Electrical Engineering Programme Based on Vocational School

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Abstract *— In 2002 Telemark University College (TUC) took advantage of vocational school reforms to establish a three years bachelor programme in electrical engineering for two pilot classes. The radical change in this programme is the reduction from four to three years without reducing the theoretical level. The students of these classes, all holding at least one relevant trade certificate, were presented a redesigned programme intended to produce an output engineer 'at least as good as' the engineer graduating from an ordinary programme. In order to verify this hypothesis all exam results from the academic years 2002 -2004 were carefully investigated. The sensational result of this investigation was that both the average grade and the percentage of passing the exams in the pilot classes were significantly better than student groups recruited the ordinary way concerning the first pilot class. The second pilot class showed satisfactory results but now the difference with the ordinary classes was not so clear. It is supposed that the students from vocational school are higher motivated, but the Hawthorne effect, describing that if participants know they are part of an experiment it will lead to improved efforts of the people involved, cannot be neglected. These pilot bachelor students which will be graduated in 2005 and 2006 are supposed to be well accepted by the employers, since several of the main employers' federations is supporting and quality assuring this new programme.*

Index Terms *— equivalence, bachelor, passing ratio, grade point ratio*

1. INTRODUCTION

The enrolment of students has for the past decade been declining both at Telemark University College (TUC) and in Norway in general. In addition the percentage of the enrolled students passing the exams has decreased from approximately 90 % to 60 %. Several employer's federations have registrated that both the amount of new engineering graduates and the quality of them have been reduced in this period. In 2002 TUC finally succeeded to commence a new bachelor programme based solely on vocational school in electrical, electronical, and control profession, [1]. One strong limitation is that each student must have at least one relevant trade certificate. The students from vocational school have for the past 30-40 years needed a scientific pre-engieering year in order to be adjusted to the standard engineering programme. Since 1994 the quality of vocational school in Norway has been increased by a large reform from the Ministry of Education and Research (UFD). Thus the time was mature to establish a new three year bachelor programme to replace the four year programme (i.e. one plus three years), [1,2].

The crucial idea with this new programme is to acknowledge the vocational school to be equivalent to the theoretical senior high school with respect to higher technical education. To realise this idea the vocational programme (VOC) and ordinary senior high school programme (ORD) must be different in the beginning. Some introductory courses (e.g. DC fundamentals, digital theory, analog theory) is replaced by elementary mathematichs, physics, written communication in the VOC programme, [3]. The VOC programme is temporarly permitted by UFD and will be scrutinized at least to 2006 before permanent permission will be given. This paper will focus on the achieved results the VOC students have produced since 2002 with a thorough comparison with the ORD students.

2. ENTERING TESTS OF THE NEW STUDENTS

Test 1 was given in 'engineering mathematics', where a standard test was used. Entering freshmen with background from senior high school's general (not scientific) departments to a scientific pre-engineering year (PRE) and ordinary freshmen (FRESH) with a strong background in mathematics and physics were used as reference groups.

Test 2 concerned digital engineering fundamentals. Here it made no sense using other freshman students as a reference group, since they had no background in digital theory. In stead, TUC's own sophomore class (SOPH) was used, as digital fundamentals is a TUC freshman course.

Test 3 intended to check the status of the level of electrical engineering (EE) fundamentals. Even in this case TUC had to use its own sophomore students as a reference, since electrical engineering fundamentals is a TUC freshman course. The results are shown in Table I.

TABLE I
ENTERING TESTS OF DIFFERENT GROUPS OF STUDENTS, AVERAGE VALUES 2003. (IN PARENTHESIS THE RESULTS FROM 2002, [1].)

	Subject	VOC	PRE	FRESH	SOPH
1	Mathematics	43 (40)	34 (33)	51 (53)	
2	Digital fund.	7.8 (16)			52 (47)
3	EE fund.	55 (57)			54 (48)
	No of stud.	45 (35)	68 (22)	119 (57)	30 (31)

By inspecting Table I, it is evident that no group performed really well with respect to the maximum score (100). It should be remembered, though, that these tests came unprepared to all groups. However, Test 1 in mathematics shows the interesting result that the VOC-group scored better than the PRE-group.

In Test 2 (digital fundamentals), the TUC sophomores performed much better than the VOC group. However, several VOC-students remarked that this course was taught early in vocational school, and in details much forgotten since the material had not been practiced.

Test 3 on EE fundamentals gave the surprising result that the VOC group performed slightly better than the SOPH group.

3. QUALITY REFORM AND STATISTICS

From August 2003 the Quality Reform was introduced to all higher education in Norway. The reform consists of many topics [4], but concerning our new engineering programme the most important are: i) Grading by use of a letter scale from A till F. ii) The financing system is based on how many students that are 'producing' credits. iii) All universities and colleges must have a quality assurance system.

Until August 2003 the grading system was 1.0 till 6.0 with 1.0 as the highest grade and 4.0 as the lowest passing grade. The new letter grading system is an adaptation to the European grading system with E as the lowest passing grade. In order to increase the quality assurance of our engineering programme, thorough statistics of each student seem to be necessary. Equations (1) and (2) is derived to give exact quantitative statistics on the passing ratio (pass ratio) and the grade point average (GPR). It is important to increase the pass ratio since higher pass ratio will increase the financial support from UFD. More than 90 % of all universities and colleges in Norway are own by the State and free of charge for all students. The grade point average (GPR) is calculated using the transforming A=5, B=4, ..., F=0.

$$pass\ \ ratio = \frac{\sum_{i=subject.1}^{subject.n} stud.i \cdot \#credit.i}{\frac{60}{\#stud.recorded}} \qquad (1)$$

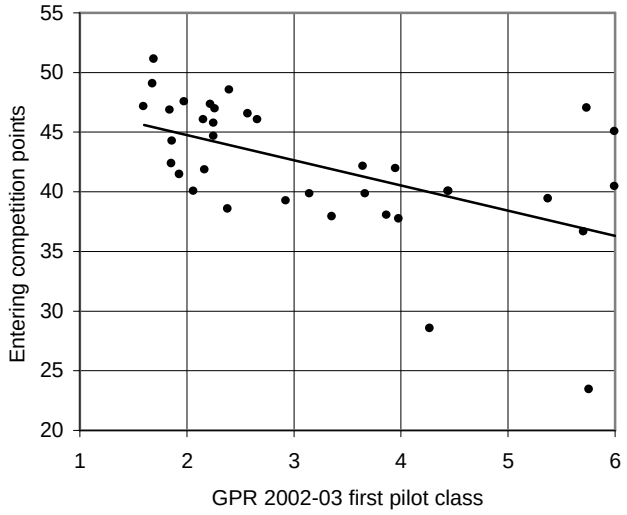
$$GPR = \frac{\sum_{i=subject.1}^{subject.n} average\_grade.i \cdot credit.i}{\#credit} \qquad (2)$$

stud.i = No of students passing subject no *i*
stud.recorded = No. of students recorded at TUC on October 1
credit.i = No of credits of subject no *i*
#credit = No of credits

4. RESULTS FROM THE VOCATIONAL STUDENT CLASSES

The first pilot class commenced in 2002 with 36 students. The number of applicants was 51 and all of them were accepted. Each student's entering competition points was calculated based on the grades from vocational school. The maximum possible entering competition points was 60 points in 2002. Figure 1 shows the results of each student. Failing and no show up are transformed to 6 for statistical reasons. The correlation line shows a 'medium' correlation of -0.54. In reality the correlation is positive, but due to the old grade scale the number turns out negative. 8 of 36 students achieve a GPR of better than 2.0 (very good). Also 8 of 36 students achieved a GPR worse than 4.0 (failed). Scrutinizing the failing students we find that 5 of them have good or very good entering competition points.

FIGURE. 1
CORRELATION BETWEEN COMPETITION POINTS FROM VOCATIONAL SCHOOL AND GPR OF THE FIRST PILOT CLASS IN 2002-03. EACH DOT SHOWS THE GPR OF EACH STUDENT.



In 2003 the second pilot class commenced with 46 students. Due to good marketing by the employers federations, see acknowledgement, the new programme was now quite popular with 128 applicants. Now we introduced a lower limit of entering competition points. In Figure 2 the results of the second pilot class is shown. Failing and no show up are now transformed to 0 for statistical reasons. The maximum possible entering competition points was 66.6 points in 2003. The correlation line shows a 'weak' correlation of 0.24, which is surprising. 2 of 46 students achieved a GPR of better than 4 (B), and 11 of 46 students achieved a GPR worse than 1 (E), i.e. failed.

FIGURE. 2
CORRELATION BETWEEN COMPETITION POINT FROM VOCATIONAL SCHOOL AND GPR OF THE SECOND PILOT CLASS IN 2003/04.

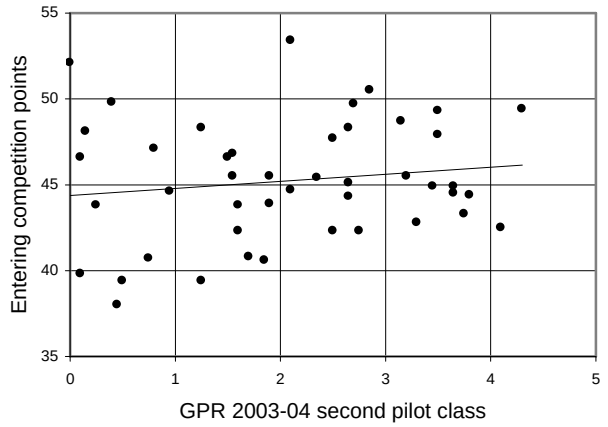
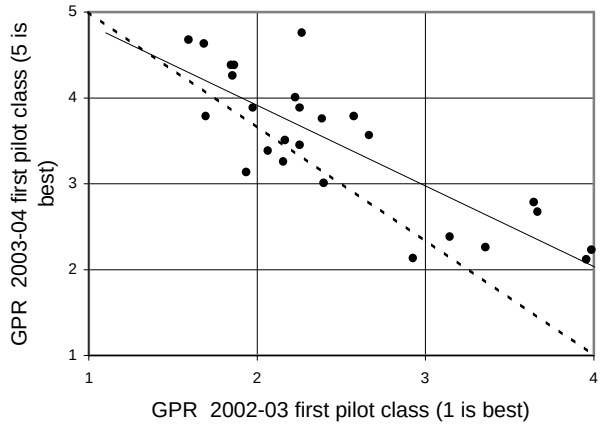


Figure 3 show the progress of 26 remaining students in the first pilot class from 2002 to 2004. The dotted line represents a quantitative conversion between the old grade scale (abscissa) and the new grade scale (ordinate). 20 of 26 students lies above the dotted line indicating better GPR in the second year of study compared with the GPR in the first year. The correlation is -0.82, which indicate a 'strong' positive correlation between the first and second year of the bachelor programme.

FIGURE. 3
CORRELATION BETWEEN FIRST YEAR OF STUDY AND SECOND YEAR OF STUDY CONCERNING THE FIRST PILOT CLASS.



5. COMPARISON BETWEEN VOCATIONAL AND ORDINARY STUDENT CLASSES

Table II shows the comparison of both passing ratio and total GPR of all VOC and ORD students using (1) and (2). Details from each subject are shown in [2] concluding that in all comparable subjects (24 of 60 credits) both the passing ratio and GPR was better for the VOC students. The preliminary conclusion was therefore that the vocational pilot class was a success. In Figure 1 22 % of the VOC students had a GPR characterized as 'very good' while among the ordinary students only 7 of 102 (6.9 %) achieved the same result.

TABLE II
RESULTS FROM THE FIRST PILOT CLASS (VOC) VERSUS ORDINARY STUDENTS 2002-03.

	VOC	ORD
No of students recorded	36	102
Passing ratio	78 %	72 %
GPR (1 is best)	2.45	2.76

In Table III the results from 2003-04 show a more balanced view between the VOC and ORD students. The passing ratio is surprisingly constant (78 and 77 %) concerning the VOC pilot classes, while it is slightly reduced among the ORD students. Both groups of students have GPR at C-, but now the VOC pilot class is weaker than the ORD class.

TABLE III
RESULTS FROM THE SECOND PILOT CLASS (VOC) VERSUS ORDINARY STUDENTS 2003-04.

	VOC	ORD
No of students recorded	46	102
Passing ratio	77 %	68 %
GPR (5 is best)	2.61 (C-)	2.77 (C-)

The GPR of the VOC students is based on the detailed results shown in Table IV. In 4 of 5 comparable subjects the VOC students are better than the ORD students. In Chemistry the VOC grades was very weak. An analysis of Chemistry in the vocational school exposed a lack of fundamental Chemistry in the vocational curriculum. By doing this statistical analysis it is now easier to expose bad adjustment between vocational school and the new bachelor programme. In autumn 2004 the third VOC pilot class will therefore meet a more adjusted teaching in Chemistry.

In Table I the VOC students failed in the entering test of digital fundamentals. Due to this fact extra lectures (6 x 45 min.) were introduced enabling the VOC students to follow the sophomore subject programmable electronic circuits. The good result of this initiative is shown in the first line of Table IV showing that the VOC students performed better than the ORD students on the final exam.

TABLE IV
RESULTS FROM THE SECOND PILOT CLASS (VOC) VERSUS ORDINARY STUDENTS 2003-04.

Subject	Credits	VOC	ORD
Programmable Electronic Circuits	6	2.74 (C-)	2.26 (D+)
Chemistry	9*	1.62 (D-)	2.30 (D+)
Introduction to Programming	3	3.74 (B-)	3.38 (C+)
Theory of Electricity I	3/6**	2.91 (C)	2.57 (C-)
Business Economy, an Introduction	6	2.79 (C)	2.75 (C)
Mathematics Introductory I	9	2.20 (D+)	
Mathematics Introductory II	12	2.66 (C-)	
Communication and Project	12	3.11 (C)	

* 6 of 9 credits are identical
** VOC students have 3 credits while ORD students have 6 credits

In Table II the first VOC pilot class showed surprisingly good results. This good trend is even enhanced during the second year as shown in Table V. In all comparable subject but one, the VOC students were better than the ORD students.

TABLE V
RESULTS FROM THE FIRST PILOT CLASS (VOC) VERSUS ORDINARY STUDENTS 2003-04. SECOND YEAR OF BACHELOR PROGRAMME.

Subject	Credits	VOC	ORD
Linear systems	6	4.44 (B+)	3.95 (B)
Theory of Electricity II	6	3.76 (B)	2.36 (D+)
Organisations and Leadership	6	3.38 (C+)	3.13 (C)
Mathematical Methods I with Maple	6	3.35 (C+)	2.57 (C-)
Object-based Programming in Delphi	6	3.08 (C)	3.09 (C)
Linear Algebra	6	2.45 (D+)	1.79 (D)
Physics	6	2.81 (C)	2.26 (D+)
Electrical Machinery	9	3.80 (B)	2.78 (C)
Control theory	6	4.11 (B)	3.14 (C)

The GPR presented in Tables II-V are based on passing grades only.

There are four main explanations on why the VOC students are doing so well at TUC even though the bachelor programme is reduced from four to three year. i) The vocational students have learnt elementary electricity, electronics, and control in the practical way. ii) To gain a trade certificate in Norway the vocational students must have 1-2.5 years of practical training in a relevant company after two years of vocational school. During this practical training the students reach important experience and get paid. It is supposed that a trade certificate holder who is quitting a job with relatively good salary is highly motivated for higher education (in Norway the difference in average salary between trade certificate holders and fresh engineers is small). iii) The entering competition point of VOC group is slightly higher than from the ORD group. iv) The well-known Hawthorne effect, [5], describes that if participants know they are part of an experiment it will lead to improved efforts of the people involved. Time will show how much impact this effect has.

6. CONCLUSIONS

The vocational pilot classes show a higher passing ratio than the ordinary classes.

The vocational pilot class' GPR was better in 2003, while worse in 2004. However, the second vocational class had weaker GPR in only 1 of 5 comparable subjects. The results from the two first pilot classes indicate that vocational students will be 'as good as' or better engineers than the ordinary students.

To be currently updated on the grades and passing ratio in each subject help the coordinator and teachers to be more prepared to give optimal teaching.

7. ACKNOWLEDGEMENT

This new bachelor programme would not have commenced without financial support from the Electrical Contractors Association of Norway (TELFO), the Federation of Norwegian Manufacturing Industries (TBL), Norwegian Electricity Industry Association (EBL), the Defense represented by the Air Force (FLO), the Electrical Industry Developing Centre (ELBUS), the Confederation of Norwegian Business and Industry (NHO), and Federation of Norwegian Process Industries (PIL).

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