EXPLORING STUDENT PERSPECTIVES ON AN EXTENDED MECHANICAL AND INDUSTRIAL ENGINEERING PROGRAM

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ABSTRACT – Many students find the transition from high school to university difficult specifically in engineering. It has been established that there is a gap in mathematics ability between high school and university. Internationally the high school curricula focus on increasing access to tertiary institutions. Many of these curricula teach superficial learning to high school students. At University level deep learning is required. Students who do not meet entry requirements for engineering first year have the option to enter an extended program.

This paper explores whether the extended program offered at the University of Johannesburg for mechanical and industrial engineering students is perceived as beneficial. A survey was conducted on first- and second-year students that started their qualification with the extended program. The results were statistically analysed. Information from the Higher Education Management Information System (HEMIS) system was used to compare performance of students who completed the extended program and those in the mainstream. Based on the research it seems that the extended program does benefit students.

Keywords: Academic development, extended program, student perception.

INTRODUCTION

Academic development programs are described in different ways. They are called academic development programs, bridging programs, foundation programs and extended programs. For the purpose of this article it will be referred to as the extended program. Academic development programs have been instituted at major universities across South Africa in response to the need for accommodating students from academically disadvantaged backgrounds, specifically in science and engineering programs. (Boug, 2010). The transition from high school to university it was found to be difficult by many students, especially in in engineering. This is specifically true for students from previously disadvantaged backgrounds.

It has been established that there is a gap in mathematics ability between high school and university mathematics in South Africa (Wolmarans, Smit, Collier-Reed, & Leather, 2010). Internationally the high school curricula focus on increasing access to tertiary institutions. The high school curricula teach the pupils superficial learning (Hoyles, Newman, & Noss, 2001) while, at University level deep learning is required. For those who do not meet the entry requirements in first year main stream engineering program, they have the option to enter an extended program.

South African higher education has, for a long time now, adopted bridging programs in line with The National Plan of Education (Ministry of Education, 2001). These programs assist and supports motivated learners to access and achieve in their university programs.

RESEARCH OBJECTIVE

Research shows conflicting results regarding the efficiency of this kind of intervention (Case, Smith, & Van Walbeek, 2014, Dhunpath & Subbaye, 2018). It can be inferred that further research is required. The aim of this article is to investigate whether the extended program offered by the Academic Development Centre (ADC) at the University of Johannesburg, for mechanical and industrial, engineering students, adequately prepares students for their entry into mainstream. The following questions need to be addressed:

- Have students improved their knowledge and skills in mathematics, English and computer literacy?
- Have students made the transition from superficial learning to deep learning during the extended program?
- How do students' experience the extended program and what is their perception of the support and efficiency of the communication received in the program?

THEORETICAL BACKGROUND

Superficial learning and deep learning

Often, at high school, students are taught superficially (Hoyles, Newman, & Noss, 2001). At University level deep learning is required (Ro, Lattuca, & Alcott, 2017). The aim of extended programs have been to ensure that students are equipped with certain skills to bridge the gap between high school and university specifically for academically disadvantaged students. One of these skills is to enable students to move from superficial learning to in-depth learning (Kloot, Case & Marshall, 2008). Deep learning or higher order thinking has been found to be a critical predictor of success (Lee & Choi, 2017). Deep learning is the ability to understand and apply knowledge in various environments (Case & Marshall, 2004). Deep learning is associated with understanding, using analytical skills, paying attention to the underlying meaning, cross-referencing and independent thinking. Deep learning tends to be internally motivated by desire to understand and not simply to pass (Warburton, 2003). Students need to become engaged with the study material and this normally follows from developing a strong personal interest in the field.

Controversy regarding the efficiency of extended programs

Conflicting results have been reported regarding the benefits of extended programs. An interesting finding is that students who do well in foundation programs perform better in later degree studies than students admitted directly into mainstream programs (Wood & Lithauer, 2005). However, in other studies it was found that the success rate was lower for students from extended programs than for mainstream students (Mathews, 2012). It was also found through statistical analysis that students from academic development programs did not significantly improve the throughput rates (Case et al., 2014).

Davidowitz and Schreiber (2008) investigated how effective factors correlates with adjustment and academic functioning and ultimately reflects on performance. This study conducted on students in an extended program revealed that “This programme seems to have enhanced the students’ experience and adjustment to University of Cape Town (UCT) and by extension possibly enhanced their academic functioning and performance.”

One of the factors that was found during interviews with students who dropped out from South African universities, was that many of the interviewed students were unable to integrate academically, and that there was no proper academic support to address the needs of students (Moodley & Singh, 2015).

A study was conducted on the foundation program of Natural and Agricultural Sciences at the University of Pretoria. The program had an 18 month long preparatory phase after which the students joined the mainstream program. Their approach was to consider three performance bands, namely good, moderate and poor and report the experience through the lens of each performance band. The study concluded that the poor performance band students voiced their inability to cope with academic demands of programs. These students should be better prepared with regard to academic demands and life skills. This foundation programs will assist them to adapt to the challenges of a university and help them to find assistance if required (Potgieter, Somo, Harding, Engelbrecht, & Kritzinger, 2015).

Success rates of students enrolled in foundation preparatory programs have been steadily increasing over time according to Dhunpath & Subbaye (2018) thus, justifying the substantial increase in funding from the state budget for such interventions. They indicate that, despite the different risk profile of students admitted in extended programs, their success rate is comparable with the mainstream student body and their performance is on the same level as their better prepared peers.

A similar opinion was expressed by Ssempebwa, Eduan, & Mulumba (2012) who analysed the performance of students taking the conventional route versus those taking a bridging program route. They found that the difference in performance was in favour of the bridging-route category and that may be due to early exposure to the general learning environment. This would reduce, the stressors at the start of the mainstream degree program.

Although the efficiency of extended programs has been scrutinized in various ways, with the use of one criteria or another, the reality as presented by the Department of Higher Education is that

almost half the students entering undergraduate degrees, never graduate (DHET, 2017). The students' under-preparedness may be addressed by this type of intervention however, due to their limited enrolment number in these programs, their success rate contributes very little to the mainstream throughput statistics. Jacobs et al. (2014) concluded that "Institutions should seriously consider placing more students in these programmes to ensure throughput and ultimate graduation." It is pointed out that, regardless of the financial support from the government towards foundation programs, they do not represent a quick-fix solution to the challenges faced by higher education in South Africa with regard to improved numbers of graduates (Kloot et al., 2008).

In general, the academic research is advocating the usefulness of the extended programs but there are few that argues their effectiveness (Case et al., 2014). Considering that foundation programs initiatives have been around for a long time, there has been ample time to assess and consider improvements. Implementation of these programs should benefit the students not only in knowledge gained but in better integration into the university system. Also these programs should aid with increased throughput rates.

Extended program

What initially started as bridging programs with the intention of filling the gap between inadequate schooling and demands of academia, have been re-framed in 2005 into foundation programmes. Soon thereafter these became extended curricula in engineering. These programs are now funded by the Government (Case & Heydenrych, 2015). The extended curricula has become a formal degree. The qualification is extended by 12 to 18 months, depending on the Higher Education Institution.

At the University of Johannesburg (UJ), the extended program for engineering students is offering introductory courses in key subjects and aims at developing student's academic literacy and learning skills. It is designed to prepare a more diverse student body by improving the graduation rates of previously disadvantaged students.

The Bachelor in Engineering Technology (BET) is a three-year program, whereas the BET extended program is a four- year program. The BET extended offers the same modules for both mechanical and industrial students in their first year. The students in the extended program will have to successfully complete all eight of first year academic development modules offered by Academic Development Center (ADC) in order to join the mainstream program. If students fail any one of their academic development modules they will be academically excluded. Their first year experience is different from a mainstream student's first year experience as this extra year will reinforce knowledge, and allow time for better academic integration. The modules offered by ADC extended program are shown in Table 1. Characteristic features of this additional year are:

- The syllabus of one semester is extended over the entire academic year so that there is enough time for profundity and deep learning;
- There are components of Life skills (i.e. Workplace preparation) where issues like goal setting, time management, study skills, exam stress and integration to university environment are addressed;
- The foundation mathematics and physics are reinforcing the high school knowledge. New topics are covered in depth in order to better prepare for the demands of the qualification;
- The program provides basics computer skills and facilitates revision of high school English language.

Table 1. First year modules in the extended program in mechanical and industrial

CPSED01	Computer Skills (Year Module)
FOMED01	Foundation Mathematics (Year Module)
FPYED01	Foundation Physics (Year Module)
FRRED01	Fundamental Research Practice (Year Module)
MDRED01	Mechanical Engineering Drawing (Year Module)
PMEDP01	Physics (Mechanics) Practical (Year Module)
PMEDT01	Physics (Mechanics) Theory (Year Module)
WPPED01	Workplace Preparation (Year Module)

METHODOLOGY

To determine whether the extended program prepares students adequately for their engineering studies a questionnaire was developed for surveying these students. This study was a quantitative research study. There were 29 questions in four sections. The sections were:

A. demographics,

B. questions about the specific subjects,

C. progress and communication during the extended program and

D. experience gained and lessons learned during the extended program.

Likert scale was used as well as polar questions for the closed ended questions and there were 4 open ended questions.

Questions were developed based on informal interviews with students about their experiences in the extended program. Personal experience as lecturers in mechanical and industrial engineering have revealed general concerns regarding language, mathematical proficiency and communication abilities. These were explored further in the questionnaire. Literature also guided some of the questions asked about in depth learning (Kloot et al., 2008) and about adjusting to the university environment (Davidowitz & Schreiber, 2008).

The questionnaire was given to first and second year mechanical and industrial engineering students studying Extended Bachelor in Engineering Technology in the Mechanical and Industrial Engineering Technology Department (MIET) at UJ. A total of 122 students completed the questionnaires out of a total of approximately 170 students that started in the extended program. Mechanical and Industrial engineering students at UJ come from various cultures, socio-economic backgrounds and home languages. All teaching and learning at UJ is in English so all students should have a basic proficiency in the English language.

First year students were asked to complete the questionnaire as they were still at the beginning of their engineering studies and their experience in extended program was recent. The second year students that have already finished their first year, would have better insight as to the benefits of the extended program to their engineering studies. Of the responses 54% were from first year students and 46% were from second year students.

We obtained ethical clearance from the University Ethical Committee for this research. Students were approached in one of their class periods. Participation was voluntary and anonymous.

The questionnaire contained both open and closed ended questions. Data was captured and analysed using IBM SPSS Statistics.

The Higher Education Information Management System (HEMIS) data was interrogated to compare, the percentage achieved in mathematics and science of the students who started in the extended program with the students in the mainstream.

Reliability was achieved by using Cronbach alpha testing. This is a measure of internal consistency.

RESULTS AND DISCUSSION

The statistics showed that a larger number (54%) of the students surveyed were first year students. The reason was some students drop out at the end of their first year and therefore there is a smaller second year class. There were more industrial engineering students than mechanical engineering students as annually the university accepts approximately 60 students into the extended program for industrial engineering technology and only 40 for mechanical engineering technology. The university accepts approximately 45 students into mainstream for industrial engineering technology and 80 for mechanical engineering technology. Of the 122 questionnaires completed 62% were completed by industrial engineering technology students.

English proficiency

The survey showed that only 13% of the students spoke English as their home language yet 90% of the students were taught mainly in English. This is not surprising as most schools in South Africa offer tuition in native languages until grade three and thereafter students are taught in English. Students reported that they did not experience difficulty with understanding mathematical terms in English, only 8% of students indicated that they experienced some difficulty at the beginning of the course. After the extended program was completed only 2.5% reported that they still experienced some problems with mathematical terms in English. The proficiency in the English language was reported by 84% of students between intermediate and expert. However the authors of this study and their colleagues in the MIET department, regularly experienced that students did not understand the questions in test and exams. It was apparent from reports written by students that the grammar and spelling of English were lacking and sometimes it was difficult to understand what students were trying to say. Language is therefore still considered a problem even though students are taught mainly in English and they report proficiency in the language.

Enjoyment and difficulty of subjects

In the section on specific subjects, students reported that they enjoyed the subjects in the extended program as indicated in Table 2. However, 54% of student reported that they found engineering drawing difficult. The reason given was that they did not have the subject in high school and it was new to them. Physics (Mechanics) Theory was also identified by 52% of students as a subject they experienced difficulty with, see Table 2. Students reported this subject as complex.

Table 2. Statistics on enjoyment and difficulty of specific subjects

	Enjoyed subjects		Difficult subjects	
	No	Yes	No	Yes
Foundation Mathematics	5.80%	94.20%	89.10%	10.90%
Engineering drawing	33.10%	66.90%	46.60%	53.40%
Foundation Physics	17.40%	82.60%	84.80%	15.20%
Fundamental Research Practice	38.80%	61.20%	79.50%	20.50%
Computer skills	14.90%	85.10%	84.00%	16.00%
Physics (Mechanics) Theory	21.50%	78.50%	47.90%	52.10%

The extended program assisted students to become familiar with the administration processes at the university. Over 90% of students reported that they became familiar with the universities exam and test regulations and over 80 % reported that they became acquainted with the university rules and regulations. During the extended program it was easy to adapt to the university environment according to 72% of students.

Transition to deep learning

The responses of 87.7% of students agreed and strongly agreed that they were now aware of the need to understand the work rather than memorising it. When asked whether they were able to apply knowledge in different environments, 91% agreed and strongly agreed. The majority (92.6%) agreed and strongly agreed that they were responsible for their studies. It appears that

the extended program does assist in helping students to progress from surface learning towards deep learning as can be seen in Figure 1. To truly establish whether deep learning is taking place further investigation is required regarding their ability to apply knowledge.

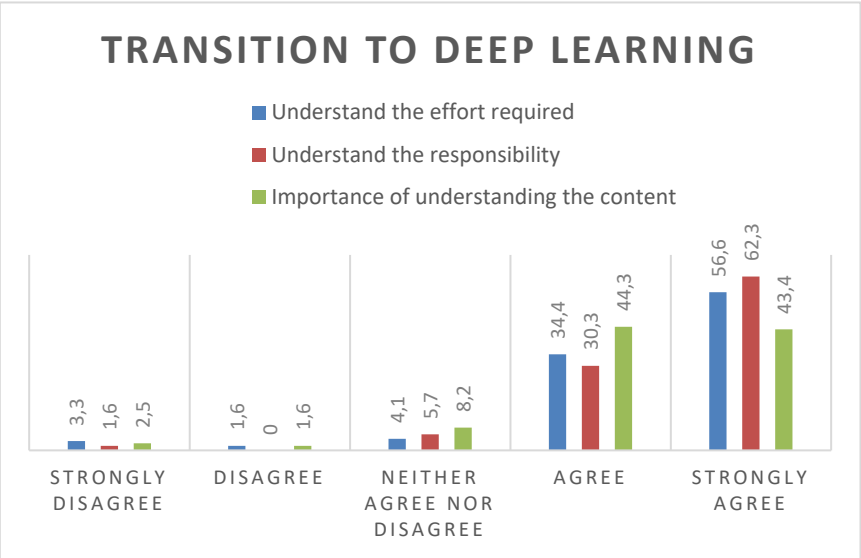

Figure 1: Results from questions regarding deep learning

Communication and support services

Students agreed and strongly agreed (86.1%) that the subject promotion requirements were clearly communicated by lecturers. The majority (81.4%) indicated that they were now moderately familiar and extremely familiar with various support services at the university.

Future plans

Of the students who completed the questionnaire, 79% of students agreed or strongly agreed that the extended program positively contributed to their aspirations to become engineers. Future plans in terms of dropout can be seen in Fig. 2. In the survey 5% of students indicated that they were planning to leave or seriously considering to leave the engineering program after the extended program and 11% were neutral about leaving. When the number of students who drop out are taken into consideration, 5% of students considering or planning to leave is low. It might be that these are a portion of the students who might voluntarily drop out and not drop out because of other factors such as finance or poor academic performance.

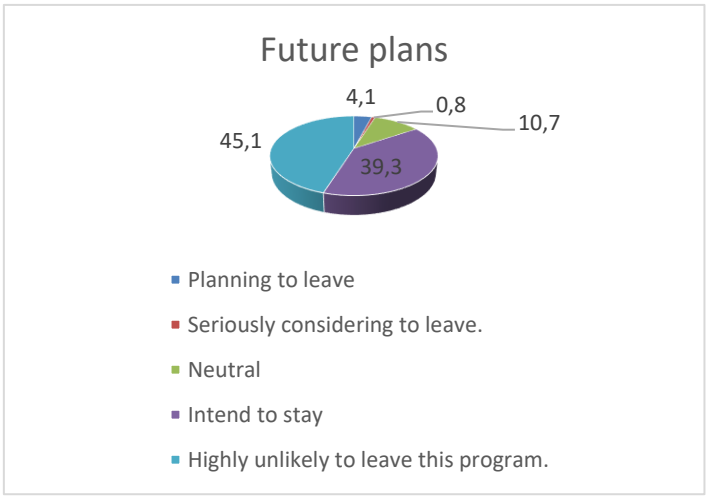

Figure 2. Future plans in terms of dropout

Benefits of the program

Students were asked in an open-ended question how the extended program benefitted them the most. Some of the responses were:

"Adapt to university easy and be familiar. It gives me aspirations to become an engineer."

"Allowed me to enrol in this Degree (through extended). Not too sure if I would be accepted into regular course."

"Helped me adapt to the university life and helped me have a better handle on my future and academic development."

"It has increased my language a lot It also taught me how to be independent in terms of academic life. It even helped me to be familiar with the university environment."

"It helped me cope with pressure and be able to depend on myself and team to get things done."

"It helped me most on mathematics and some modules whereby I can easily determine which best way to study or achieve pass for my test and exams (*sic*)."

"The extended programme gave me the fundamentals necessary for pioneering my career as an engineer. It gave me basic math and physics principles"

Three students reported that it had been a wasted year and that the work was too easy. It seems that many of the student benefitted from the extended program because it assisted them with the realisation that they needed to work hard and take responsibility for their work. Language skills and fundamental knowledge in mathematics and physics were also improved. The extended program appears to have eased the transition to university environment.

Comparison of academic results

From the HEMIS data the performance of the mainstream students were compared with the performance of the students from the extended program. These students were together in the same class, with the same lecturers. The pass rate of students in the course at the end of the semester, were higher for students from the extended program as indicated in Figure 3. There was a more pronounced difference in traditionally difficult subjects, such as electro-technology and mathematics, where the failure rates are high. It is still too early to compare graduation rates as this qualification is new, and 2016 was the first year for enrolment into this course. A longitudinal study will be done to track the differences between these groups.

Suggestions for improvement

When students were asked in an open ended question to give suggestions to improve the extended program some of the responses were:

"I think they should put breaks in some classes and student shouldn't be expected to attend from 8 - 5 3very day it is too exhausting (*sic*)."

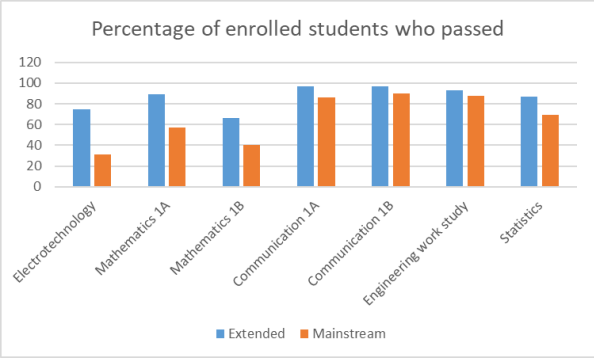

Figure 3: Percentage of students passed per subject

"Add more breaks between classes as it is hard to focus on every class"

"It is fine like that, I think it will help a lot of people as it has helped me"

"Time table is too full."

"To communicate well with the student."

“I think learners need to be more informed of the benefits in the extended program and they should be advised about it and they should be told not to take an extended program lightly”

The students specifically had no lunch break.

CONCLUSIONS

This study showed that students in the extended program seemed to be better prepared in terms of foundation knowledge for mainstream studies. Student experienced a more gradual transition into the university environment. Students were generally positive about their experience in the extended program and perceived many benefits from it. A few students were frustrated by the level of the work, finding it too easy. It may be that the students who were frustrated did not come from academically disadvantaged backgrounds. This could be explored further.

Students from the extended program seemed to perform better than students directly from high school into the mainstream, when their performance is compared per subject. This is especially so for the more difficult subjects. Therefore, the study may indicate that the extended program bridges the gap between high school and university. Further research will be required to confirm.

From the survey results it appears that students from the extended program have made the transition to take responsibility, make the effort and ensure that they understand the work rather than just rote learning. These students also report to adapting to university with ease.

RECOMMENDATIONS

Further research is required to establish whether deep earning is truly taking place. A Longitudinal study is also recommended to track the performance of students who started in the extended program compared to those who started in mainstream. This will provide confirmation that the extended program bridges the gap to university and is to the benefit of the students.

Based on the study it is clear that the timetable should be adjusted to provide a lunch break for students.

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