Proceedings of the Second Biennial Conference of the South African Society for Engineering Education

11 – 12 June 2013

Vineyard Hotel
Cape Town, South Africa

Edited by Brandon Collier-Reed

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Message from the President of SASEE

It is my great pleasure to welcome you to the second biennial conference of the South African Society for Engineering Education (SASEE). SASEE was formally launched at its first conference held in 2011, and the two years have rolled around in a busy way. Two workshops were held in 2012, to keep the momentum going – one on curriculum and another on teaching large classes. We have been delighted at the attendance and engagement so far at SASEE events, and the emergence of this dynamic community.

We have had a very good response to our call for papers for this conference and we have an interesting three day programme lined up. This year we headlined our call with the theme of "Teaching professionals / Professional teaching: towards an ethical, efficient and engaged engineering education" and we look forward to discussions that respond to this challenge. We are aiming a focus towards the building of professionalism in engineering education, interrogating not only efficiency (the current focus on throughput) but also the ethical basis for our teaching and the need for engagement.

The stunning Vineyard Hotel will form the backdrop for our deliberations. We particularly welcome all out of town guests to Cape Town! We are hoping for critical engagement with the current challenges we face in engineering education as well as the presentation of innovative work that is designing and trialling new ways forward. The SASEE conference is an important coming together of both research and practice-based scholarly work, covering topics at all the levels of policy, curriculum, and teaching and learning.

We are particularly grateful to our sponsors who have assisted in making this event happen. ECSA (The Engineering Council of South Africa) has played an on-going role in supporting SASEE at so many levels and we are also delighted that this year they have sponsored the Welcome Reception. We are pleased to welcome a new sponsor in FNB Platinum who made a generous contribution. Finally, we would also like to thank our exhibitors, Oxford University Press and Juta, for their participation in this event.

Prof Jenni Case
President, SASEE

Conference Review Procedure

These proceedings are a published record of the Second Biennial Conference of the South African Society for Engineering Education (SASEE). The purpose of these proceedings is to disseminate original research and new developments within the discipline of Engineering Education.

All papers and extended abstracts accepted for this conference went through a multiple- review process *prior to publication*. Authors initially submitted extended abstracts which were double-blind reviewed by at least one member of the SASEE or Centre for Research in Engineering Education Executive. Based on the outcome of this review, authors were invited to either develop this extended abstract into a full paper, or were invited to revise their extended abstracts based on the reviewers comments for resubmission. The resultant papers and extended abstracts were then further reviewed by at least two reviewers using a double-blind peer review process. Authors were required to consider and implement the suggested changes where required.

The reviewers for the papers and extended abstracts were drawn from the SASEE Executive, SASEE membership, and the Centre for Research in Engineering Education (CREE) as appropriate.

The rejection rate for full papers was **14%** and for extended abstracts was **13%**.

SASEE Biennial Conference Organising Committee, 2013

Prof Jenni Case UCT)

Dr Debby Blaine (US)

Dr Keith Jacobs (UNISA)

A/Prof Brandon Collier-Reed (UCT)

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Extended Abstracts

The academic benefit of experiential learning for Civil Engineering students on the Pietermaritzburg campus of the Durban University of Technology

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The experiential learning model adopted by the Department of Civil Engineering on the Pietermaritzburg Indumiso Campus of the Durban University of Technology requires students to complete at least the first six months of this training before registration for the final academic semester of their studies. Due to the limited number of placement opportunities, many Universities of Technology have waived this requirement. It is the author's view that despite the shortage of placement opportunities, the benefit derived by students being exposed to real work situations better equips them to perform academically, and retaining the requirement thus outweighs the difficulty of sourcing placements.

The objective of experiential learning is for the student to learn in the context of application, which is mainly problem-based and guided by the specific requirements of the industrial sector in which the work is undertaken. Students exposed to industry acquire valuable and specialized knowledge and skills by working with experienced professionals and mentors while becoming better acquainted with the work processes. Apart from experiential learning contributing to more effective learning it also has the potential to be of benefit to students and the company that trains them.

The aim of this research project was to determine whether the anecdotal evidence that students do perform better once they have been exposed to a work environment, can be backed up with statistical data on a cohort of students, using academic data of 181 Civil Engineering students who have completed their studies towards a National Diploma: Engineering: Civil between 2010 and 2012.

Since the final academic semester follows at least one period of experiential learning, the author believes that the ability of students to relate the experience gained during experiential learning should be reflected in better overall academic performance.

Keywords: Academic performance, Civil Engineering, co-operative education, experiential learning, student success, training.

Introduction

The National Diploma: Engineering: Civil (and most other engineering programmes offered by Universities of Technology) comprise four academic semesters, and two work based experiential learning semesters. The sequence in which these academic and experiential learning semesters are interspersed varies from programme to programme, and from institution to institution.

Experiential learning has as its main objective the opportunity for the student to learn in the context of application (Rainsbury et al, 1998), which is thus mainly problem-based and guided by the specific requirements of the industrial sector in which the work is undertaken. Whilst in industry students acquire valuable and specialized knowledge and skills by working alongside experienced professionals and mentors while becoming more familiar with the work processes (Hicks, 1996; Rainsbury et al, 1998). In addition to the experiential learning contributing to more effective learning (Schaafsma, 1996) it also has the potential to assist the student to better understand the theoretical aspects of their field of study.

Experiential Learning

Although there is no hard and fast rule regarding when a student should undertake their experiential learning, unless the experiential learning is integrated with periods of full time academic study, the benefit of the time spent in industry will not be evident in the performance of the student. The options with regards when experiential learning can be positioned within the qualification are reflected in Table 1.

Table 1. Alternative Positioning of Experiential Learning Semesters within Curriculum

S1	S2	P1	P2	S3	S4
S1	P1	S2	S3	S4	P2
S1	S2	S3	P1	S4	P2
S1	S2	S3	S4	P1	P2
S1	S2	S3	P1	P2	S4
S1	P1	P2	S2	S3	S4
S1	P1	S2	P2	S3	S4
S1	S2	P1	S3	P2	S4

The experiential learning model, sometimes referred to as co-operative education, adopted by the Department of Civil Engineering based on the Pietermaritzburg Indumiso Campus of the Durban University of Technology requires students to complete at least the first six months of this training before they will be permitted to register for the final academic semester of their studies. Due to the limited number of placement opportunities, many Universities of Technology have waived this requirement. It is the author’s view that despite the shortage of placement opportunities, the academic benefit derived by students being exposed to real work situations better equips them to perform academically, and retaining the requirement thus outweighs the difficulty of sourcing placements.

Student Performance

The aim of this research project was therefore to determine whether or not the anecdotal evidence that students seem to perform better once they have been exposed to a work environment, can be backed up with actual data on a cohort of students. The National Diploma: Engineering: Civil comprises twenty-five academic subjects some of which are modularized at the Durban University of Technology (see curriculum design in Table 2 below). Nineteen of the subjects are undertaken during the first three academic semesters (S1, S2 & S3) prior to undertaking the compulsory experiential learning component (P1), the remaining six subjects are done in the final semester of study (S4). Many of the subjects at all levels are modularized, particularly at the S3 and S4 level of study. In most cases these modules are design specific software modules requiring the student to master a particular design package to an acceptable level of competency. There are thus many levels of learning required and this results in an increased workload on a student.

Table 2. Academic Curriculum of Access and Main Stream Programme

Access Programme
Communication Skills I
Computer Skills I
Mathematics I
Foundation Science I *(not credit bearing for main stream)* **Semester 1**
(S1) Applied
Mechanics I
Computer Skills I *(unless passed in access programme)*
Construction Materials I
Drawing I
Mathematics I *(unless passed in access programme)*
Surveying I (Module I)
Surveying I (Module II)
Semester 2 (S2)
Construction Methods I
Communication Skills I *(unless passed in access programme)* Drawing
II Mathematics II
Management : Civil I
Survey : Civil II (Module 1)
Survey : Civil II (Module 2)
Theory of Structures II
Semester 3 (S3)
Geotechnical Engineering II
Management : Civil II (Module 1)
Management : Civil II (Module 2)
Structural Analysis II (Module 1)
Structural Analysis II (Module 2)
Structural Steel & Timber Design III (Module 1)
Structural Steel & Timber Design III (Module 2)
Transportation Engineering II (Module 1)
Transportation Engineering II (Module 2)
Water Engineering II (Module 1)
Water Engineering II (Module 2)
Semester 4 (S4)
Documentation III (Module 1)
Documentation III (Module 2)
Geotechnical Engineering III (Module 1)
Geotechnical Engineering III (Module 2)
Reinforced Concrete & Masonry Design III (Module 1)
Reinforced Concrete & Masonry Design III (Module 2)
Structural Analysis III (Module 1)

Structural Analysis III (Module 2)
Transport Engineering III (Module 1)
Transport Engineering III (Module 2)
Transport Engineering III (Module 3)
Water Engineering III (Module 1)
Water Engineering III (Module 2)
Water Engineering III (Module 3)

Since the final academic semester in the case of Durban University of Technology Civil Engineering students studying on the Pietermaritzburg Indumiso Campus follows minimally the first period of experiential learning (P1), the author believes that the ability of students to relate the experience gained during experiential learning should be reflected in better overall academic performance. This theory will be tested statistically.

A cohort of one hundred and eighty one students, being those students who completed all the requirements for the award of National Diploma: Engineering: Civil were studied. One hundred and five of these students who were admitted directly into the main stream programme; the remaining seventy-six students were students who were required to first enroll for the engineering access programme. The engineering access programme is designed to accommodate students who do not meet the minimum university entrance requirements, but who minimally meet the Department of Higher Education prescribed entrance requirements for entry to a diploma programme. These students thus would under normal circumstances take one semester longer than the main stream students to complete the academic component of the programme. Since three subjects of the four undertaken in the Access Programme are credit bearing for the Main Stream Programme, the time spent on the Access Programme needs to be included in the analysis of this cohort of students.

Before considering the combined data of the cohort, the data for the Access Programme and Main Stream Programme will be examined, with particular reference to the average marks obtained at the S4 semester level on the first attempt, when compared with the average marks obtained for the first three (four in the case of access students) semesters of study.

Table 3. Change in Average S4 compared with Average S1-S3 Percentage Marks of Access students only

Range	**No of Students**
-20	0
-15	6
-10	10
-5	12
0	22
5	23
10	0
15	0
20	3

Table 4. Change in average S4 compared with Average S1-S3 Percentage Marks of Main Stream students only

Range	No of Students
-20	1
-15	4
-10	10
-5	32
0	32
5	16
10	8
15	1
20	1

Now consider the improvement distribution for the combined cohort, as reflected in Table 5:

Table 5. Change in Average S4 compared with Average S1-S3 Percentage Marks of Combined cohort of students

Range	No of Students
-20	1
-15	10
-10	20
-5	44
0	54
5	39
10	8
15	1
20	4

These changes are best illustrated graphically.

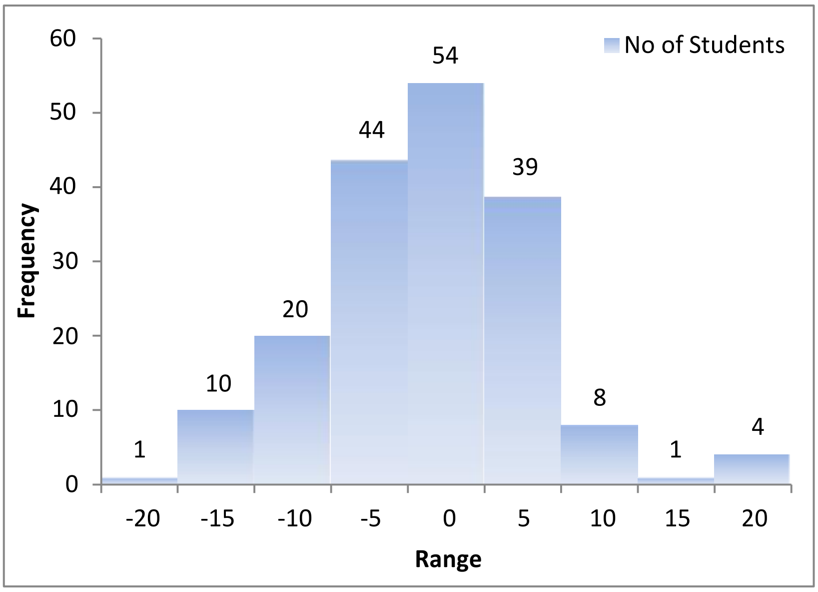

Figure 1. Distribution of average change of combined cohort of students

The above cohort distribution would indicate that only 28,73% of the combined cohort experienced an increase in their average mark at the S4 level. This is however better illustrated graphically by comparing the individual students' averages as illustrated below.

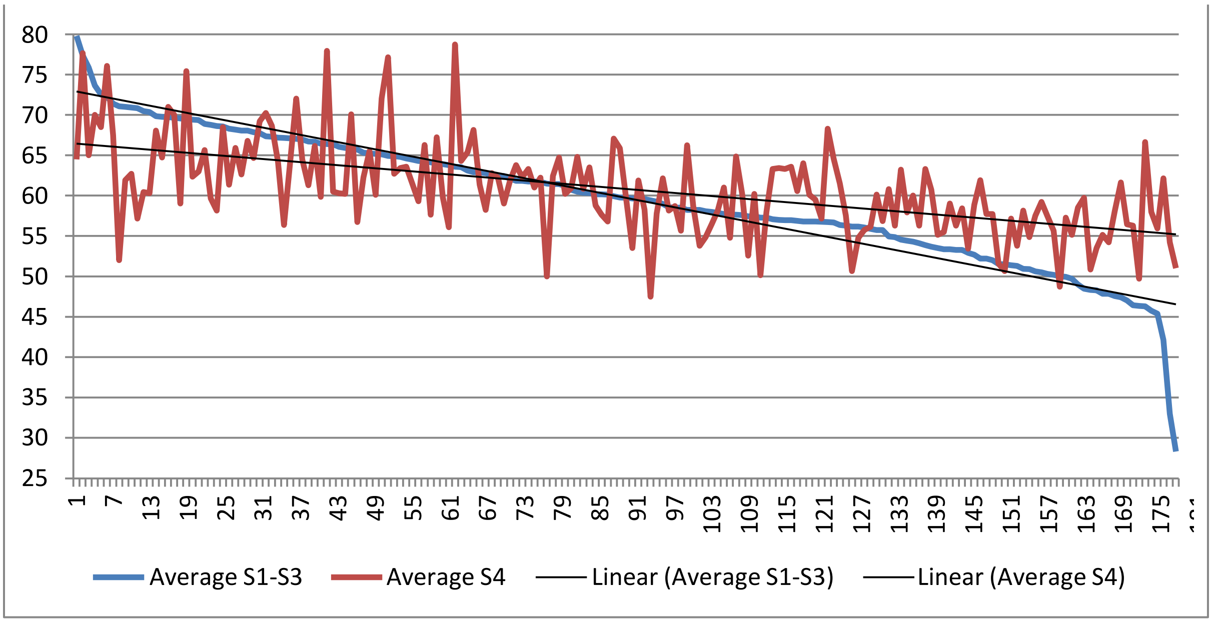

Figure 2. Comparison of individual student's average performance

Figure 2 shows the average performance per student (blue line), **sorted from the highest to the lowest average marks for S1-S3.** The mark obtained is the calculated average mark on the first attempt for all subjects from S1 to S3. The red line indicates the same student's result for the S4 semester. It is interesting to note how clearly this graph indicates the benefit of experiential training for the weaker student (towards the right hand side of the graph).Since universities are now funded on the basis of throughput as one of the prime variable, it would be useful to compare the average time taken for students to complete the first three semesters (four in the case of access programme students) of study when compared to the final academic semester of study which follows the experiential learning period.

From the analysis below only 76 (41,99%) of the cohort completed S4 in the minimum time of one semester whilst 9 (4,97%) of the same sub-set of students completed S1-S3 in the minimum time of three semesters.

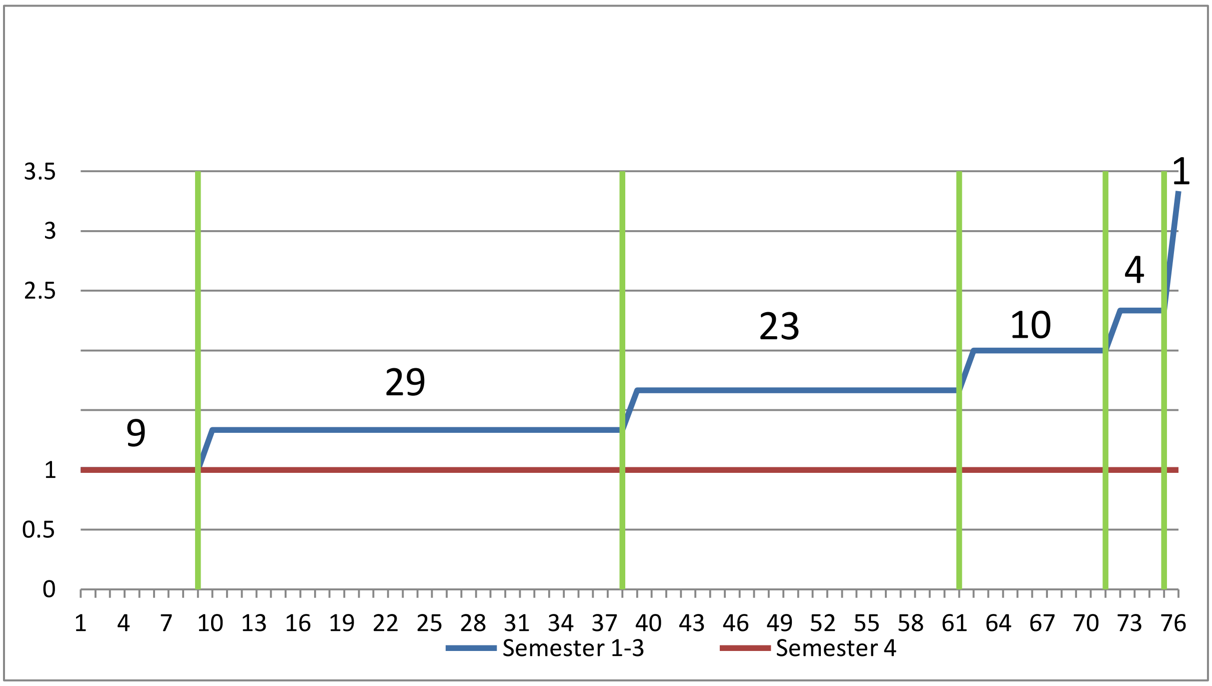

Figure 3. Ratio of Actual time spent on studies : course length

Of these **76** students who passed S4 in the minimum required time period (1 semester), 9 finished their S1-S3 course in the minimum period, 29 students took 33% longer than the minimum period, 23 students 66%, 10 students double the minimum period, and 5 students remained at the institution for more than double the minimum period for the completion of S1-S3.

Table 6. Average time taken to complete S4 when compared with Time taken to complete S1-S3

S1-S3 Semesters	S1-S3 Actual/Ideal	S4 Actual/Ideal	No of Students
3	1.00	1.35	14
4	1.33	1.42	48
5	1.67	1.60	42
6	2.00	1.95	42
7	2.33	2.05	22
8	2.67	2.50	10
9	3.00	2.00	1
10	3.33	2.00	2

This table indicates that the weaker students (who finish S3 in 5 or more semesters), do better in finishing S4 in a relatively shorter period of time. The stronger students during the first 3 semesters, however, indicate a small decline in marks during their S4. The reason for this could be that the weaker students, having completed at least part of their experiential learning, have a better understanding of the relevance of the material being covered, and also what is expected from them, as well as a greater commitment to succeed. The average student that passes S4 within the minimum specified period of one semester, spent on average 35% longer than the proposed time period to finish his/her S1-S3. This is best demonstrated graphically as in Figure 4 below.

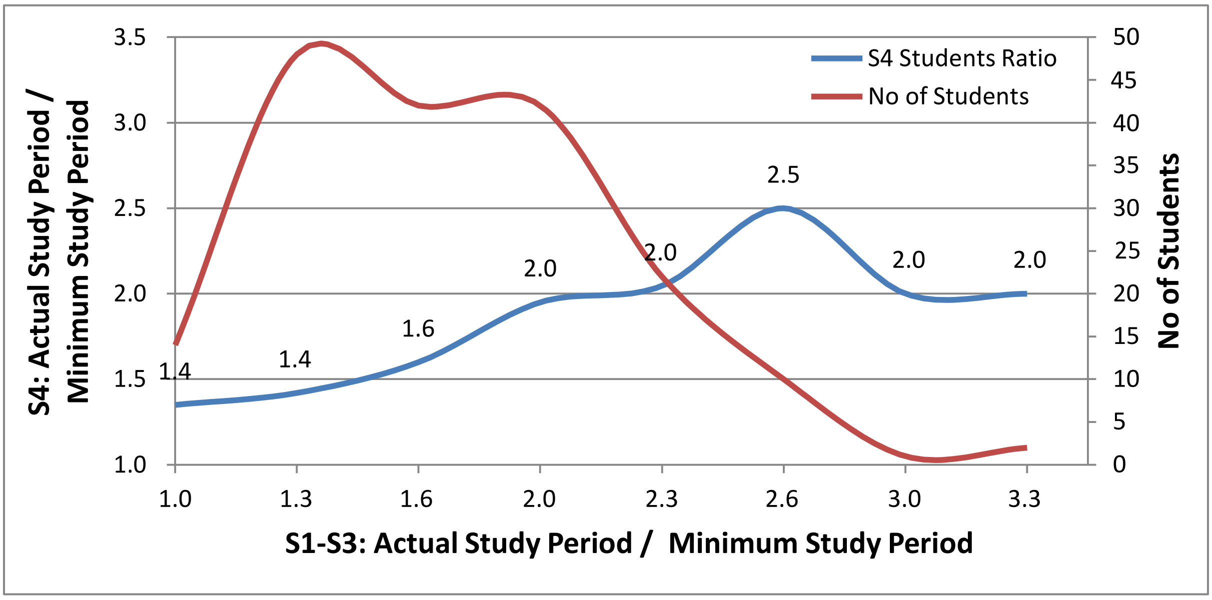

Figure 4. Student Progression in S4 compared with study period ratios during S1-3

The graph shows that the students who tend to spend more than the minimum required time to complete S1-3 (three semesters), tend to perform better in S4 and hence take a shorter time on average. By way of example, students who finish S1-3 in in the minimum required period, takes on average 30% longer to finish S4. Students who – on average – spend more than 67% of the minimum time period to finish S1-3, tend to perform better in S4 thereby taking less time on average. The graph also reinforces the benefit of experiential training for students who struggle to finish the first 3 semester in the minimum period of time.

Given these results, it is necessary to test the following hypotheses:

H_0: There is no significant difference between the average mark of the S1-3 and S4 results of a student

In order to reject the above hypothesis, it must be proved that there exists a statistical significant difference between the two stages of study, and that the difference is not the result of mere chance. Consider firstly the students averaging 60% or less on their first attempt of each subject at S1-S3.

Table 7. Results of t-Test: Paired Two Sample for Mean

	Average S1-S3	Average S4
Mean	59.716	60.835
Variance	63.121	33.009
Observations	181	181
Pearson Correlation	0.561	
Hypothesized Mean Difference	0	
df	180	
t Stat	-2.247	
P(T<=t) one-tail	0.013	
t Critical one-tail	1.653	
P(T<=t) two-tail	*0.026*	
t Critical two-tail	1.973	

Since the t-Test value in this case is less than 5%, we can therefore reject the null hypotheses, which means that the differences are not as a result of chance and can therefore statistically be ascribed partially to the compulsory experiential learning period of at least six months that proceeded the S4 period of study.

In order to find whether or not the success rates at the S4 level of study could be further improved, it is necessary to examine the success rates on the first attempt of each individual module.

Table 8. Module Average Pass Rates distribution

Subject	**Number of Students per Range**										**% Pass on First Attempt**
	<10	**<20**	**<30**	**<40**	**<50**	**<60**	**<70**	**<80**	**<90**	**>90**	
DCMT311	0.00	0.00	0.55	6.08	14.92	49.72	22.65	4.97	1.10	0.00	**78.45**
DCMT321	0.00	0.00	0.00	0.00	0.55	12.71	53.59	32.60	0.55	0.00	**99.45**
GTCE311	2.76	0.00	1.10	12.15	32.04	35.36	13.26	2.76	0.55	0.00	**51.93**
GTCE321	0.00	0.55	2.21	0.00	4.42	17.68	25.41	19.34	20.44	9.94	**92.82**
RCMS311	3.87	0.00	0.55	9.94	29.83	40.33	12.71	2.76	0.00	0.00	**55.80**
RCMS321	0.55	0.00	0.00	1.66	6.08	49.17	14.92	14.92	10.50	2.21	**91.71**
STAL311	4.42	0.00	0.55	4.42	9.94	32.60	24.31	13.81	9.39	0.55	**80.66**
STAL321	0.00	0.00	0.00	2.21	1.66	36.46	21.55	20.44	12.15	5.52	**96.13**
TRNE311	0.55	0.00	0.00	2.21	9.94	26.52	32.60	18.23	9.94	0.00	**87.29**
TRNE321	1.66	0.00	0.00	0.55	7.18	22.65	35.91	23.20	7.73	1.10	**90.61**
TRNE331	0.00	0.00	0.00	0.00	0.00	17.13	58.01	16.57	7.18	1.10	**100.00**
WTRE311	0.55	0.00	0.00	0.00	1.66	38.12	41.99	14.92	2.76	0.00	**97.79**
WTRE321	0.00	0.00	0.00	1.66	6.08	42.54	34.25	13.26	2.21	0.00	**92.27**
WTRE333	0.00	0.00	0.00	0.00	0.00	20.44	46.96	29.28	3.31	0.00	**100.00**

These success rates can be illustrated graphically as shown in Figure 8 below.

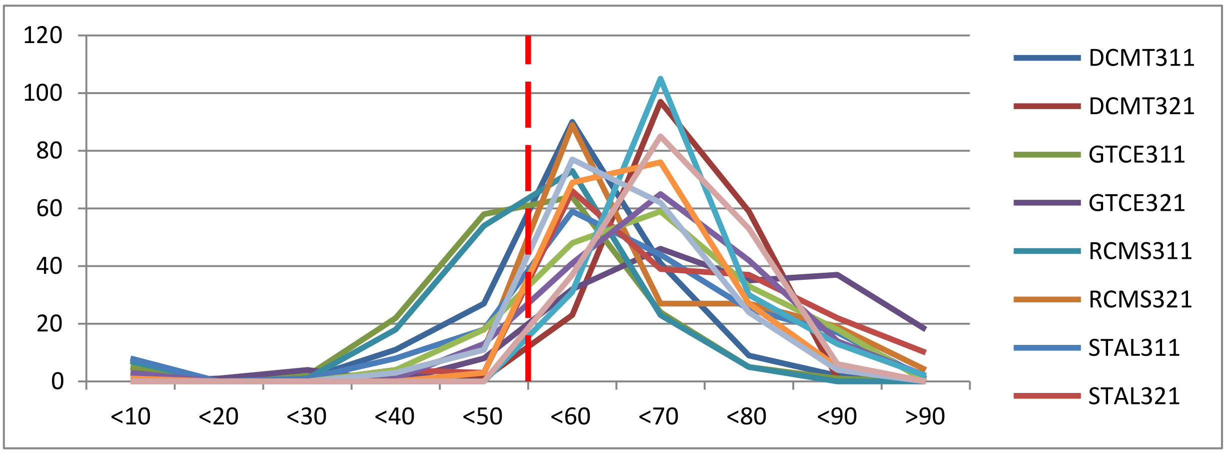

Figure 5. Frequency Distribution Curves for Pass Rates of S4 Modules

There are two modules which have a poor success rate, namely Geotechnical Engineering III Module 1 (GTCE311) and Reinforced Concrete & Masonry Design III Module 1 (RCMS311). Further detailed analysis of these two modules will be required in future research to determine the reasons for the poor performance by students.

Since all students studying the National Diploma Engineering Civil on the Pietermaritzburg Campus are compelled to undertake at least six months experiential learning prior to registering for S4, it has not been possible to compare the average results of this cohort study against a cohort that progressed directly to the S4 semester without undertaking experiential learning. The Durban Campus has recently revised their rules to allow this option for selected students, on academic merit. The first cohort of eight students will only complete their S4 studies at the end of the First Semester 2013. This research study will need to be reviewed once a sufficiently large cohort of Durban students has completed the qualification to see whether there is an significant difference between these students and those who were compelled to undertake experiential learning prior to S4..

Conclusion

Although this research has examined the academic performance of students before and after undertaking the compulsory minimum six months of experiential learning, it is acknowledged that there may well be many other contributing factors, like maturity and a better understanding of how to cope with tertiary education. Nonetheless, the statistical data supports the notion that weaker students in particular perform better academically after experiential learning, whilst those who were already performing adequately drop off slightly although they improve the average time taken to complete the component of study. The study is not conclusive, but has highlighted areas for further research to continue to strive for improved student performance.

Acknowledgement

The author would like to acknowledge the assistance of Mrs Lida de Villiers in conducting the statistical analysis of the research data.

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