

Assessing Engineering students performance in Electronics course during first year of studies

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Abstract

This research study was designed to evaluate the performance of foundation extended program and mainstream students pursuing Bachelor of Technology in Electrical Engineering at the Tshwane University of Technology, eMalahleni campus, South Africa. The variables under assessment are the academic performance (students' scores) in Electronics 1 for foundation (year course) and mainstream (semester course) levels. Data were acquired using 574 students' scores in Electronics 1 course. The students' scores for the years 2013 and 2014 were used for the investigation. T-test statistical analysis was used to evaluate the results. The findings reveal that students' performance has no significant difference since $p > 0.05$. In addition, the mean score of the students in the year 2013 is better compared to 2014 academic year. Furthermore, generally comparing the mean scores between the groups under investigation, it is evident that the mainstream students outperformed the foundation students. The study concludes that base on the findings, the continuous assessment evaluation method is not adequate for improving the students' performance. It provides insight to the process of improving teaching and learning pattern for Electronics courses in order to improve students' pass rate.

Keywords

Electronics, electrical engineering, foundation learners, mainstream learners

1. Introduction

Electronics is one of the compulsory subjects for all students enrolled for electrical engineering (EE) studies. Students enrolled in the Department of Electrical Engineering, Faculty of Engineering and the Built Environment at the Tshwane University of Technology (TUT), South Africa either get admitted through the mainstream program or extended curriculum program with foundation provision (FP). The mainstream program is completed within 3 years (6 semesters) while FP minimum duration is three and half years. Thereafter, the students go for experiential learning in Electrical or Electronics engineering industries depending on their field of interest (light or heavy current). The experiential learning is a year program after which the students will register for BTech program to complete the undergraduate degree. The mainstream students normally offer Electronics 1 in semester one, Electronics 11 in semester two, Electronics 111 in semester 3 and Electronics 1V at BTech level. For FP students, Electronics 1 runs for one year before registering for Electronics 2 in semester one of second year of study, Electronics 111 in semester two of the second year and Electronics 1V at BTech level. To qualify for the mainstream admission, student must obtain an Admission Points Score (APS) of (at least) 28 in matric result with Mathematics, Physical Science and English as compulsory subjects. Applicants with APS between 20 and 27 with the compulsory subjects inclusive could be considered for FP admission. The students' performance in electronics 1 course has significant influence for future success in light current Engineering.

TUT runs Electrical Engineering degree courses in two campuses (Pretoria and eMalahleni campuses). eMalahleni campus is considered to be a disadvantage campus when compared to Pretoria campus. Most students enrolled to study electrical engineering in eMalahleni campus are from rural areas. According to (Azaola, 2014, Arnove, 1973, Tamayo *et al.*, 2017), rural education systems have greater obstacles to inclusion as compared to their urban counterparts. Students from high schools in the rural areas are faced with challenges in getting science teachers to teach the students. In addition, most students struggle with communication skills using English language, which is the approved official language for teaching in TUT. They are used to speaking their native languages. Some of the students find it difficult to understand lecturers while teaching in class using the English language as a medium of communication. Furthermore, lack of enough learning facilities such as computer systems, laboratory equipment and the Internet also contribute to the performance of the students. Due to the background of study prior to entrance into the higher institution, students have performance challenges in some engineering subjects such as Electronics and Mathematics. This study evaluates eMalahleni campus students' performance in Electronics 1 for the year 2013 and 2014 academic session.

The Department of Electrical Engineering (DEE) and the Faculty of Engineering identified students' low pass rate performance in this course. This has been a major concern to the institution and the faculty has been looking for ways to alleviate the problem. According to (Popham, 1971), one of the most indefinable targets in the history of educational study is a valid index of teacher effectiveness. Hence, the low pass rate performance was attributed to either method of teaching or the students' lack of preparation for semester tests and examination (Čukušić *et al.*, 2014, Cooles *et al.*, 2014, Tsai, 2016). Other factors contributing effectively to the quality of learners' performance according to (Farooq *et al.*, 2011, Ali *et al.*, 2013, Eamon, 2005) could be the following variables; student factors, family factors, school factors, socioeconomic factors and peer factors. Interacting with some of the eMalahleni engineering students, we discovered that students enrolled for Electrical Engineering not because they have interest or passion for the engineering career but either they were forced to pick the career by their parent/s or have no other option. Before 2013, the method of evaluation had been based on class tests 10%, semester test 1, 30%, semester test 2, 30%, practical test 30% (with subminimum 50%) all summing up to 100%. Predicate marks are calculated base on the aforementioned criteria. Students with 40% total mark and above are qualified to write the semester/year examination. The average of the predicate and examination marks determines the final mark of each student. Students with exam scores between 45% and 49% will write supplementary examination while students with marks below 45% will repeat the course. Unqualified students will repeat the subject. Due to the low pass rates of the students with this evaluation method, the Faculty decided to change the mode of evaluation to continuous assessment method of evaluation to ascertain the cause of students' poor performances.

Under continuous assessment evaluation, the assessment criteria for Electronics 1 are as shown in table 1. The continuous assessments consist of assignments, project, class tests, group presentations, practical and written test. The total mark for all the criteria is 100% and pass mark start from 50% and above. Students with marks below 50% will repeat the course.

Table 1: FPELC01 and ELC111T Assessment Weightage in percentage

Assessments	AS	CT	EV	HM	PJ	PR	WR	Total
Assessments 1		0.5				5.5	12.0	18.0
Assessments 2		0.5				5.5	12.0	18.0
Assessments 3		0.5				5.5	12.0	18.0
Assessments 4	5.5	0.5					12.0	18.0
Assessments 5		0.5				5.5	12.0	10.0
VETO			0.5	0.2	7.5			
	5.5	2.5	0.5	0.2	7.5	22.0	60.0	100

Note: VETO-Compulsory; AS-Assignments; CT-Class Test; EV-Evaluation; HM-Group presentation; PJ-Projects; PR-Practical; WR-Written tests

Electronics 1 is built on basic principles of physics. Students are assessed both in theory and practical. The learning outcomes of the course are as follow:

Students must demonstrate proficiency in

- Electronic components identification
- Verifying circuit behaviour of AC-to-DC power supply, circuits analysis including capacitor filtering
- Analysing and demonstrating measurement of voltage-current relationship of semiconductor devices such as diodes, Bipolar junction transistors and Field Effect Transistors
- Building working operation amplifier circuit, identify the configurations and predict circuit behaviour in DC domain of multiple operation amplifier circuits

The main objective of this study is to evaluate and compare the performance of foundation students and mainstream students (S1) in Electronics 1 course.

The following research questions are used for the study:

- What is the performance of Foundation and mainstream students in Electronics 1 using continuous assessment evaluation method?
- Is there any significant difference in the performance of the foundation and the mainstream students?
- Are the performances of the foundation students comparable with Electronics 1?

Normally, it would be expected that the mainstream students should be able to perform better in Electronics 1 as compared to FP students because of their performance in their matric results.

The following null hypothesis (H_0) were used for the results analysis:

- (i) There is no significant difference in performance in Electronics 1 between FPELC01 2013 students and FPELC01 2014 students
- (ii) There is no significant difference in performance in Electronics 1 between FPELC01 2013 students and ELC111T 2013 students
- (iii) There is no significant difference in performance in Electronics 1 between ELC111T 2013 students and ELC111T 2014 students
- (iv) There is no significant difference in performance in Electronics 1 between FPELC01 2014 students and ELC111T 2014 students
- (v) There is no significant difference in performance in Electronics 1 between FPELC01 2013 students and ELC111T 2014 students

2. Course Description

2.1 Electronics 1

This course provides an introduction to Electronics and it is built on basic principles of physics such as atomic theory, electrical charge, electrical voltage, current, resistance, series and parallel circuits, conductors and insulators. It introduces semiconductor devices by studying the operation of P-N junction diodes, bipolar junction transistors, Field Effect Transistors and operational amplifiers. It also includes the identification, characteristics and uses of electronic components for building and analysing circuits so as to understand the combination of the components in Electronic circuits.

The course structure for Electronic 1 is as shown in Table 2. The structure is divided into 5 modules to cover within 15-weeks of semester 1 for mainstream and 30 weeks for the FP. These topics form the introduction to Electrical Engineering (Schultz, 2016).

Table 2. Course outline for Electronics 1

Topic no	Theme	Content
Module 1	▪ Passive and Active Electronic Components	• List of electronic components electronic symbol and function. Classification as active or passive component. • Electronic units
	▪ The Resistor Colour Code.	• Resistor Colour Code and application.
	▪ Introduction to measuring instruments	• Project 1: Using Multimeter and Oscilloscope
	▪ Introduction to DC Signals.	• Ohm's Law: Series, parallel & series-parallel circuits

		<ul style="list-style-type: none"> • Voltage Dividers
Module 2	<ul style="list-style-type: none"> ▪ Power Supplies 	<ul style="list-style-type: none"> • Waveform theory. • Power stage block diagram
	<ul style="list-style-type: none"> ▪ Semiconductor theory. ▪ Diode and Application 	<ul style="list-style-type: none"> • Half-wave rectification • Full wave rectification • Centre Tap & Bridge. • Filtering & Regulation
Module 3	<ul style="list-style-type: none"> ▪ Bipolar Junction Transistor Construction & biasing techniques 	<ul style="list-style-type: none"> • Base • Voltage divider • Emitter • DC load line for a transistor circuit. • Locate the Q point on dc load line. • Design a switching circuit using a base bias circuit
Module 4	<ul style="list-style-type: none"> ▪ Field-Effect Transistors ▪ MOSFET 	<ul style="list-style-type: none"> • Construction, Operation & Biasing Techniques • Transconductance curve • Load line
Module 5	<ul style="list-style-type: none"> ▪ Operational Amplifiers 	<ul style="list-style-type: none"> • Electronic Implementation of Simple Mathematical Operations. • Understanding basic Operational Amplifier principles. • Operational Amplifier circuits; choosing OPAMP configurations to satisfy simple processing needs. • Understand basic analogue building blocks using Operational Amplifiers.

3 Methodology

Survey research method was used for this investigation. The year 2013 to 2014 electronics 1 students' (male and female) scores were used for the evaluation. The total number of students' score used was 574 and the same lecturer taught the students in the years under investigation. Electronics 1 results for semester 1, semester 2 for the year 2013 and 2014 were compiled. Also compiled were years 2013 and 2014 foundation students scores in Electronics 1. The scores are graded into high (75% and above), above average (65% - 74%), average (50 % - 64%) and below average (below 49%). Each student's final mark is calculated based on the student's scores after adding all the assessments marks together. The following is the breakdown of the total number (574) of students used in the study.

- Foundation (FPELC01) 2013 = 202; Mainstream (ELC111T) 2013 = 116
- Foundation (FPELC01) 2014 = 158; Mainstream (ELC111T) 2014 = 98

4. Findings

It was found that in both years (2013 and 2014), only three students obtained above 75% marks in the FPELC01 subject. This is the maximum number of students has obtained average marks in both years. In 2013, 11.4% of the students have scored above average marks in comparison to 6.9% obtained in 2014. A 65% of the students have achieved average marks in 2014 compared to 54.4% of the students in 2013. For below average grade, the percentage is similar at around 30% for both years' programs. Figure 1 shows the result distribution for electrical engineering foundation students (FPELC01) in the year 2013 and 2014. Generally, the performances of the students were better in 2013 than 2014.

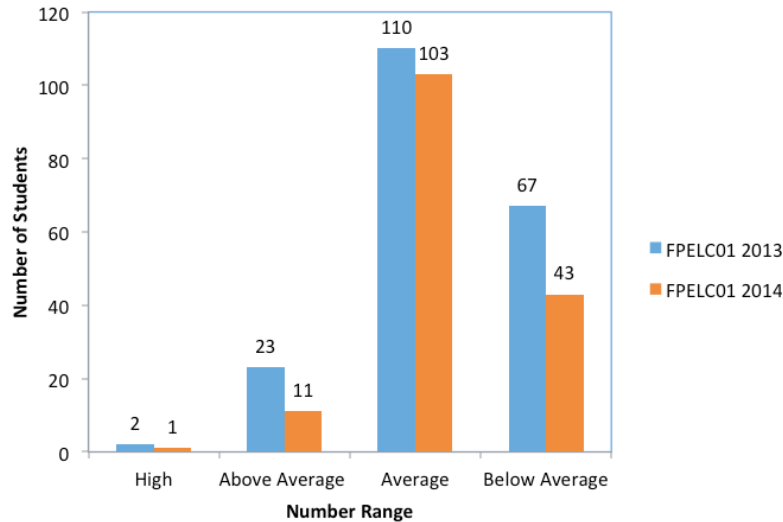


Figure 1: Performance distribution for foundation (FPELC01) students in 2013 and 2014 academic year

For ELC111T 2013 and 2014, it was found that in the year 2014 that only two students obtained more than 75% marks in the subject. This is the maximum number of students obtained average marks in both years. It is also observed that the percentages for above average in both years are almost the same. For below average grade, the percentage is 33.62% in 2013, which is higher than 22.44% in the year 2014. Figure 2 shows the result distribution for electrical engineering students for ELC111T 2013 and 2014. Even for the ELC111T subject, the performances of the students were better in 2013 than 2014.

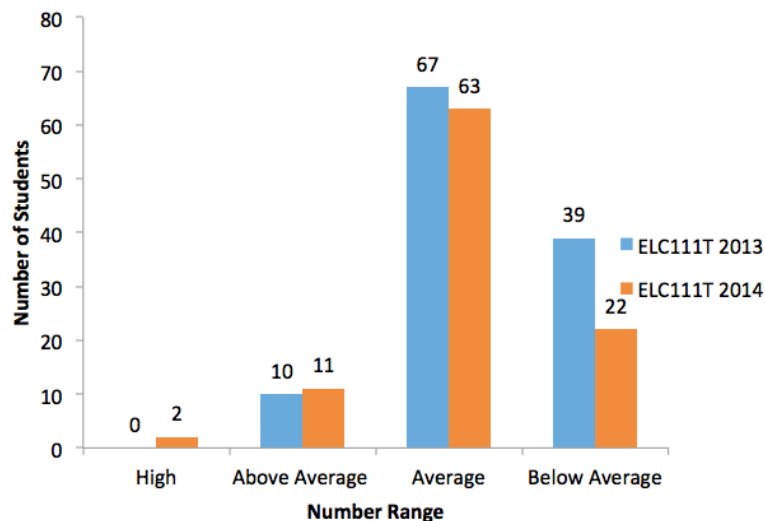


Figure 2: Performance distribution for mainstream (ELC111T) students in 2013 and 2014 academic year

Based on the research hypothesis stated above, T-test statistical analyses were conducted on the results to compare performance score between foundation (subject codes FPELC01) and mainstream (subject codes ELC111T) electrical engineering students. The risk level (Alpha level) was set at 0.05. Tables 3 – 7 presents the hypothesis results. The T-test formula is given as:

$$t = \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{Var_T}{n_T} + \frac{Var_C}{n_C}}}$$

Where T and C represent the two groups under evaluation, \bar{X} represents mean value, Var is the variance and n represents number of counts

Table 3 presents hypothesis (i) statistical result. The results show that there is no significant difference in the performance score between Foundation 2013 ($M=51.64$, $SD=13.32$, $t(375) = -0.78$, $p=0.43>0.05$) and foundation 2014 ($M=52.60$, $SD=9.978$, $t(375)= -0.78$, $p=0.43>0.05$) Electronics 1 students. Result reveals that the variance of performance score at 0.05 level of significance between 2013 and 2014 foundation students is not statistically significant. Hence the null hypothesis is rejected.

Note that, from the mean results, the 2013 foundation students has better mean score value compare to the 2014 students.

Table 3. Results of T-Test performance score for hypothesis (i)

Hypothesis (i)	Program	N	Mean	Std. dev	t	df	p	Min. diff
Performance Score for Electronics 1	FPELC01 2013	202	51.64	13.32	-0.78	375	0.43	-0.96
	FPELC01 2014	158	52.60	9.978				

Hypothesis (ii) results are shown in Table 4. Comparing both foundation ($M=51.64$, $SD=13.32$, $t(375)= -0.78$, $p=0.43>0.05$) and mainstream ($M=50.03$, $SD=14.16$, $t(228)= 1$, $p=0.31>0.05$) scores for 2013, the result shows that there is no significant difference between the two groups. The variance in performance score is not statistically significant between the foundation and the mainstream Electronics 1 students at 0.05 significant level. Hence the null hypothesis is rejected. Also note that from the mean score results, it is evident that mainstream students have better mean score value compare to the foundation students.

Table 4. Results of T-Test performance score for hypothesis (ii)

Hypothesis (ii)	Program	N	Mean	Std. dev	t	df	p	Min. diff
Performance Score for Electronics 1	FPELC01 2013	202	51.64	13.32	1.0	228	0.31	1.61
	ELC111T 2013	116	50.03	14.16				

Show in Table 5 is the hypothesis (iii) results. Foundation 2014 ($M=52.60$, $SD=9.98$, $t(156)= 0.11$, $p=0.91>0.05$) and Mainstream ($M=52.41$, $SD=14.28$, $t(156)= 0.11$, $p=0.91>0.05$) scores for 2014 are presented. The result in the Table shows that there is no significant difference between the two groups. The variance in performance score at 0.05 level of significance between foundation 2014 and mainstream 2014 Electronics 1 students is not statistically significant (null hypothesis rejected). From the mean results, mainstream 2014 students' mean score value is better compared to the foundation 2014 students.

Table 5. Results of T-Test performance score for hypothesis (iii)

Hypothesis (iii)	Program	N	Mean	Std. dev	t	df	p	Min. diff
Performance Score for Electronics 1	FPELC01 2014	158	52.60	9.98	0.11	156	0.91	0.19
	ELC111T 2014	98	52.41	14.28				

Table 6 presents hypothesis (iv) results. The table compares mainstream 2013 ($M=50.03$, $SD=14.16$, $t(206)= -1.22$, $p=0.22>0.05$) with mainstream 2014 ($M=52.42$, $SD=14.28$, $t(206)= -1.22$, $p=0.22>0.05$) scores. The result shows that there is no significant difference between the two groups. The variance in performance score is not statistically significant between mainstream 2013 and mainstream 2014 Electronics 1 students at 0.05 significant level. Hence, the null hypothesis is rejected. Also note that from the mean results, it is evident that mainstream 2013 students has better mean score value compare to the mainstream 2014 students.

Table 6. Results of T-Test performance score for hypothesis (iv)

Hypothesis (iv)	Program	N	Mean	Std. dev	t	df	p	Min. diff
Performance Score for Electronics 1	ELC111T 2013	116	50.03	14.16	-1.22	206	0.22	-2.39
	ELC111T 2014	98	52.42	14.28				

Table 7 presents hypothesis (v). It compares foundation 2013 ($M=51.64$, $SD=13.32$, $t(181) = -0.45$, $p=0.65>0.05$) with mainstream 2014 ($M=52.42$, $SD=14.28$, $t(181) = -0.45$, $p=0.65>0.05$) scores. The result shows that there is no significant difference between the two groups. Variance in performance score at 0.05 level of significance between the foundation and the mainstream Electronics 1 students is not statistically significant. Hence the null hypothesis is rejected. But from the mean results, it is evident that foundation students have better mean score value compare to the mainstream students.

Table 7. Results of T-Test performance score for hypothesis (v)

Hypothesis (v)	Program	N	Mean	Std. dev	t	df	p	Min. diff
Performance Score for Electronics 1	FPELC01 2013	202	51.64	13.32	-0.45	181	0.65	-0.78
	ELC111T 2014	98	52.42	14.28				

5. Discussion and Conclusion

The t-test analysis reveals that the performance between the foundation and the mainstream students in Electronics 1 for the period under investigation has no significant difference. For all the tests conducted, p values are greater than 0.05 ($p>0.05$). The result shows that the students' performance does not represent the connection between the program of study and the course content. This could be due to the students' educational background prior to registering for the program or lack of interest as earlier mentioned. It may also imply in the first year of study that students are not yet conscious of the fact that workloads in the higher institution are more challenging as compared to high school workload and methods of study need to be tactically and properly planned.

According to (Hari *et al.*, 2016, Simpson and Fernandez, 2014), the lower mean value is better than higher mean value. Consequently, comparing the mean scores obtained in hypothesis (i) and (iv), both mainstream and foundation students' performances are better in 2013 compare to 2014. The low performance in 2014 could be associated with the increased workload that the students had to undergo. For hypothesis (ii), (iii) and (v), the mean scores reveal that the mainstream students performed better than the foundation students. The low performance of the foundation students could be associated to the entering admission point scores. In addition, the students' academic background prior to admission could play a crucial role in their performances. Furthermore, the results show in general that the continuous assessment evaluation method is not adequate for improving the students' performance since the students' performance did not increase as shown in our findings. Further evaluation work will be conducted to establish these findings.

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References

- Ali, S., Haider, Z., Munir, F., Khan, H. & Ahmed, A., Factors contributing to the students academic performance: A case study of Islamia University Sub-Campus, *American Journal of Educational Research*, 1, 283-289, 2013.
- Arnové, R. F., Education and political participation in rural areas of Latin America, *Comparative Education Review*, 17, 198-215, 1973.
- Azaola, M. C., Community school programmes in Latin America: Imagining the long-term impact of developing pupils' agency, *International Journal of Educational Development*, 38, 80-86, 2014.
- Cooles, P. E., Harrigan-Vital, M. & Laville, A., Student performance and grading changes in a systems-based curriculum, *Medical education online*, 19, 2014.
- Ćukušić, M., Garača, Ž. & Jadrić, M., Online self-assessment and students' success in higher education institutions, *Computers & Education*, 72, 100-109, 2014.
- Eamon, M. K., Social-demographic, school, neighborhood, and parenting influences on the academic achievement of Latino young adolescents, *Journal of youth and adolescence*, 34, 163-174, 2005.
- Farooq, M. S., Chaudhry, A. H., Shafiq, M. & Berhanu, G., Factors affecting students' quality of academic performance: a case of secondary school level, *Journal of Quality and Technology Management*, 7, 1-14, 2011.

- Hari, Z., Anuar, A., Mokhtar, M. & Mokhtar, R., Evaluating engineering students performance in physics courses during foundation studies, *Engineering Education (ICEED)*, 2016 IEEE 8th International Conference on, IEEE, 214-217, 2016.
- Popham, W. J., Performance tests of teaching proficiency: Rationale, development, and validation, *American Educational Research Journal*, 8, 105-117, 1971
- Schultz, M. E., Grob's basic electronics, *McGraw-Hill Higher Education*, 2016.
- Simpson, J. & Fernandez, E. Student performance in first year, mathematics, and physics courses: Implications for success in the study of electrical and computer engineering, *Frontiers in Education Conference (FIE)*, 2014 IEEE, 2014. IEEE, 1-4.
- Tamayo, M., Rebolledo, J. & Besoain-Saldana, A., Monitoring inclusive education in Chile: Differences between urban and rural areas, *International Journal of Educational Development*, 53, 110-116, 2017.
- Tsai, N. W., Assessment of students' learning behavior and academic misconduct in a student-pulled online learning and student-governed testing environment: A case study, *Journal of Education for Business*, 91, 387-392, 2016.

Biography

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