International Journal of Engineering Education Vol. 38, No. 4, pp. 1151–1158, 2022
Printed in Great Britain
0949-149X/91 $3.00+0.00

Improving Student Preparedness to Study Engineering: A Case Study in South Africa*

ARTHUR JAMES SWART** and DANRI DELPORT
Central University of Technology, Faculty of Engineering, Built Environment and Information Technology, Bloemfontein, South Africa.

Students who complete their high school education are, at times, not adequately prepared for further studies in higher education. Some of these students struggle to meet the challenges associated with heavy workloads, extra laboratory work and a blended-learning environment. These underprepared students need additional academic support if they are to succeed with their university studies. One such support includes an additional year of study (part of an Extended Curriculum Programme aimed at improving student preparedness) prior to enrolling in a mainstream programme where they may study towards a Diploma or Bachelor's degree. The purpose of this article is to contrast the performance of these students to those who directly entered a mainstream programme, thereby highlighting the benefit of an additional year of study in helping students to become better prepared. This contrast is primarily based on their main examination grades that they achieved in a first-year compulsory module that forms part of a National Diploma in Electrical Engineering. Sixty-four students, with an additional year of study, are contrasted to 487 students who entered a mainstream programme directly between 2016 and 2017. Both groups of students struggled with questions relating to design which is correlated to the synthesis level in Bloom's Taxonomy. However, the average grade difference between the two groups never exceeded 10%, with the average being 6.9%. The contribution to education is the positive results achieved by these first-year students who enrolled for an extended curriculum programme, thereby supporting its continuance.

Keywords: university of technology; Extended Curriculum Programme; Mainstream Programme; first-years

1. Introduction

"Only the prepared speaker deserves to be confident" [1]. These words, by a former American writer, Dale Carnegie, well testifies to the fact that confidence can stem from being prepared, among other accepted factors. This same principle applies to students entering higher education; if they are prepared, then they should have a measure of confidence that may lead to success. However, the opposite is also true. Underprepared students may lack the confidence required to overcome many of the challenges associated with higher education, thereby setting themselves up for failure.

It has been increasingly recognized in recent decades that US high school students are underprepared to choose and complete STEM (science, technology, engineering and mathematics) majors at university, leading to a major shortage of domestic students taking careers in science and engineering [2]. This is similar in South Africa (SA), where first-year students have been found to be underprepared for the challenges that they may encounter within the higher education context [3]. These may include a heavy workload, extra laboratory work and a blended-learning environment. Several academic support mechanisms have been introduced to try help these students to better cope with some of these challenges as they transition between high school and university life. This includes supplementary instruction [4], peer mentoring [5] and an additional year of orientation prior to enrolling in a mainstream programme (MSP, such as a 3-year Bachelor's programme). This additional year forms part of what is called an Extended Curriculum Programme (ECP) in SA.

ECPs were introduced in a number of universities in SA as one mechanism for addressing issues of equitable access, low success rates and the need to better bridge the gap between school and higher education [6]. It is a state-funded initiative aimed specifically at improving both student access to higher education (especially by disadvantaged students who narrowly miss the minimum admission requirements for the MSP) and their overall success. This was primarily in response to an increasing number of 'underprepared' students who have entered higher education in recent decades.

A number of studies have sought to determine the effectiveness of this state-funded initiative in SA, given the number of resources and time dedicated to it. For example, Sutherland [7] reviewed the success rates of students enrolled for an ECP programme between 2016 and 2018 at a university of technology in the Gauteng province of SA. Results suggested that these students performed well and contributed to the overall success rate of the engineering faculty. Another study [8] sought to determine the effective-

** Corresponding author: drjamesswart@gmail.com

* Accepted 5 March 2022.

ness of an ECP programme offered at a university of technology in the Western Cape Province of SA. Results indicated that academics (63% of those polled) disagree that MSP students outperform ECP students. This indicates that ECP students are better prepared after their year of additional study and are more than capable of achieving the same outcomes as the MSP students. Finally, Engelbrecht, Harding and Potgieter [9] conducted an evaluation of the successes of a 2008 cohort of ECP students using five quantitative criteria, namely retention, completion rate, migration to other faculties, comparison with other institutions and enrolment in graduate studies. Their overall conclusion was that the programme is reasonably successful regarding retention and completion rate in comparison with similar programmes offered at a university in the Kwa-Zulu Natal Province of SA. These foregoing results are all based on a complete ECP programme. However, what do the results of an individual first-year engineering module reveal that requires previous knowledge of mathematics and physical sciences? This is especially relevant as the minimum pass mark is only 30% for these two subjects at school level in SA [10].

Therefore, the purpose of this article is to contrast the performance of ECP students to MSP students over a 3-year period by analyzing their main examination grades, in order to determine if students exposed to an extra year of orientation can successfully cope with a first-year engineering module that focuses primarily on mathematics and physical sciences. A time-lag study is used with a non-experimental descriptive design where the collected data is analyzed quantitatively. The basic structure of an ECP is firstly discussed, followed by its implementation at the Central University of Technology (CUT). The research context of the study is then provided, followed by the research methodology, results and conclusions.

2. The Extended Curriculum Programme in South Africa

The majority of higher education institutions in SA (23 out of 26) received designated funding from government to offer different types of access programmes during the 2010 decade, which included extended, augmented and foundation programmes [11]. In 2017, ECPs attracted over $12 million in government funding for institutions in SA. This amount well exceeds all other allocations intended to support and strengthen the quality of the curricula and teaching and learning activities across the sector [12]. At the heart of all ECP programmes is the "recognition that for the majority of potential students in South Africa, success at higher education is severely constrained by systemic faults . . . and ECP has constituted an attempt to address these faults at curriculum level" [13].

The term "systemic" refers to the entire interconnected system and includes all forms of education from childhood to adulthood. For example, children in SA do not read well enough to enable meaningful learning and cannot do basic mathematics [14]. This is in part, due to the shortage of libraries and books within rural schools and communities. More teenagers are experiencing concentration difficulties, more frequent headaches and increased pressure [15]. Studies have linked this to the common statement: 'FOMO' – The Fear of Missing Out. This can drive teenagers to stay awake for all hours of the night as they are connected to their electronic devices, making choices they would otherwise not make. This in turn can have a negative impact on their education. Many adolescents in SA are exposed to multiple types of violence, socio-economic disadvantage and low-quality education [16]. These challenges combined give rise to the term "systemic faults" that would also include challenges within the school environment focusing on the quality of teachers and the curriculum. They are all interconnected in one way or another and impact on the preparedness of students to enter and succeed in higher education.

ECP's do not completely eradicate all these challenges but help to mitigate some of them to a certain degree. For example, the academic content is delivered at a slower pace than in the normal MSP's, so students have more time to engage with and read the subject content [9]. Additional modules such as language and study skills and academic information management are offered, and extra support through career guidance and counselling is provided, that can help students to better manage their time and priorities. Besides attending smaller classes, the students also attend lectures in large groups to prepare them for the transition to the MSP and which can help them to improve on their interpersonal skills.

It must be noted that a number of enabling factors are required for the success of an ECP [17]. These include leadership and ownership of the programme, organizational arrangements between mainstream and academic development staff, sufficient resources, and student placement practices (linked to entry requirements) at the start of the programme.

3. The Extended Curriculum Programme at the Central University of Technology

ECP's were introduced for the first time at the Engineering Faculty of CUT in 2010. It was designed to equip students who do not meet the minimum requirements with the necessary competencies to be successful in their studies [18]. Academic support and skills development were integrated with regular academic work. Government funding to this programme at CUT averaged around $140 000 per year while the average pass rate for students in this programme between 2010 and 2017 fluctuated between 61% and 91%.

Students were required to have passed Mathematics and Physical Sciences at school level with a minimum mark of 40% (equates to a point's score of 3) to gain entry into the ECP. They also needed to achieve a minimum total score of 22, which could be reached by considering their other school subjects. Only 35% of the school class of 2020 achieved the minimum mark of 40% [10]. A similar bleak horizon exists for physical sciences where only 42% achieved more than 40%. This low pass rate has been evident for several years, indicating that only a small pool of learners would qualify to study Engineering. However, the possibility of them being underprepared for the level of Mathematics and Physical Sciences required in Engineering is very real, thereby necessitating an additional year of study. Table 1 shows the scores that are awarded to different percentages for school subjects that are used to calculate if students meet the minimum score of 22 for the ECP and 27 for the MSP.

Students would need to pass all instructional offerings of the first year of the ECP in order to continue with the second year of study in the ECP, which would equate to the first year of the MSP. The ECP would thus cover 4 years of study which would need to be completed by the student. The additional first year of study included introducing students to important academic literacy skills (to help improve English language proficiencies) and personal competencies (such as time management skills and the impact of stress on student academic achievement [19]). This would be offered in a module called Life Skills. Even students with high academic potential often struggle to progress in their studies due to a general low level of academic English proficiency. Two other modules (Materials and Physics) were offered during this year that provided information applicable to each field of Engineering offered at CUT (Civil, Mechanical or Electrical). A concise breakdown of the four modules is shown in Table 2.

Table 1. MSP versus ECP entry criteria

Criteria	MSP points	ECP points
40–50% for a school subject	3	3
50–60% for a school subject	4	4
60–70% for a school subject	5	5
70–80% for a school subject	6	6
Minimum points required for Mathematics	4	3
Minimum points required for Physical Sciences	4	3
Minimum score from all school subjects	27	22

4. Research Context of this Study

The research context is limited to a module termed Electronics 1, offered at CUT in SA. Undergraduate engineering students need to complete this compulsory module as part of a Diploma qualification in Electrical Engineering. The course structure is shown in Table 3. This Diploma is an NQF (National Qualifications Framework) Level 6 qualification that requires students to obtain a minimum of 360 credits (equates to 3600 notional hours over a three-year period). This is similar to the United Kingdom (UK), but different in other countries of Europe where 20 hours of learning is sometimes equated to one credit point [20].

Approximately 200 students register for this 12-credit module in the first semester of each year of the MSP, which is offered between February and May. Approximately 100 students register for the module in the second semester, which is offered between August and November. The syllabus covers seven units focusing on the oscilloscope, fundamental electrical principles, resistors, capacitors, semiconductors, diodes, transistors and the

Table 2. Four modules with their content that was offered to ECP students during their extra year of study

Module	Content
Life Skills	Portfolio development, reading skills, assignment writing skills, note taking, memory skills, learning skills, examination techniques, critical thinking, self-awareness, self-management, coping with stress, problem-solving skills, time management, marinating a healthy lifestyle and interpersonal skills.
Materials	Water flow and its applications, appropriate tests required for material testing, set-up and use of dumpy levels and concrete cement reactions with different environments.
Mathematics	Fundamentals of number sets, algebraic expressions and equations, basic graphs and functions, trigonometric graphs and waveforms, exponents and logarithms.
Physics	Mechanics focusing on fundamentals of physics, vectors, kinematics, dynamics and statics. Electricity and magnetism focusing on electrostatics, electrical circuits, magnetic fields and electrodynamics.

design of power supplies and amplifiers. The primary purpose of the module is to introduce students to the analysis and design of electronic circuits and is a pre-requisite (foundation module) for higher level modules in the Diploma [21].

The module features a blend of face-to-face and online learning. Online learning is primarily characterized by eight online self-assessments while the face-to-face lectures featured PPT presentations with animations along with a number of active learning sessions involving problem-based learning. A main assessment is usually scheduled during Week 9, with a main examination during Weeks 15–18. The main examination contributes 50% to the final grade of the student, while the course mark contributes the other 50%. This examination features a blend between lower-order and higher-order cognitive questions, based on Bloom's Taxonomy. Action verbs such as define, identify, calculate, design and sketch are often used in the assessment to determine student learning. Most of the assessment includes mathematical calculations, while around 20% is dedicated to physical science. Calculations must be used to analyze time domains, to simply complex resistor circuits, to design a power supply and an amplifier. Physical science questions cover fundamental electrical principles that include electron flow, energy, and power.

5. Research Methodology

A time-lag study is used with a non-experimental descriptive design. A time-lag study determines the impact of a particular event on a group of students over a specific period of time [22]. In this study, the period of time is from 2016 to 2017. Although four semesters occurred during this time, data from one semester had to be discarded as there were no ECP students present for that semester. These groups comprised students from both the ECP (n = 64) and MSP (n = 487). Although the mean of a large sample is a good representation of the mean of a population, sample sizes greater than 30 are considered sufficient in order to get a good approximation of the bigger population [23]. The particular event relates to different levels of cognitive questions that these students were required to answer in the main examination, which primarily covered mathematical calculations and physical sciences. The examination grades and final grades of these students were thus analysed in SPSS 19.0 with no specific intervention, or experiment, occurring during the time period.

The Main Examination at the end of each semester comprised six main questions that covered five of the six levels of Bloom's Taxonomy. Question 1 was a mix of knowledge (recall) and application (calculation) questions focusing on the oscilloscope

Table 3. Course structure for Electronics 1

Time period	Theory (face-to-face) 2 x 90 minutes / week	Assessment (online)	Weightings	Practical 1 x 90 minutes / week
Week 1	Unit 1 – Introduction and basic frequency measurements	Student support – Online anywhere	25% to the course mark (T1) 5 online self-assessments contribute to Test 1 (T1)	Preparatory work in the laboratory
Week 2	Unit 2 – Fundamental electrical principles	Unit 1 – Online anywhere		Assignment 1
Week 3	Unit 3 – Semiconductors	Unit 2 – Online anywhere		Assignment 1
Week 4	Unit 4 – Diodes	Unit 3 – Online anywhere		Assignment 2
Week 5	Unit 5 – Basic design principles for power supplies	Unit 4 + Unit 1 – Online anywhere		Assignment 2
Week 6	Unit 6 – Bipolar Junction Transistors	Unit 5 + Unit 2 – Online anywhere		Assignment 3
Week 7	Review – Units 1 – 5			Assignment 3
Week 8	Review – Units 1 – 5			Practical Test
Week 9	Main Assessment	Units 1 – 5 – Controlled lab	40% to the course mark (T3)	
Week 10	University recess			
Week 11	Unit 7 – Basic design principles for amplifiers	Unit 6 – Online anywhere		Assignment 4
Weeks 12 – 14	Review – Units 1 – 7	Unit 7 – Online anywhere	35% to the course mark (T2)	Assignment 4
Weeks 15 – 18	Summative main examination	Units 1 – 7 – Online in a controlled laboratory environment	Contributes 50% to the final grade	

Table 4. Descriptive statistics of scores of ECP students and MSP students for the first semester of the 2016 academic year

Descriptive Statistics						
	ECP Students			**MSP Students**		
	Mean	**Std. Dev.**	**N**	**Mean**	**Std Dev.**	**N**
Q1	45.4	16.06	10	53.03	17.32	209
Q2	43.0	17.67		44.26	16.02	
Q3	55.9	13.15		65.55	17.38	
Q4	52.1	17.51		66.02	20.62	
Q5	33.8	28.98		30.03	22.15	
Q6	48.0	27.08		54.61	23.82	
Final Score	47.1	14.30		52.81	13.03	

or time domain analysis. Question 2 featured a mix of comprehension and application questions focusing on resistors and simplifying series/parallel circuits. Question 3 included only knowledge and comprehension questions covering physical science. Question 4 focused primarily on the analysis of graphs and circuits relating to the semiconductor diode. Question 5 and 6 required students to design (part of synthesis in Bloom's Taxonomy) a power supply unit and a transistor amplifier. A seventh question was included in the first semester of 2017 which covered a mix of comprehension and analysis questions that focused on datasheet interpretation, as this was deemed missing from previous examinations.

To contrast the performance of ECP students to MSP students over the 3-semester period required the examination grades and final grades, or scores, of students in both groups to be analyzed by means of descriptive statistics (means and standard deviations). With regard to inferential statistics, a *t*-test for independent samples was conducted to determine if there is a statistically significant difference between the mean score of the ECP group of students and the mean score of the MSP group of students. The independent sample *t*-test was conducted for each question in the main examination as well as for the final grade (50% of the examination added to 50% of the course mark) of the students. The test was conducted for each of the 3-semester periods. The statistical software package SPSS was used to analyze the data.

6. Results and Discussions

To test whether the groups differ significantly with regard to their scores in this engineering module, the independent sample *t*-test was conducted. The significance level was set at 5%. The results of the independent *t*-test are reported by including the *t*-statistic value, the degrees of freedom (df), as well as the significance value of the test (*p*-value). The ECP group consisted of 10 students and the MSP group had a total of 209 students for the first semester of 2016. From the descriptive statistics shown in Table 4 it is evident that the ECP students performed best in Question 3 (recall-type questions relating to physical sciences that correlates to the lowest two levels of Bloom's Taxonomy) with a mean score of 55.9. They performed worst in Question 5 (a design-based question that correlates to the synthesis level within Bloom's Taxonomy) with a mean score of 33.8. The MSP students performed best in Question 4 (an analysis-based question requiring calculations that correlates to the analysis and application level within Bloom's Taxonomy) with a mean score of 66.02 and the worst in Question 5 (mean = 30.03). Furthermore, the MSP group had a higher final mean score of 52.81 than the ECP group of students (mean = 47.1). To test whether the groups differ significantly with regard to their scores in this engineering module, the independent sample *t*-test was conducted. Apart from analyzing the final scores (50% from the examination and 50% from the course mark) of both groups of students, the researchers also investigated whether there was a difference between the two groups with regard to the different questions in the Main Examination. As such, several *t*-tests were conducted, and the results are shown in Table 5.

The *t*-test showed no statistically significant difference between the final scores of the two groups ($t = 1.35$, $p = 0.179$). However, the results do show that the groups differed significantly with regards to Question 4 ($t = 2.1772$, $p = 0.0305$). This

Table 5. Inferential statistics for the first semester of the 2016 academic year

Inferential statistics			
Question	***t*-value**	***df***	***p*-value**
Q1	1.3643	217	0.173
Q2	0.2415		0.8094
Q3	1.7303		0.0850
Q4	2.1772		0.0305*
Q5	0.5179		0.6052
Q6	0.8157		0.3953
Final Score	1.35		0.179

Table 6. Descriptive statistics of the scores of ECP students and MSP students for the second semester of the 2016 academic year

Descriptive Statistics						
	ECP Students			**MSP Students**		
	Mean	**Std. Dev.**	**N**	**Mean**	**Std Dev.**	**N**
Q1	56.46	20.16	39	61.85	20.46	81
Q2	32.28	14.73		32.23	15.53	
Q3	52.92	18.51		62.26	19.25	
Q4	44.46	21.65		47.91	22.71	
Q5	15.26	18.60		30.79	26.77	
Q6	22.82	17.45		26.05	18.65	
Final Score	36.0	12.13		41.79	13.17	

Table 7. Inferential statistics for the second semester of the 2016 academic year

Inferential statistics			
Question	***t*-value**	***df***	***p*-value**
Q1	1.3582	118	0.1770
Q2	0.0160		0.9823
Q3	2.5188		0.0131*
Q4	0.7914		0.4303
Q5	3.2615		0.014*
Q6	0.9068		0.3663
Final Score	2.3131		0.0224*

was an analysis-based question where students had to use mathematical calculations to interpret the operation of a semiconductor diode by extracting specific information from numerous graphs. It does seem that the MSP students were more adept at this, suggesting that they have a better graphical literacy ability. The topic of graphical literacy is considered to be an important aspect of a student's science education [24], which may need more attention in the additional year of study for the ECP students. The use of scales and axis indicators may also need to be reinforced in the ECP students.

There was a total of 39 ECP students and 81 MSP students in the second semester of 2016. From the descriptive statistics shown in Table 6 it is evident that ECP students performed the best in Question 1 (mix of both knowledge and application questions) (mean = 56.46) and the worst in Question 5 (design-based question) (mean = 15.2564). MSP students performed the best in Question 3 (knowledge and comprehension questions) (mean = 62.25) and the worst in Question 5 (mean = 30.79). Furthermore, the MSP students had a higher final mean score of 41.79 compared to the ECP students (mean = 36).

The results of the *t*-test are shown in Table 7 that indicates no significant difference between the ECP and MSP group of students with regard to Questions 1, 2, 4, and 6. However, the mean scores of students in both groups differed significantly with regard to Question 3 (t = 2.5188, p = 0.0131), Question 5 (t = 3.2615, p = 0.014), as well as their final score (t = 2.31, p = 0.0224). This suggests that the ECP group struggled more than the MSP students with the recall-type questions relating to physical science (Q3 in Table 4 and Table 5) and with the design-based questions requiring many mathematical calculations (Q5 in Table 4 and Table 5). This may also explain the impact on the final scores of these students. Again, questions relating to physical science and mathematics proved more challenging to these ECP students, who would have obtained a lower final matric score for these subjects as compared to MSP students (see Table 4).

From the descriptive statistics in Table 8, it is shown that 15 students were in the ECP group, and 197 students were in the MSP group for the first semester of 2017. Please note that the main assessment featured an extra question (Question 7) which focused on datasheet analysis. The ECP students performed the best in Question 5 (design-based question) (mean = 64.67), and the worst in Question 2 (mix of comprehension and application) (mean = 26.33). The MSP students performed the best in Question 3 (knowledge and comprehension questions) (mean = 76.09), and the worst in Question 2 (mean = 40.13). The ECP group had a final mean score of 46.47, while the MSP group of students had a higher final mean score of 55.94. A possible reason for the good performance in Question 5 relates to more time being devoted to this part of the syllabus during this first semester of 2017. Additional time and discussions were given to this question to try and overcome the poor performance of the previous two semesters. The poor performance of engineering students with regard to design-based questions has been noted in recent years [25].

The results in Table 9 show significant differences between the two groups with regard to different levels of questions. The independent sample *t*-test showed significant results between the ECP and MSP students with regard to Question 2 (t = 2.7622, p = 0.0063), Question 7 (t = 2.4263, p = 0.0161), as well as the final score of students (t = 2.1114, p = 0.0161). This suggests that ECP students struggled more with the comprehension and appli-

Table 8. Descriptive statistics of the scores of ECP students and MSP students for the first semester of the 2017 academic year

Descriptive Statistics						
	ECP Students			**MSP Students**		
	Mean	**Std. Dev.**	**N**	**Mean**	**Std Dev.**	**N**
Q1	63.33	21.46	15	69.89	21.91	197
Q2	26.33	21.33		40.13	18.97	
Q3	62.67	13.29		76.09	27.76	
Q4	50.13	28.40		58.75	28.34	
Q5	64.67	25.27		64.82	39.13	
Q6	43.07	44.06		52.87	34.27	
Q7	34.13	32.66		44.59	15.95	
Final Score	46.47	17.46		55.91	16.64	

Table 9. Inferential statistics for the first semester of the 2017 academic year

Inferential statistics			
Question	***t*-value**	***df***	***p*-value**
Q1	1.1190	210	0.2644
Q2	2.7622		0.0063*
Q3	1.8024		0.0729
Q4	1.1433		0.2542
Q5	0.0147		0.9883
Q6	1.0717		0.2851
Q7	2.4263		0.0161*
Final Score	2.1114		0.0359*

cation questions relating to resistors and their use in series and parallel circuits as compared to the MSP students. It must be noted that Question 2 was also daunting to the MSP students, but more so to the ECP students. Again, this points to the struggle that ECP students had with physical science combined with mathematics (evident by Question 2 focusing on calculating the flow of electrons in a series/parallel circuit). Noteworthy also is the fact that the average grade for Question 2 never exceeded 45% for all three semesters for both groups.

7. Conclusions

The purpose of this article was to contrast the performance of ECP students to MSP students over a 3-year period by analyzing their main examination grades, in order to determine if students exposed to an extra year of orientation can successfully cope with a first-year engineering module that focuses primarily on mathematics and physical sciences. The final average grades of the MSP students were never more than 10% higher than the ECP students over the 3 semesters.

Both groups of students struggled with design-based questions in 2016 which required many calculations. This was given more attention in 2017, resulting in an improved performance, especially for the ECP students. Students from both groups performed well when knowledge and comprehension questions were asked. This suggests that these engineering students are more comfortable with the lower levels of Bloom's Taxonomy (being knowledge and comprehension) than with the higher levels (being synthesis). However, it must be noted that these are first-year engineering students who may not have been exposed to any engineering modules during their high school career. They would need to engage more with the higher levels of Bloom's Taxonomy as they progress towards the end of the qualification. The quantitative knowledge that they would receive in their first year (which is evident by their performing well on the knowledge and comprehension levels) would change to more qualitative knowledge (application, synthesis, and evaluation levels) in their final year of the qualification.

The study was limited to only three semesters, as the module was being phased out and replaced by another module in a new Diploma programme. Another limitation exists with the sample size of the ECP (n = 64) students that was much smaller than that of the MSP (n = 487) students. This is understandable, as only a small portion of students would narrowly miss the entry criteria to the main programme. However, their individual academic results do support the continuance of an extended curriculum programme as the average examination grades of the ECP students did not differ by more than 10% from the MSP students. Furthermore, the sample size of the ECP students is more than 30, which is sufficient for this research as noted in the methodology section. The researchers furthermore had no control over the small sample size since no randomisation was used. Whole-frame sampling, a convenience sampling technique, was rather employed as the students were already available and formed part of the formal ECP class. Since the research was conducted at one specific University of Technology (CUT), and no randomisation was used, the results may not be generalisable to all first-year engineering students at other universities.

A recommendation is to include additional examples of graphical literacy in the first year of the extended programme, as the ECP students did struggle to analysis and interpret numerous graphs. It is also recommended to ask more physical science questions that require calculations rather than basic recall questions, as the ECP students struggled more with these type of combination questions involving both physical science and mathematics.

Additional academic student support will always be required in higher education, as students find themselves on different levels of cognitive development. Some may be more adept at synthesis, while others may be more inclined to comprehension. It is the ongoing role of academics to try and support all these students to improve on their own development, so that they may become better prepared and more confident graduates who may contribute to the socio-economic development of their communities.

References

1. Brainy Quote. *Homepage*. Available: http://www.brainyquote.com/quotes/. Accessed: 10 March 2020.
2. W. Fan, Y. Zou and J. Bahrman, Choice to take Advanced Placement course (s) in preparing students for STEM majors: The role of identification with academics and school motivation, *International Journal for Cross-Disciplinary Subjects in Education*, **7**(4), pp. 2913–2917, 2016.
3. F. Strydom, M. Mentz and G. Kuh, Enhancing success in South Africa's higher education: Measuring student engagement, *Acta Academica*, **42**(1), pp. 259–278, 2010.
4. J. Wilmot, K. Peralez and N. Telang, Supplemental Instruction Pilot Program for an Introductory Electrical Engineering Course, in *Conference Proceedings of the First Year Engineering Education Annual Conference*, Columbus, Ohio, 2016.
5. A. J. Swart, L. Coughlan and N. Joannou, Student perspectives of a peer mentorship programme introduced at a university of technology in South Africa, *GJEE, Global Journal of Engineering Education*, **21**(3), pp. 220–226, 2019.
6. G. H. Bass, Social and academic integration in an extended curriculum programme, *The Independent Journal of Teaching and Learning*, **6**(1), pp. 45–54, 2011.
7. T. Sutherland, Did the four-year extended programme make a difference towards the success rate of the engineering faculty?, in *Balkan Region Conference on Engineering and Business Education*, Sibiu, Romania, 2019.
8. K. R. Blumberg, *The effectiveness of the extended curriculum programme in the electrical engineering department at a University of Technology in the Western Cape, South Africa*, Cape Peninsula University of Technology, 2017.
9. J. Engelbrecht, A. Harding and M. Potgieter, Evaluating the success of a science academic development programme at a research-intensive university, *African Journal of Research in Mathematics, Science and Technology Education*, **18**(3), pp. 287–298, 2014.
10. Department of Basic Education. *National Senior Certificate 2020 Examination Report*. Available: https://www.education.gov.za/2021NSCExamReports.aspx. Accessed: 18 August 2021.
11. M. Rollnick, Identifying potential for equitable access to tertiary level science: Digging for gold. Milton Keynes: Springer Science and Business Meadia, 2010.
12. A. Staak, *Welcome address, Regional Extended Curriculum Programme Symposium*, ed. Cape Town: Cape Peninsula University of Technology, 2017.
13. Council on Higher Education, *Higher education reviewed: Two decades of democracy*, DHET, Pretoria 2016.
14. S. Gravett and S. Eadie, The Sandbox project: Developing competencies for a changing world in South African schools, in *Embedding Social Justice in Teacher Education and Development in Africa*, ed: Routledge, pp. 163–178, 2021.
15. C. Jorgensen, The impact of cyberbullying on the mental health of teenagers, *Mental Health Matters*, **7**(2), pp. 26–28, 2020.
16. R. Herrero Romero, J. Hall and L. Cluver, Exposure to violence, teacher support, and school delay amongst adolescents in South Africa, *British Journal of Educational Psychology*, **89**(1), pp. 1–21, 2019.
17. S. Shay, K. Wolff and J. Clarence-Fincham, *New generation extended curriculum programmes: Report to the DHET*, Cape Town: University of Cape Town, 2016.
18. Central University of Technology, *Extended Curriculum Programme*, Available: https://www.cut.ac.za/extended-curriculum-programme-ecp. Accessed: 18 August 2020.
19. A. J. Swart, The impact of stress on student tardiness and subsequent throughput rate of engineering students – A case study, *IJEE, International Journal of Engineering Education*, **24**(4), pp. 794–801, 2008.
20. T. Wall and D. Perrin, *We Know, but Still*, in Slavoj Žižek, P. Gibbs, Ed., ed Cham: Springer, pp. 37–48, 2015.
21. L. Meda and A. J. Swart, Graduate Attributes in an Electrical Engineering Curriculum: A Case Study, *IJEE, International Journal of Engineering Education*, **33**(2), pp. 210–217, 2017.
22. W. Goddard and S. Melville, *Research Methodology: An Introduction*, 2nd Edition ed. Lansdowne: Juta & Co, 2006.
23. J. S. Croucher, *Introductory Mathematics and Statistics*, 6th ed. Australia: McGraw-Hill, 2013.
24. P. Marsh, *An Analysis of Science Teachers' Perceptions of Graphical Literacy within the Context of the Secondary Science Classroom*, Doctor of Education, The Graduate College, University of Nebraska at Omaha, 2020.
25. A. J. Swart and P. E. Hertzog, Research topics that prove challenging for engineering students in a problem-based learning module, *GJEE, Global Journal of Engineering Education*, **23**(2), pp. 128–123, 2021.

Arthur James Swart. Associate Professor at the Central University of Technology. Fields of interest include Engineering Education development, improving student engagement by using educational technology and energy monitoring techniques.

Danri Delport. Senior Lecturer at the Central University of Technology. Fields of interest include mathematics and statistics education.