

Does Self-Regulating E-Learning Assist in Secondary School Preparation for Engineering Education?

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Abstract- One of the most prominent issues in engineering education is the proper preparation of prospective engineering students in the subjects of mathematics, physics, and English during their senior secondary school years. South Africa is particularly disadvantaged in this regard as international assessments have shown South African secondary students have consistently been shown to perform poorly in this regard. In order to try to address this issue, a proposed solution is through the use of IT (Information Technology) to provide individualized instruction in these subjects using a multi-media platform. Some advantages of using IT for instruction is that it provides better differentiation of instruction that can be tailored to an individual's learning style and enables students to take charge of their own learning. This IT solution, with the research conducted therein, was provided through a privately-funded interventionist program for Grade 11 students who attend IT-aided classes in mathematics, English, and physics for six hours every week at a university of technology. In this paper, we determine the effects of this program in terms of their school final subject Grade 11 grades relative to their school Grade 10 baseline.

Keywords: e-learning, secondary school, education,

I. INTRODUCTION

High mathematics and physics grades, along with an ability to communicate well in English, is a prerequisite for most engineering programs at universities. However, the majority of South African school children have difficulty in achieving these criteria. In international assessments, a small majority, 10% of South African students in mathematics and 13% in science, score higher than the Low International Score. Attempts to resolve this issue of low math/science scores is problematic because a combination of factors, rather than a simple single factor, has been identified. One possible solution to improve scores is the supply of supplemental textbooks so that students could work by themselves outside the classroom setting[1].

Extra tutorials in mathematics, English, and physics for secondary school students are another option which was embraced by a professional body. This body funded these tutorials for six hours every Saturday during term times at a university of technology. This group consisted of Grade 11 students from schools in disadvantaged areas; teachers at each of the schools in these area, in compliance with the professional body's selection criteria, selected three students from their school who had the best potential to achieve a final

average grade of A in the South African subjects of English, physics, and mathematics.

In order not to be involved in the selection of the students, the sponsor relied on a network of schools, in disadvantaged areas, that were established by an earlier educational researcher at the university. Disadvantaged areas in South Africa are defined as being high in general indices of deprivation such as high unemployment, poor health and educational facilities, and little or no service provisions. [21] The teachers in this network of schools were asked to select three students in each of their school, who in their opinion, would be best able to benefit from the additional tuition provided by the program in order to obtain a final average grade of A in the subjects of English, physics, and mathematics. By selecting three students from each school, it was felt that they would be able to provide a fair representation of each school within the network while not overburdening the resources of the program.

A pilot project for this program began with traditional instruction in these subjects using textbooks but the end results were not encouraging. Consequently, the project then adopted an online learning platform for mathematics and physics and

another for English, which operated on laptops provided by the funding body. An administrator, who manages administrative and logistic issues, and a mentor, who is present in the classrooms at all times, are supplied by this funding body. The e-learning platform provides instruction using texts and figures, videos, and simulations; this instruction allows students to learn at their own pace. An online tutor is available for students to ask questions on the material and to receive answers. Regular online quizzes assess students periodically on the material that they learnt.

The goal of this program is to assist in improving students' mathematic, physics, and English scores at their respective secondary school. With improved scores, it is hoped that this program would enable more students to qualify for entrance. In this paper, we examine the mathematics, physics, and English secondary school grades of students during the final year of Grade 10, just before they entered the program, and their subsequent secondary school grades in these subjects throughout their Grade 11 year, as they participate in the program in order to determine the effectiveness of the e-learning intervention.

II. LITERATURE REVIEW

South Africa's education system, according to Simkins [2], suffers from consistently poor standardized test results. In both 2003 and 1999, South African students were in last place in the Trends in International Mathematics Study tests. Although there are 7 000 secondary schools in South Africa, only a tenth of these schools produce sixty percent of university-eligible students. [3]. A number of reasons for these low scores and school disparities are suggested. Although teachers are required to deliver 22.5 and 27.5 instruction hours per week, a Department of Education study in 2005 discovered that instruction hours in the classroom averaged only 16 hours per week due to early departures of teachers and little teaching on Fridays. [2] Other issues identifying as contributing to low test scores include lack of teaching resources, poor teacher training, insufficient departmental support, lack of teaching resources, administrative overload, and overcrowded classrooms[4]

In order to address these problems, a number of possible solutions have been proposed, including the provision of instruction through e-learning. E-learning could be defined as an electronic system that disseminates knowledge to students regardless of time or geographical location.[5]. By allowing the delivery of material at a student's own pace, e-

learning enables students to learn at a time of their choosing and outside the traditional school infrastructure. E-learning provides personalized instruction, which can be creatively customized to suit individual preferences and learning styles and which allows e-students to feel more in control of their environment. [6]

A number of possible solutions to these problems have been proposed, including instruction through e-learning. E-learning is a web-based or electronic system that allows knowledge to be provided to students without regard to time or geographical restrictions. [5, 7] By providing material at an e-learner's convenience, it allows the e-learner to bypass the traditional school infrastructure and hours and allows the e-learner to customize their material to suit their individual preferences and styles in order to feel more in control of their learning and learning environment [6, 8]

E-learning has been found to be the most effective means of instruction by some. Different educational pedagogies, such as peer and self-instruction, were studied by Kroesbergen and it was found that self-instruction was the most effective learning method. [9, 10] Of these self-instruction methods, computer-aided instruction was found to be the most effective. [11] Because computer – aided instruction allows students to take responsibility for their own learning and to proceed at their own pace, this instruction has additional benefits such as reduced learning time, proof of completion, and increased student retention of material. [8]

Self-regulated learning is a special subset of e-learning where individual students are responsible for their own learning. [12] Students, in a self-regulated learning environment, select and set their own goals and use individual strategies to keep track of and control the various aspects of the learning process[13] This control, along with the learner's processes of organizing and transforming their learning into meaningful material, provides statistically significant performance improvement in mathematics and other technical subjects in secondary school relative to an instructor-led learning environment. [14-16]

However, not all students easily adapt to self-regulated learning; some students experience problems adjusting to the structure of the online course, managing their time, or dealing with the absence of an instructor[17]. Students, with low self-regulatory skills and who require frequent direction from an instructor, may feel discouraged by an online course. [18] This discouragement may be reduced if the online course is combined with

regular opportunities for personal interaction with a physically present instructor.[19]

This program combines online learning, where students came proceed at their own pace, with frequent personal interactions with a mentor for those students who require it. Hence, we look at how successful this blended approach of self-regulated online learning, with a physically-present mentor, is in terms of school marks improvement.

III. METHODOLOGY

Our approach is a comparative analysis, by term and grade range, of secondary school grades achieved by the students enrolled in the program before, during, and after the e-learning intervention program. This analysis was motivated by several previous efforts. As the schools chose the best 3 students from their school, comparison of grades achieved by this group with a similar control group is difficult; consequently, it was decided to compare their final Grade 11 secondary school grades with their final Grade 10 grades as a baseline comparison.

At the beginning of 2013, the program sponsors conducted a pilot survey of these students in order to measure certain aspects of the effectiveness of the program. The survey was composed of ten themed quantitative, close-ended, and Likert scaled questions and several open-ended questions that allowed comments. The themes of the survey focused on the value of the session, the venue, and the helpfulness of the peer mentor. A few of the questions with their results are given in Table 1.

Question	Always (%)	Mostly (%)	Sometimes (%)
The venue was well organized	92	4	4
The facilitator gave assistance when needed	58	25	8
The session was of value	33	33	25

TABLE 1. SOME RESULTS OF PILOT SURVEY

Given the ambiguous results of the pilot survey, particularly in regards to the session's value, further investigation was considered to be warranted in order to determine the program's effectiveness.

Given the inconclusiveness of the pilot study, a more comprehensive investigation using a focus group interview was scheduled for December, 2013. This focus group interview was partially based on Sun's [5] thirteen factors of e-learning satisfaction, which formed the themes of the

interview questions. These themes included both their perceptions on their perceptions on the e-learning system's software, content, structure, assessments, and educational benefits and on the facilities with suggestions for improvement. Using the results of the interview, the student's responses will be coded and analyzed using the qualitative research tool, Nvivo. The results of this interview are not yet ready. The purpose of this interview will be to determine the effectiveness of the program, from the student viewpoint, and to identify areas of improvement.[20]

Our approach measures the secondary school grades, categorized by grade groups A-F, by terms (South African semesters). Grade grouping was performed to make analysis of marks easier. Average scores and standard deviation for each subject per term is used to ensure that grade grouping does not obscure results. Descriptive statistics will be used to measure grade improvement of the program students relative to their Grade 10 grade baseline. Twenty-six students completed the program with available grades.

IV. RESULTS

Our results were hampered by a number of factors:

- a) The number of students who attended these sessions and who reported their school marks varied from term to term, which may have skewed the results.
- b) A number of students (approximately 6) attended the program throughout the year but after writing their final exams in December, their grades were still not submitted to the program coordinator so their results could not be analyzed. In addition, not all grades for the previous terms of all students were not submitted so data for different subjects in terms is not available. Better data collection procedures need to be implemented and enforced.
- c) As the preliminary results of our focus interview revealed, a number of students suffered from Internet outages, laptop problems, and login issues which prevented them from utilizing the e-learning facilities. [20]
- d) Some of the students indicated, in our focus group interview, that they never used laptops before so it took some time for them to adjust and readjust to use them. [10]. An example, only eight of the students in the programme had some basic prior computer usage, with just one learner having an email account.

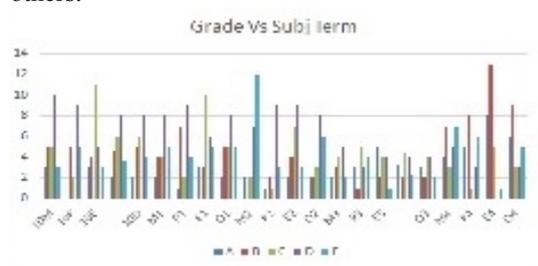
- e) The length of travel also likely played a role. A number of students had to travel three hours each way to reach the university for a six hour tutorial. Often, after they arrived from their long journey, they would find that due to Internet outage or laptop problems, the tutorial was no longer viable and they had to travel the three hours back with no learning gained. [20]

Our results indicate that the intervention did play a significant role in improving student marks.

	10-T1	11-T1	11-T2	11-T3	11-T4
Avg Subj	60%	57%	52%	64%	65%
Std Dev	0.13	0.16	0.14	0.16	0.15

TABLE 2: AVERAGE AND STD DEVIATION

As seen in Table 2, the subject grades for all present students in the subjects of physics, mathematics, and science are averaged in order to determine grade improvement along with a calculation of standard deviation in order to determine improvement variance amongst this group of students. There is a rise in the average subject grade from 58% in Grade 10 to 65% at the end of Gr 11 with a subsequent slight increase in the standard deviation from Grade 10 to the final term of Grade 11. These figures suggest that the majority of students did benefit to some extent by this program but some students did better than others.



Legend: {Number1}{Letter}{Number1}-{Number2}
GradeYear(M)ath/(P)hysics/(E)nglish TermNumber

FIGURE 1 : DISTRIBUTION OF GRADES

Figure 1 details the number of students achieve a grade group by subject per term. In regards to the Grade 10 base of an average of Ds in math and physics with a C in English, this program details, in Fig 1, a steady improvement in these subjects' marks throughout the third term. The dip in marks during Term 2 could be attributed from the sudden change in South African math and physics curriculum from OBE (Outcome-Based Education) to CAPS which created a lot of confusion and difficulty for secondary school students, in the second term of Gr 11, which shows high failure

rates in mathematics and physics. One subject that show the most grade improvement throughout all of the terms was English. Although the reason for improvement in this particular subject warrants further investigation, one possible reason is that the tutorial material was all in English and the students, most for whom English is a second language, would have been forced to learn additional English incidentally in order to progress through the program.

Gr	Gr10-T4	Gr11-T3	Gr11-T4
A	2	3	6
B	5	2	9
C	6	4	3
D	8	4	3
F	4	1	5

TABLE 3: STUDENT NUMBERS BY GRADE (GR) BY TERM(T)

As indicated in Table 3, when you look at the number of students achieving an A or B grade, the number increased 31% from Grade 10 to 11 (final term). The number of students achieving a C dropped by 12% and the number of students who achieved a D dropped by 19%. The number of students that failed dropped by 1 person or less than 1%.

V. CONCLUSION

Any analysis of student performance in this program must consider the lack of complete marks for all students who completed the programme which makes a full and detailed analysis of their grade performance difficult. This program, viewed in light of secondary school scores of students who stayed throughout the program, suggests that the number of students that achieved higher grades of A and B, relative to their Grade 10 grades, was significantly increased. In addition, the number of students achieving an average grade of C or D seems to have decreased quite significantly. The number of failure grades remained roughly the same.

The provision of this e-learning program seems to have been effective to high-potential students, who were scoring below their potential and who were given learning resources that were unavailable to them before. It also appears to be quite effective for borderline students who seem to have improved their mark significantly.

VI. FUTURE WORK

As those students who achieved an A or B combined average in the subjects of mathematics, English, and physics will continue on with the program in Gr 12 and a new group of students from

Gr 11 have begun this program this year, opportunities are presented for both a longitudinal study of the original group as to their secondary school performance (with their matriculation results) and their perceptions of the program, as it changes in response to problems encountered earlier on (lack of wireless in many instances). In addition, the new group provides fresh opportunities to determine their degree of improvement with the newly-adapted program.

Future analysis of online assessments completed by the students will include correlation of assessment scores with relevant statistical information such as time allocated per subject per session, number of assignments per module and per subject, time taken to complete each assignment (average and standard deviation), number of assignment between assessments, and time allocated per assessment.

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