathematics, Science and Technology,KwaZulu-Natal.