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An epic consequence of classroom revision of course content for first-year African engineering students

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ABSTRACT: Regularly reviewing classroom work is vital, if students are to understand, retain and apply information. A key component of such reviews includes classroom revision of course content. The purpose of this article is to highlight the positive impact of classroom revision on the pass rates of African engineering students enrolled for a first-year module at a university of technology in South Africa. The seminal work of Schön and the forgetting curve by Ebbinghaus form the theoretical framework for this research, which makes use of a longitudinal study. Four cohorts of first-year electrical engineering students, enrolled for Electronics 1 from 2016 through 2017, form the target population. The average pass rates for three cohorts exposed to a three-week period of regular distributed classroom revisions at the end of the module, was 76%, while the cohort who completed no classroom revision only achieved 55%. A key recommendation is to actively encourage academics to schedule at least two-weeks of active classroom revision at the end of a course or semester.

INTRODUCTION

Repetitio est mater studiorum. This Latin phrase tells us that *repetition is the mother of learning*, while psychological research shows how one should distribute those repetitions in order to maximise the impact on memory performance [1]. However, simply repeating a solution to the same problem at specific distributed intervals may not result in critical thinking, although it may impact on memory. More is required.

Critical thinking has been defined as self-reflective thinking, which is the art of analysing thinking with the purpose of improving it [2]. Therefore, when students engage in repetition that requires self-reflective thinking, then critical thinking is promoted. Noteworthy is the fact that students must engage at regular distributed intervals to analyse their thinking or understanding of a theoretical concept, in order to identify any gaps or misconceptions, which need to be resolved.

Self-reflective thinking may be linked to reflective practice. Reflective practice is defined by Schön as …*the practice by which professionals become aware of their implicit knowledge base and learn from their experience* [3]. As students are developing into professionals within their own field of study, reflective practice must be promoted among them, in order for them to refresh and enforce their theoretical knowledge in a way that it may be applied to various contexts or problems. One way in which reflective practice may be promoted, is through the use of classroom revision at the end of a module or semester.

Classroom revision of course content is defined, in the context of this article, as the review and repetition of theory by applying it to new contexts or problems; thereby, strengthening or reconstructing practice within a classroom environment before the main assessment period commences. The word *revision* literally means *to see again* [4], and conveys the idea of seeing the theory again, but this time at work in different contexts. The primary goal of this classroom revision is to better prepare students for their final examination, while granting them further opportunities for reflective practice and student engagement.

A study from the field of analytics showed that students who were active on more days before an examination and had more and longer learning sessions, achieved better grades in their final examination [5]. However, simply solving large amounts of exercise questions several times before an examination is not an ideal learning practice [6].

Subsequently, scheduling regular distributed classroom revision periods of the course content at the end of a semester may help to keep students active ahead of the examination. However, this classroom revision must not simply cover theory, but rather the application of theory to new contexts or problems. This may be achieved by using problem-based learning (PBL), which has been identified as an important pedagogy in engineering education [7].

The purpose of this article is to highlight the positive impact of classroom revision on the pass rates of African engineering students enrolled for a first-year module at a university of technology in South Africa (SA). The theoretical framework is firstly explained, followed by the context of the study and the research methodology. Descriptive statistics are then used to present the quantitative data, along with appropriate discussions. Succinct conclusions round out the article.

THEORETICAL FRAMEWORK

The theoretical framework for this study is grounded upon the seminal work of Schön [3], and the *forgetting curve* of Ebbinghaus as reported by Schneider [8]. Schön identified three types of reflective practices; namely, reflection-in-action, reflection-on-action and reflection-for-action. All three practices find application within higher education, with all being applicable to classroom revision of course content. This is especially true with PBL, where academics may provide a problem to students who must solve it using the iUSE principle (identify the type of problem, seek to understand the problem, determine viable solutions for the problem and, then evaluate which solution is more feasible) [9].

For example, a problem may be presented in designing an appropriate power supply unit, which students may use to charge their mobile phones. This requires students to reflect on information, which they have already received during the semester, choosing the most appropriate theory to apply to this new problem (reflection-on-action in terms of what they have done in the past). They will need to choose Kirchhoff's voltage and current laws, Ohm's law and specific design principles. They then need to apply this theory in practice, seeking to find a solution to the problem. However, as students' progress through the design, they may encounter a challenge or obstacle, which they need to overcome.

The academic may facilitate a number of suggestions, from which the students may choose. This requires that students reflect on their present practice, on their present understanding of the theory; thereby, requiring reflection-in-action. As they discern gaps in their thinking or errors in their practice, they can start to adjust or reconstruct their practice for present and future use; thereby, determining a viable solution and evaluating its feasibility for the current problem. They are, therefore, also engaging in reflection-for-action, as they contemplate how they will apply their new understanding in future problems or assessments. Subsequently, their fusion of theory and practice may be enhanced, by means of reflection, that is promoted by classroom revision of the course content at the end of the semester. Reflective practice indeed forms the basis for deep-learning, critical thinking, self-directed learning and lifelong learning skills [10], which students need to carry away from higher education. Yes, students need to carry knowledge away from a university in the form of logical reasoning and critical thinking [11], which does impact on memory.

In the late 19th Century, a German psychologist, Hermann Ebbinghaus, was interested in determining how the ability of the brain to retain memory decreases over time. He conducted a series of tests on himself, which included memorisation and forgetting of meaningless three letter words. He memorised different nonsense words, such as *kaf*, *wid* and *zof*. He then tested himself to see if he could retain the information after different periods of time. The results consequently obtained were plotted in a graph, which is now referred to as the *forgetting curve* [8]. Ebbinghaus theorised that humans start losing the memory of learned knowledge over time, in a matter of days or weeks, unless the learned knowledge is intentionally reviewed time and again [12].

Figure 1 illustrates the typical Ebbinghaus *forgetting curve*, which illustrates that students may forget up to 79% of first-hand information, which they receive in a classroom environment within 31 days.

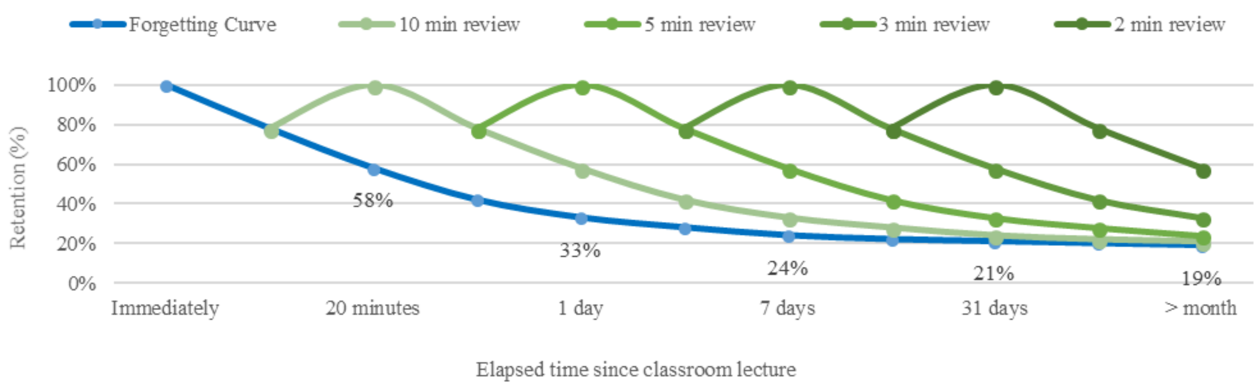

Figure 1: Overcoming the Ebbinghaus *forgetting curve* (Ebbinghaus, 1885).

However, if they were to regularly review the information (in only small-time blocks), then they would be able to retain up to 80% of the first-hand information after 1 month. For example, only a 10-minute review is required after 1 day, while a two-minute review would suffice after 30 days. This implies that the review time diminishes over time, because of the regular revision. This is of course applicable to each new concept discussed in the classroom lecture, and not to all the information presented during that time. Classroom revision of course content would align with the time period beyond 31 days, where students must also be encouraged to review information in small-time blocks at regular distributed intervals. In other words, the classroom revision must cover different aspects of the syllabus in small time periods, granting students the opportunity to link pockets of knowledge together, rather than working in silos. Opportunities for reflective practice were made available to all students in Electronics 1 at regular distributed intervals throughout the semester [13][14], with additional opportunities during the final three weeks of the semester, just before the final main assessment period.

RESEARCH CONTEXT

Electronics 1 is a compulsory offering in the National Diploma: Engineering: Electrical qualification offered at the Central University of Technology (CUT) in South Africa. The National Diploma is a NQF (National Qualifications Framework) Level 6 qualification that requires first-year students to obtain a minimum of 360 credits to complete it. The majority of modules, including Electronics 1, have a credit value of 12, that requires students to dedicate at least 120 notional hours to them. Many students register for this module in the first semester of the year, with less numbers in the second semester (14 weeks in duration). This is primarily due to the end of the previous school year, which ended in November, with many more school leavers entering higher education in February for the first time.

The syllabus of Electronics 1 covers six sections, which is exactly the same in both semesters. These include the operation and application of the oscilloscope, electrical basics, Thevenin's theorem, Kirchhoff's laws, Ohm's law, resistors, capacitors, diodes, transistors and the design of power supplies and amplifiers. The structure of the module is shown in Table 1, where the anomaly of the second semester of 2016 is highlighted.

It was during this time that the #FeesMustFall movement reached a climax in SA, with students demanding the decolonisation of the curriculum and free education for all. Student unrest during this time disrupted the day to day functioning of many universities, resulting in financial losses, reduced student engagement, student psychological problems, disruptions to career path planning, faculty administrative burdens and the endangerment of public safety [15]. During this time, no classroom revision of course content was done as all classes were suspended. However, in the other three semesters, no such challenge occurred, with three weeks of classroom revision being completed with the first-year African engineering students in Electronics 1, just prior to the main assessment.

Table 1: Course structure anomaly for the second semester of 2016.

Semester 1 - 2016; Semester 1 - 2017; Semester 2 - 2017	Semester 2 - 2016
Unit 1 - unit 7 presented consecutively over 7 weeks	Unit 1 - unit 7 presented consecutively over 7 weeks
Seven on-line self-assessments completed by week 8	Seven on-line self-assessments completed by week 8
First five on-line self-assessments contribute to T1	First five on-line self-assessments contribute to T1
Main test written in a computer laboratory in week 9	Main test postponed due to student unrest
University recess during week 10	University recess during week 10
Classroom revision of content for week 11-13	No classroom revision due to classroom suspension
Practical work completed and grades given in week 14	Practical work not completed and adjusted grades used

The syllabus of Electronics 1 is divided into 7 units, with each unit being discussed over a period of one week. Once a unit is complete, then an on-line self-assessment was made available for 6 days to further engage students with the content. The first five on-line self-assessments contribute to Test 1 and counts 25% towards the course mark. Students need to obtain a course mark of at least 40% to gain entry into the final summative examination (classroom based). This process of promoting reflective practice of the course content at regular distributed intervals through the semester helped to negate the *forgetting curve* of Ebbinghaus [13].

However, this is not sufficient in helping students to adequately prepare for their final main assessment at the end of the semester. This requires classroom revision during the final three weeks of the semester, which has many benefits for first-year students. One of the benefits is that it helps learning to mature [16]. In other words, refreshment of theory occurs when academics help students to apply theory to new contexts or problems during the revision process; thereby, helping them to resolve any gaps in thinking or errors in their practice. Revision does help students become more proficient at learning from their own errors [17].

When this process is repeated, then synapses within the brain are strengthened and reconstructed to reflect the correct practice of theory. Brain synapses are formed and continuously restructured throughout life with an amazing specificity and activity-dependent plasticity based on our different experiences, which ultimately shape us as individuals with unique memories, thoughts, skills, and personalities [18]. This, in turn, may encourage more on-going self-revision of theory by the students, which may also promote further student engagement with the theory, before the main assessment [14]. Encouraging more on-going self-revision and engagement with the course content results in students being more active before the main examination, that may help to lessen examination stress and subsequently contribute to academic success. That final benefit is highlighted in this study.

RESEARCH METHODOLOGY

A longitudinal study involving quantitative data is used along with descriptive statistics. Longitudinal studies are defined as studies in which the outcome variable is repeatedly measured [19]. In this study, the outcome variable is the impact that classroom revision of course content has on the final pass rates of first-year African engineering students at a university of technology in SA. This is done for a two-year period (2016-2017) and features four semesters of quantitative data. Each additional wave of data (or data from each successive semester) from a longitudinal study increases the reliability and precision of measuring change and adds power to the results [20].

Descriptive statistics, rather than inferential statistics, are used as the results are interpreted with regard to specific electrical engineering students enrolled for Electronics 1, which constitutes the target population. Descriptive statistics include the student profile and the final academic results of all the enrolled students during 2016 and 2017; thereby, requiring no sampling technique.

RESULTS AND DISCUSSIONS

Figure 2 highlights the profile of the first-year African students enrolled for Electronics 1 over the four-semester period which forms part of this longitudinal study. Males outnumber females by almost 4:1. The engineering education community does recognise the gap between females and males in engineering [21], which is why a global drive exists to promote more women in engineering. The dominant age bracket is less than 24 years of age, as the majority of enrolments have just completed their high school career, having obtained a Matric Certificate (NQF Level 4 qualification in SA). The average age for Grade 12 learners in SA is 18 years of age [22]. The home language of the majority of students is Sesotho, which is indicative of the Free State Province in SA [23], where CUT is located. The profile thus confirms that the majority of students are African male Sesotho speaking who have entered higher education for the first time (referred to as first time entering students in SA). These students would have to adapt to higher education, adjusting their study habits from their high school career. Ongoing student support is thus vital, if these students are to reap academic success at the end of their different modules.

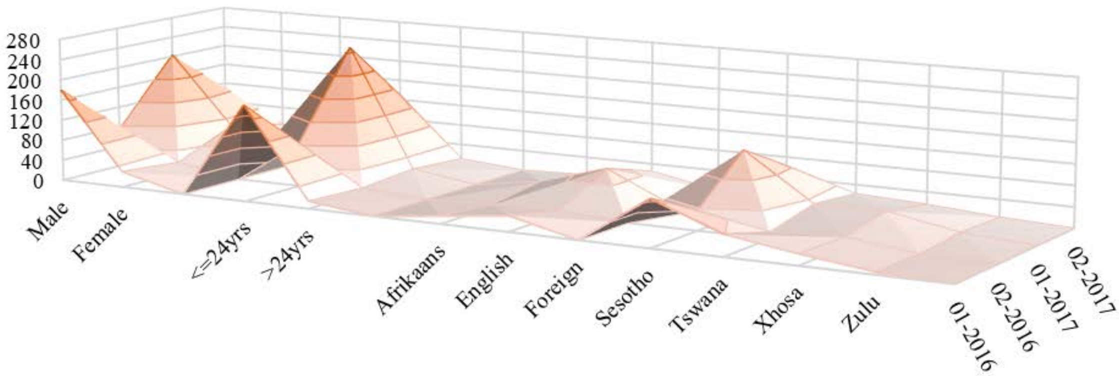

Figure 2: Profile of the students enrolled for Electronics 1.

One such support is the use of repetition founded on the principles of reflective practice by using classroom revision of the course content at the end of the module. This was applied by the academic responsible for Electronics 1 in order to keep students active and longer engaged with the course content ahead of the main assessment period. This was done in the first semester of 2016 and in the two semesters of 2017. The final pass rates for students in these three semesters averaged 77.7% (80% for 2016 with 77% and 76% in 2017 - see Figure 3a).

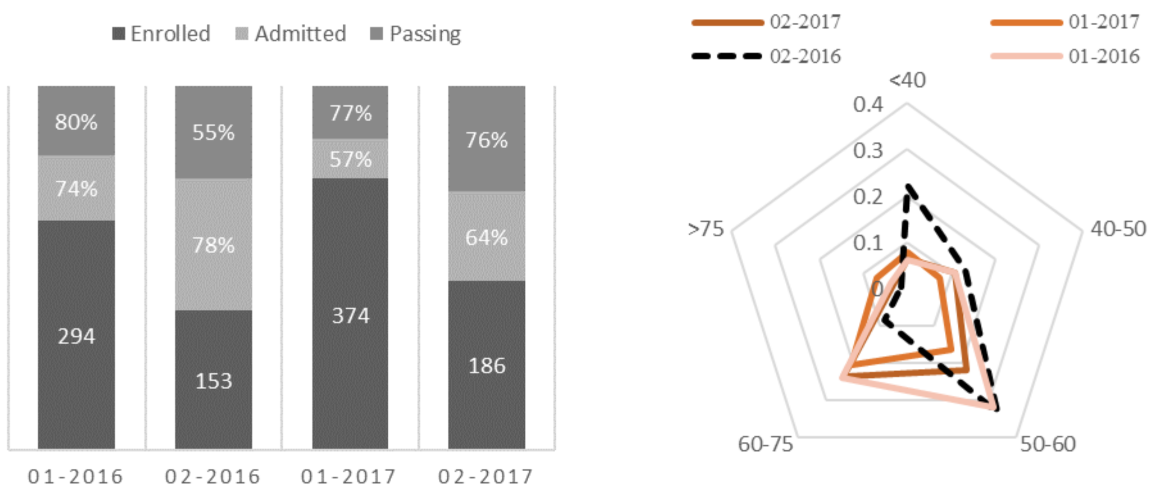

Figure 3: Student academic results: a) enrolments and pass rates; and b) grade distributions.

However, in the semester where no classroom revision occurred due to student unrest, the final pass rates was 55%, resulting in a significant decrease of more than 20%. Student enrolments are also visible in Figure 3a, which indicates that the first semester of each calendar year has the largest number of students due to the completion of their school career in November of the previous year. The distributed grades of these four cohorts of students are shown in Figure 3b (four distributions shown from less than 40% to more than 75%). A similar distribution is visible for the three semesters of classroom revision (solid lines), with a peak between 50 and 60%. However, a secondary peak is visible at less than 40% for the semester with no classroom revision (black dotted line representing semester 2 of 2016). This confirms that a larger number of students struggled to obtain the minimum requirement of 50% to pass their final examination.

CONCLUSIONS

The purpose of this article was to highlight the positive impact of classroom revision on the pass rates of African engineering students enrolled for a first-year module at a university of technology in South Africa. The majority of students were African males under 24 years of age, with Sesotho being the dominant home language. Students who were exposed to regular classroom revisions for a period of three weeks prior to the main examination achieved a higher pass rate (average of 77.7%) than students who had no classroom revision (55%).

This classroom revision of course content featured PBL, where students had to solve different engineering problems using their acquired theoretical knowledge obtained during the semester. This helped students to remain active before the main assessment and promoted reflective practice. A key recommendation of this research is to encourage academics to schedule at least two weeks of active classroom revision at the end of a course or semester.

This repetition may be seen as the mother of learning, as students were able to identify gaps in their thinking and errors in their practice ahead of their main assessment. Subsequently, strengthening and reconstructing of brain synapses should have occurred in these first-year African engineering students, which lead to an epic consequence - a 22% higher pass rate for them as compared to their fellow students who had no classroom revision of course content at the end of their semester.

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