Engineering in open distance learning - a female and male comparative study in a mechanical engineering design module

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ABSTRACT: This research focuses on a comparison of female and male student performance in a mechanical engineering module offered through distance learning at the University of South Africa. Mechanical engineering design is a critical module for all aspiring engineering graduates to be produced by the university. In the South African context, it has been proven that females have more family responsibility than male students in general and, therefore, it is expected that academic performance may be affected. In general, teaching mechanical engineering design in a traditional contact university is a challenging task and has been shown to be so. This study seeks to add to existing knowledge by investigating how gender, age, home language, place of residence and student occupation influence academic performance in mechanical engineering design in open and distance learning. Following this research investigation, different teaching strategies have to be developed. It was found that home language, gender and place of residence contributes to the performance of students who are studying mechanical engineering design at the University of South Africa.

Keywords: Student performance, distance education, mechanical engineering design, engineering open distance learning at the University of South Africa

INTRODUCTION

The success rate of students in an open, distance learning institution is problematic in engineering studies. The failure rate of second level mechanical engineering design is especially high, and has become a cause of concern in open and distance learning institutions that offer engineering. For any institution to succeed, students in the second level must pass, so those students are available for subsequent higher levels. Therefore, it is vital to investigate the learning processes of students who are at work or staying at home for most of the time. This study seeks to add knowledge by investigating how gender, age, home language, place of residence and student occupation influence academic performance in mechanical engineering design in open and distance learning. South Africa like many other countries in the world is in dire need of engineering skills to improve and contribute to the economy. Engineers in general play a critical role in the development of a country. It has been proved that a country with limited skills like engineering suffers poorer economic growth. Engineering education internationally is currently experiencing a key evolution from traditional programmes towards approaches that better prepare students for engineering in the framework of social, economic and environmental challenges of the 21st Century [1][2].

The Mechanical and Industrial Engineering Department is one of three departments in the School of Engineering, which falls under the auspices of the College of Science, Engineering and Technology. There are two disciplines in the department; namely, Mechanical Engineering and Industrial Engineering. The University of South Africa (UNISA) offers diplomas and Bachelor's degrees in engineering in the School of Engineering. Even though UNISA's main campus is situated in a city, the majority of students are from, and stay, in rural areas. South Africa has nine provinces of which the majority are in the rural communities. In rural areas of South Africa, women are still expected to perform home chores without any compromise. They are, for example, expected to look after children, to cook and clean the house and make sure that the in-laws are taken care of [3][4]. This can be challenging when a woman has enrolled for studies in engineering in an open distance learning university. In an open distance learning university, a student is expected to learn and develop her/himself with minimal consultation with the lecturer or course coordinator. Hence, the aim of this research is to find out, if women's performance in the Mechanical Engineering Design course is affected by their heavy family responsibilities.

In any society, engineers must be able to meet future requirements and at the same time fulfil the requirements of nation building [5-7]. In the current academic year, the enrolment of women in the mechanical design course is 50%.

The academic progress and performance of each student at the university is monitored by the central student administration. One of the influences on student performance is the gender of the teacher [8]. However, this does not apply in an ODL environment, since the students have minimal contact (face-to-face) with the lecturer. The quantity of appropriately competent and trained engineering graduates is essential for the modern economy. There are several factors that influence females in study engineering, including parental support and strong mathematical abilities [9]. However, a significant minority of United Kingdom (UK) engineering firms report that engineering graduate shortages and skills deficiencies are costing them money through delays in product development and additional recruitment costs [10][11].

Therefore, the specific objectives of this research are three-fold:

- Compare students' performance in mechanical engineering design for three consecutive years.
- Understand how women's chores affect their academic performance.
- Introducing teaching and delivering strategies for non-performing female students in mechanical engineering design module.

MODULE LAYOUT AND DESCRIPTION

Mechanical Engineering Design II is a semester course offered by the Mechanical and Industrial Engineering Department of the University of South Africa. The number of enrolled students for this module has grown by an average of 20% every year since 2010. The pass rate for this module is relatively low. This is a second-year level design module for the Engineering Diploma (mechanical). In this course, both female and male students are evaluated in one semester. Mechanical Engineering Design III is a year module. This is a final-year level design module for the Engineering Diploma (mechanical). Similarly, both female and male students are evaluated every semester. The pass mark is according to the University of South Africa evaluation policy. Mechanical Engineering Design II, and III have national hour credit of 4 and 6, respectively. Figure 1 shows the number of students over the period of five years.

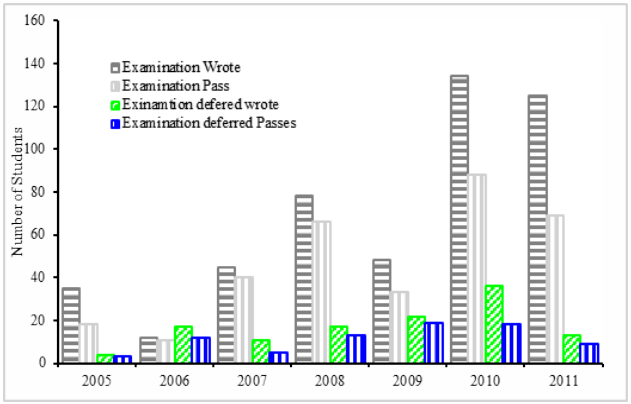


Figure 1: History of Mechanical Engineering Design II from 2005 to 2011.

Design means different things to different people. A mechanical engineer is concerned mainly with product design and accordingly must take into account the full range of features that this involves; namely, form, function and value. The exercise requires skill in synthesis just as much as in analysis and it requires, in many instances, a sense of form and elegance that is both functional and aesthetic [12][13]. The aim of mechanical engineering design is to train students to be able to understand and apply design principles in designing basic component design.

The aim of this module was to introduce students to the design process and the implementation of machine design elements. The syllabus for this module covers the following aspects: introduction to mechanical design, introduction to machine elements, design of bearings, design of shafts, design of gears, design of belts and chain drives, design of seals, design of clutches and brakes, design of springs, fastening and power screws and engineering tolerancing. Mechanical Engineering Design II is evaluated on two assignments and a final written examination, which counts 90% towards the final course mark. Teaching design in any engineering course involves several specific disciplines. The designer must be capable of identifying and analysing the key aspects of the device with which he/she is concerned. For instance, take an independent suspension system for a high performance on-off highway wheeled vehicle [13][14]. The population of students who are registered for the module number 150 per year (on average). The students who registered for the module are registered on the university central system. Their details are then obtained from the university central system.

Table 1: Evaluation for Mechanical Design II.

Evaluation	% Contribution
Assignment 1	5%
Assignment 2	5%
Examination	90%
Total	100%

RESULTS AND DISCUSSION

The data used in this study are focussed on the students registered for the Mechanical Engineering Design II in both semesters for academic years 2010, 2011 and 2012. The information and data obtained from the university central record system include student marks, gender, age, province of stay, occupation, matriculation results, home language and the number of years registered. For the period between 2010 and 2012, the total number of students registered for this module was 519 including, repeaters in both semesters.

Table 2: Descriptive statistics used in analysis.

	Descriptive of variable	All student observations	Mean	SD	Max.	Min.
Average mark course	Total number of average marks obtained	521	48.23	17.39	94	6
Occupation: engineering	Registered type of work for students	200	49.97	17.97	94	2
Occupation: unemployed	Registered type of work for students	90	47.77	16.36	77	1
Occupation: full time students	Registered type of work for students	55	49.51	16.03	89	14
Occupation: administration	Provincial examination department	171	45.94	18.1	87	2
Education Department (Western Cape)	Provincial examination department	35	45.2	19.3	86	2
Education Department (Eastern Cape)	Provincial examination department	15	49.33	15.96	79	27
Education Department (Limpopo)	Provincial examination department	23	50.26	15.36	83	23
Education Department (Northern cape)	Provincial examination department	2	44	9.9	51	37
Education Department (Mpumalanga)	Provincial examination department	23	49.74	17.87	76	5
Education Department (Gauteng)	Provincial examination department	322	48.66	17.43	94	1
Education Department (North West)	Provincial examination department	36	43.33	19.94	84	3
Matric mathematics average	Average pass mark for Mathematics	521	49.86	18.13	92	33
Age	Age of students	521	30	5.83	52	21
Language (South African Vernacular)	South African vernacular languages	330	48.26	17.39	94	32
Language (Afrikaans)	South African vernacular languages	85	48.26	17.45	94	16
Mathematics (higher grade)	Required subject for registration and admission	217	51.72	14.27	80	40
Physical Science (higher grade)	Required subject for registration and admission	263	50.07	11.36	70	40

Table 3: Examination mark performances of provinces.

	All student	0-30% examination marks	30-50% examination marks	50-70% examination marks	70-100% examination marks
Residence Province: Gauteng	322.0	14.0	38.2	37.3	10.6
Residence Province: Limpopo	23.0	8.7	30.4	52.2	8.7
Residence Province: Western Cape	33.0	24.2	39.4	33.3	3.0
Residence Province: Mpumalanga	22.0	13.6	27.3	45.5	13.6
Residence Province: North-West	36.0	27.8	36.1	27.8	8.3
Residence Province: Eastern Cape	15.0	6.7	60.0	13.3	20.0
Residence Province: Kwazulu-Natal	13.0	15.4	30.8	23.1	30.8
Residence Province: others	56.0	10.7	33.9	41.1	14.3

South Africa is divided into nine provinces, namely: Limpopo, Gauteng, North-West, Mpumalanga, Kwazulu-Natal, Eastern Cape, Northern Cape, Western Cape and Free State. Table 3 shows performance results of students in Mechanical Engineering Design II. The Gauteng province has more students registered for the module. This province is regarded as the best province in terms of resources in South Africa. Even though 61.8% of students registered for the module are from Gauteng, the province has the third highest rate of student failure of 52.2%. In terms of the failure rate,

North-West and Eastern Cape have failure rates of 63.9% and 66.7%, respectively. Unexpectedly, Limpopo province has the lowest failure rate of 39.1%. It must be noted that Limpopo is rated as the poorest province in South Africa.

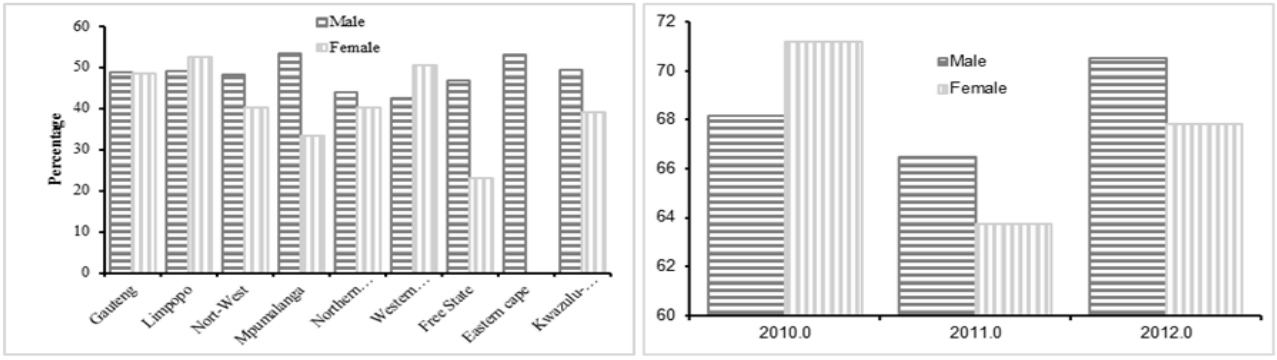
The question maybe be asked, why do Limpopo students perform better than students from other richer provinces even though they are perceived and regarded to be the poorest? It is surprising that Kwazulu-Natal has the best performing students who obtained marks between 70-100% in the module. Western Cape is regarded as the best resourced province, but it has the lowest performance on the highest marks obtained. The best question to ask is, is this due to the fact that the province has vast opportunities for students to spend most of their time?

In South Africa, there are eleven official languages; namely, Tshivenda, IsiZulu, English, Sesotho, Setswana, Xitsonga, IsiNdebele, SiSwati, Afrikaans, Sepedi and IsiXhosa. According to the 2011 South Africa Census, IsiZulu is the most spoken language followed by IsiXhosa. According to Table 3, 519 students registered for Mechanical Engineering Design II and 15% of these students received a mark between 0 - 30%, while only 37.4% received a mark between 30-50%. Only 10% of students registered for the module received marks between 70-100%.

Even if Tshivenda is the least spoken language in South and has fewer students registered for the module, nearly 35.6% of them received a mark of between 50-70%. Again, this shows that Limpopo students have performed well in mechanical engineering even though they are perceived has having few resources in terms of Internet access as compared to other provinces. This might actually suggest that government should encourage or subsidise electronic communications service providers (*telcos*) to increase their broadband coverage in Limpopo. About 68.3% of IsiZulu speaking students received marks of between 0-50%, while 54.2% of Tshivenda speaking students received marks between 0-50%. About 51% and 41% of English and Afrikaans home languages students received marks between 0-50%. Even though English and Afrikaans home languages students are in minority in mid performance, they are found to be performing well in the category of best performing students in Mechanical Engineering Design II module. Therefore, it can be concluded that home languages do not play an important role in terms of student's performance in Mechanical Engineering Design II module.

According to Census 2011 of the Republic of South Africa, men account for about 48.2%, while women account for 51.7% of the population [15]. In general, women are regarded as having more family responsibilities than men. The question is that if this is true, will this affect their academic performance in high demanding modules in engineering?

Figure 2a shows the average students' performance of male and female students in the Mechanical Engineering II module. The average student mark in academic year 2010 was 72% compared to 68% for women. In subsequent years 2011 and 2012 the male student performance then exceeded that of female students. As shown in Figure 3a, the male student performance over there academic years is averaged at roughly 50%. During these three consecutive academic years, it can be seen that Limpopo performed better during 2010, whereas Eastern Cape and North West outperformed other provinces in 2011 and 2012, respectively. The performance of female students is lower than that of male students as shown in Figure 2b.



a) b)

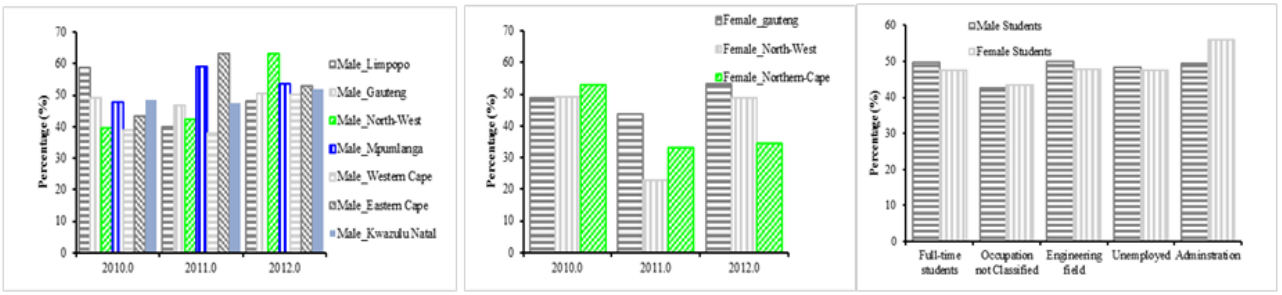
Figure 2: a) average performance of student in different provinces; and b) average grades for male and female student in three conservative academic years.

The maximum average performance for female students are found to be from those residing in Gauteng province during the academic year 2011. The best performance was for students residing in Northern Cape Province with an average of 55% mark. The academic year 2011 was the worst in terms of student's performance for most provinces, since their average mark was below 50%.

It has been proven that age in open distance learning institution plays an important role in students' performance. This has not yet been established in open and distance learning in engineering modules. Figure 3b shows average student marks per occupation category selected. The analysis is divided into five categories of occupation; namely, full-time students, occupation not classified, engineering and technical field, unemployed and administration. It can be seen that performance of students who are employed in engineering field has just hit the average mark of 50% for both female and

male students. Unexpectedly, the students who work in administration are the ones that have outperformed all other occupational categories. In general, it can be said that student occupation does not play a great role in terms of student performance in the Mechanical Engineering Design II module.

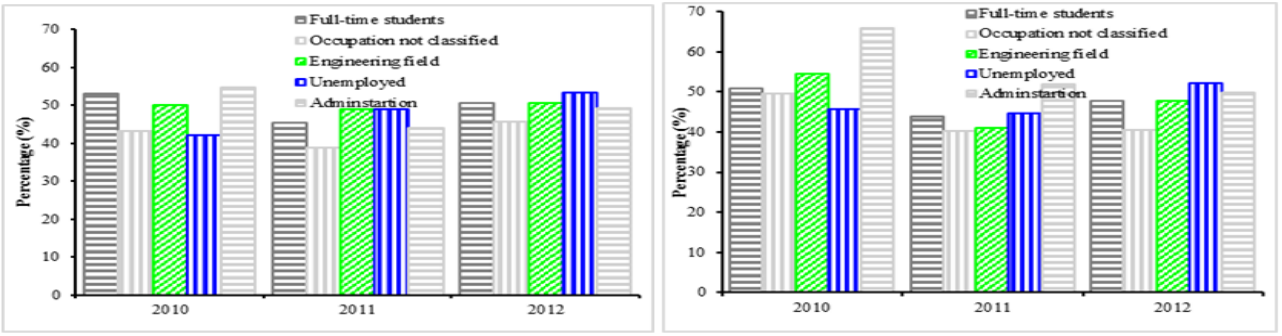
Figure 3c compares performance of female and male students for different occupation categories. It is important to note those females who are in administration are doing well and their performance outweighs that of male students. Of students that are registered as full-time students, males are performing better as compared to females. For unemployed students and those for whom their occupation is not classified, the performance for both female and male students is about equal. This means that the performance of female students who are not employed or whose occupation is not classified, does not depend on employment category.



a) b) c)

Figure 3: a) male examination performances in seven provinces; b) female performances in three provinces; and c) students' performance per occupation.

Figure 4a and Figure 4b show how male and female students performed over a period of three academic years, respectively. The student registered as full-time are expected to be doing well in the course compared to other categories. It is interesting to note that both unemployed and full-time students have the same level of performance for all academic years. For those students whose occupation status is not stated, it seems that their performance is lower as compared to the others. These students can be viewed as those who are working in an informal economy and sector. In other words, their categories where not listed in the system for students to select.



a) b)

Figure 4: Performance for a) male; and b) female student in three academic years.

Table 4: Descriptive analysis for examination marks (all students).

	Number of all students	0-30% examination marks	30-50% examination marks	50-70% examination marks	70-100% examination marks
Number of students	166.0	78.0	194.0	192.0	55.0
Percentage students	100.0	15.0	37.4	37.0	10.5
Average final mark: Mechanical Engineering Design (%)	519.0	15.0%	37.4%	37.0%	10.6%
Average age	30.0	30.0	30.3	30.9	29.1
Average number of years registered	1.5	60.0%	60.0%	100.0%	100.0%
Number of males	457.0	12.0%	38.5%	35.4%	2.6%
Number of females	64.0	14.1%	28.1%	46.9%	3.1%
Home language: Tshivenda	24.0	25.0%	29.2%	37.5%	8.3%
Home language: English	104.0	15.4%	35.6%	35.6%	13.5%
Home language: Afrikaans	85.0	9.4%	30.6%	47.1%	12.9%
Home language: IsiZulu	60.0	18.3%	50.0%	26.7%	5.0%
Home language: Others	245.0	24.5%	60.8%	62.9%	17.6%

CONCLUSIONS

Students from Limpopo province performed much better as compared to those from other provinces even if it is seen as the poorest province in South Africa. It can be concluded that student performance in an open and distance learning environment in the mechanical engineering module at the University of South Africa does not depend on how well-resourced students are.

Home language does not give any advantage in terms of students' performance studying this module. In general, student occupation category does not play a great role in terms of student performance in mechanical engineering design. The performance of female students who are unemployed or whose occupation is not classified does not depend on employment category. In addition, performance by female students was found to be on par with their male counterparts.

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BIOGRAPHY

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