

Recruiting competence from vocational schools - Paradise Regained?

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ABSTRACT: After a period of declining student enrolment, in 2002 Telemark University College (TUC) took advantage of vocational schools reforms to establish a three years bachelor programme in electrical engineering for a pilot class. The students of this class, 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. After having evaluated and assessed the programme as well as student performance during, and after the first year of the pilot class, there are indications that the pilot class performs better than student groups recruited the ordinary way. However, there are still two more years to go before the title's rhetoric question "Paradise Regained?" finally and tentatively may be answered with a firm "yes".

INTRODUCTION

For about 30 years users of graduates from engineering colleges and universities have complained that the educational programmes have been too theoretical after the requirement of practical experience in front of engineering studies had been removed. It has been claimed that this resulted in engineers without technical hands-on experience in addition to a profound lack of understanding for the organisational, social and psychological climate they met at their future workplaces.

After 25-years of reform, under The Law of Training, the vocational school, like all secondary school programmes, lasts for three years. In general, the vocational school programmes lead to a trade certificate in addition to a broad-scoped theoretical education, directed toward the needs of the technically literacy required by today's industry and businesses [1].

Due to the positive effects of these reforms, Telemark University College in 2002 commenced a pilot project on admitting vocational school graduates, holding a relevant trade certificate, to a redesigned three years engineering programme, leading to a bachelor's degree in electrical engineering.

This paper will shortly describe which structural and curricular changes that were made, the quality assurance programme - and the first year evaluation and assessment.

THE FUNDAMENTAL PRINCIPLES

Admitting vocational school graduates to engineering education, in some ways represents unusual ways of thinking [1]:

- acknowledging vocational school equivalence with respect to higher technical education admission
- acknowledging that the university level *together with* previous schools and the users of engineers are formulating the premises
- realising that a "credit hour" represents an amount of student work on premises given by the academia; it's not related to the factual course content
- accepting evaluation and assessment

In short, TUC's role as a listening, responsive "tool" to reach political, professional, and personal goals are accepted.

CURRICULAR CHANGES

The ordinary educational programme has been designed to meet the needs created by an entering student body which is highly proficient in certain theoretical fields but almost technically illiterate. Because of this, the first TUC year, in particular, has to offer technical courses to compensate for this shortage.

On the other side, the pilot class recruits students with a very solid and detailed practical *as well as* theoretical technical background. Simultaneously, their general theoretical level has been elevated, thanks to the national reform programme starting in 1974. Thus, it was possible to interchange one semester "ordinary" program containing elementary technical subjects, with the new one, emphasising liberal arts, languages, etc.

THE QUALITY ASSURANCE PROGRAMME

This programme consists of three parts, 1) the scientific evaluation by presenting papers for international conferences on engineering education and articles in international journals on engineering education, 2) an external, peer evaluation of the project with respect to pedagogical and methodical aspects, and 3) the Project Board.

The Project Board consists of the TUC rector, the TUC engineering faculty's project leader and representatives from external partners. These are 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, and the superintendent of Telemark primary and secondary schools.

Except for the superintendent, all Project Board members, in addition to the Ministry, have supported the pilot project economically. The underlying reason for their support, is their explicit hope that the project may help designing the engineering education programs of tomorrow.

Thus, these stakeholders represent almost every industry enterprise and every power company of the country, their employers' federations plus the public school system. Thus, representing about 2000 companies and their federations, the Project Board introduces new ways of customer/academia cooperation in Norway.

The Project Board acts as a forum for the dissemination of educational ideas, for offering of constructive criticism and encouragement, for maintaining direct links to the Ministry and Parliament committees, and help marketing and network building.

EVALUATION AND ASSESSMENT

First, as a part of the assessment program, a series of "surprise tests" were conducted a couple of weeks after the autumn semester start, 2002. The results indicated that 1) the pilot class performed well compared to the reference groups, and 2) some TUC educational programme changes were required for better matching to this group's factual standing in electrical and digital fundamentals [1].

After the first year of operation, the final exams were specially designed to enable an "ordinary" and "vocational" student group comparison. In the following paragraphs, the results as well as retention-related data will be tabulated and discussed.

The first, identical exam in Programmable electronics was held on October 26, 2002. The two groups were mixed so that the censors could not know to which group the candidate, represented by a student number, belonged. The results are shown in Table 1. "Ord" and "Voc" stands for ordinary and vocational students, respectively. It should be noted that "Ord" refers to the total entering class student body in tables 2, 3, 4, 5, 6, 7. In tables 1, 8, 9, 10, the electrical engineering class served as the "Ord" reference group.

For all tables, 1.0 is best and 4.0 is lowest passing grade.

Table 1: Programmable electronics exam results

Class	No show up	Fail number	Pass number	Average grade
Voc	1	4	31	2.60
Ord	3	4	31	2.80

It can be seen that that the Voc-group performed slightly better than the ordinary student reference group.

The exams in Chemistry/Physics I and Chemistry/Environment were given on December 11, 2002. The chemistry part, (67% of the total exam), was identical to all students. The second part was tailored to the different programmes which had been given the two goups. The results are listed in Table 2. In Table 3 data on group size and pass/fail can be found.

Table 2: Chemistry/Physics I & Chemistry/Environment exam results

Class	No show up	Fail number	Pass number	Average grade
Voc	3	6	27	2.54
Ord	7	28	90	2.86

Table 3: Group statistics

Class	Total group size	No show up (%)	Fail (%)	Pass (%)
Voc	36	8.3	16.7	75
Ord	125	5.6	22.4	72
All	161	6.2	21.1	72.7

In this case, all first year Ord students comprise the reference group. However, it should be noted that the courses that were given the two groups were not identical. Nevertheless, this table tends to confirm the impression that the Voc-students even in this fundamental course obtained the best results. Table 3 indicates that student retention for the Voc group may be better.

In May 2003 final exams were given all first year students in Information Technology (IT) (tables 4 and 5) and Business Economics (BE) (tables 6 and 7). In IT and BE, all students followed the same classes. Neither in these cases, the censors could know to which group the candidates belonged.

Information Technology data:

Table 4: Information Technology (IT) exam results

Class	No show up	Fail number	Pass number	Average grade
Voc	2	4	27	1.81
Ord	26	15	76	2.42

Table 5: IT Group statistics

Class	Total group size	No show up (%)	Fail (%)	Pass (%)
Voc	33	6.1	12.1	81.8
Ord	117	22.2	12.8	65.0
All	150	18.7	12.7	68.7

These tables indicate a significantly better Voc-group academic performance. Also the retention is better.

Business Economics data:

Tables 6 and 7 tend to confirm the impression that the Voc-group are *at least* at the same academic level as the Ord-group, which is officially believed to represent the best source for engineering recruitment:

Table 6: Business economics (BE) exam results

Class	No show up	Fail number	Pass number	Average grade
Voc	1	0	33	2.37
Ord	6	0	84	2.45

Table 7: BE Group statistics

Class	Total group size	No show up (%)	Fail (%)	Pass (%)
Voc	34	2.9	0	97.1
Ord	90	6.7	0	93.3
All	124	5.6	0	94.4

In the two semester course Theory of Electricity I, TUC took advantage of the significant theoretical and practical insight provided by the Voc-group's vocational school bacground. Thus, the two groups followed the same class only the spring semester. The final exams were not identical but represented equivalency with respect to abstraction level. The results are presented in tables 8 and 9:

Table 8: Theory of Electricity I exam results

Class	No show up	Fail number	Pass number	Average grade
Voc	2	5	25	2.31
Ord	6	4	35	3.07

Table 9: Group statistics

Class	Total group size	No show up (%)	Fail (%)	Pass (%)
Voc	32	6.3	15.6	78.1
Ord	45	13.3	8.9	77.7
All	77	10.4	8.9	77.9

Academically regarded, it can again be stated that the Ord-group is significally outperformed by the Voc students. Table 9 shows, not surprisingly, that the rate of passing grades for both groups improves due to the reduction of group size. Namely, at this point some of the least motivated students have dropped out of both groups.

As an important part of the pilot project, new courses in mathematics and communication/project work were designed, so that the total number of academic credit points required for graduation should be equal for the two groups. Table 10 lists the final exam (May 9, 2003) results for the pilot class (Voc-group) - no reference group existed since these exams were related to the specially designed courses mentioned above.

Table 10: Mathematics for electrical engineers (EE) I and II & Communication/ProjectWork final exams results

Course	No show up	Fail	Pass	Average grade
Math. for EE I	3	2	31	2.39
Math. for EE II	3	5	24	2.53
Commun./Project	3	2	28	2.51

In the 1.0 - 6.0 with 4.0 as the lowest passing grade, these average results may be labeled as "satisfactory to good".

WHO ARE THE "VOCATIONAL" STUDENTS?

To answer this question, the pilot class students of 36 were tabulated with respect to their vocational school final grades in selected courses, the results are shown in Table 11. They are between 37 and 18 years of age; the typical student was about 22 years old when classes started in August, 2002. They hold 11 different trade certificates within a variety of electrical, automation, and electronic trades. Thanks to the vocational school's use of interdisciplinary learning programmes, it has been possible to consider them as a fairly homogeneous group.

Table 11: Voc-group vocational school grades and relevant practical experience

Course	Best grade	Group average
Basic mathematics	6	4.47
Basic science	6	4.21
Technical sequence	6	4.13
Interdisciplinary exam	6	4.03
Relevant practice after the issue of trade certificate		33 months; averaged by 19 students

It can be seen that the group 's grades range well above average, (lowest passing grade is 2) and that over 50% of students have almost three years of "hands-on" experience before entering the engineering college of TUC. Data taken for the entering 2003 class confirms the impression that the pilot class may offer an attractive opportunity for young people combining excellent theoretical abilities with significant practical experience in their chosen fields.

It has often been claimed that it is not necessarily so, that good grades from previous schools signal good results even in succeeding schools like e.g. universities and colleges. This kind of finding has also been proposed for the Voc-group. Thus, the correlation between vocational school grades/competition points and average semester grade-point ratio (GPR) after the first academic year at TUC has been investigated.

The competition points are composed of the average vocational school grades multiplied by 10. In addition, extra points are given for:

- Relevant practice: 0.1 pt./month; max. 6 pts.
- Females: 2 pts.
- Extra certificate: 1 pt.

Maximum obtainable competition points then amounts to 66.6.

The semester GPR is defined as course grade multiplied with course credits divided by the sum of credits for the courses taken that particular semester. In the TUC grading system, then, a GPR of 1.0 is the highest obtainable.

The results are presented in Fig.1:

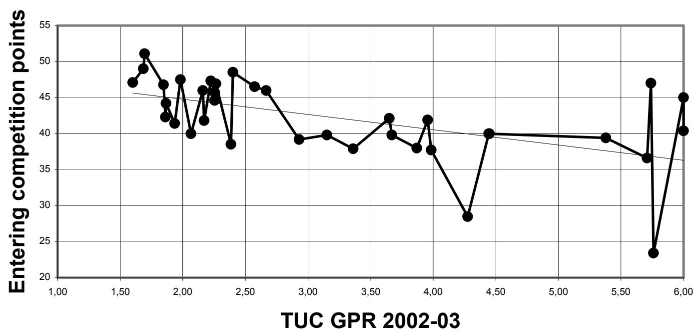

Fig. 1: Correlation between competition points and TUC GPR

This figure shows that 8 candidates obtained 2.0 or better (excellent). 10 students performed "good" (2.1 - 2.5), 10 "ordinary" (2.6 - 4.0) and the remaining 8 students failed.

DISCUSSION

Test results during and after the first year of the pilot class tend to confirm the supposition that the modernised vocational school could emerge as the most important recruitment source for recruiting engineers. The pilot group's academic results are good, sometimes excellent - and for all tests better than the reference groups.

Referring to Fig. 1, it should be pointed out that this pilot class was recruited "in the last moment", meaning that the deadline for ordinary applications had expired. Furthermore, many of the presumed "best" vocational school graduates had already been hired by their employers. Consequently, TUC had to consider *all* applicants eligible, constrained to the absolute requirement of holding a relevant trade certificate.

Based on such facts, the test results on theoretical subjects may be labeled very satisfactory. The explanation, based on teacher observations, could be maturity, self discipline, better structuring of their days and higher motivation. In this case *age* cannot explain the success, as the ordinary student group are about the same age.

However, there is even another dimension added to the story.

In the seventies, the demand for one year's practical work as an admission prerequisite for admission was removed. The following years "saw" a current of students without hands-on experience flow into the engineering school system. In addition, this was the period of quick tedious and difficult intellectual work automation. Accordingly, the educational keyword was "analysis".

Time has shown that global processes have now led to a specialisation with respect to production sites and goods. As one of the consequenses, general emphasis moves from "analysis" via "process", "system thinking", "design", liberal arts to "integration". Thus, the keywords of today's engineering education at the bachelor level include learning processes, paradigm shift and facilitator, the latter representing an apt description of the teacher role change.

In other words, "integration" could also mean the return of the engineer, combining hands-on experience with a technical education at the bachelor level or higher. This aspect of the TUC pilot class remain to be researched.

To TUC, this pilot class has until now added an valuable opportunity for taking reflected steps into the future.

First, the internal project organisation seems to have created many *owners,* ready to defend and further develop the program.

Second, an internal environment of self evaluation and criticism is being established. Thus, project evaluation has already led to adjustments in the pilot project programme.

Third, an internal culture of scientifically controlled "cut and try" culture appears to emerge.

Fourth, channels are opened up to facilitate better direct communication between regional secondary schools and TUC. For example, a signal has been sent to regional vocational schools that knowledge of logarithmic functions are essential to engineering.

Fifth, indications exist, that direct links and networks between organisations, federations, regional businesses and TUC now develop quickly.

Sixth, a tentative successful pilot project may restore hand and brain integration in the educational system - but in another and more systematic fashion than before.

CONCLUSION

So far, the academic results have been encouraging, referred to "absolute" grading standards as well as ordinary classes.

In the 17th century John Milton's (1608-74) wrote his famous poem "Paradise Regained". This title could aptly reflect the optimistic attitude of today's Telemark University College. The question may be asked, then, if such optimism is realistic.

Obviously, the answer cannot be a pungent "yes".

BUT, it may cautiously be stated that indications now exist that the former requirement of practical experience may be restored in a better structured way than ever before. Consequently, the pilot project stakeholders now find it realistic to express optimistic expectations for the country's engineering future.

REFERENCE

1. Clausen, T., Hagen, S. T., Hasleberg, H., and Aarnes, J. H., Recruiting engineering students from vocational schools. *Proc. 6th UICEE Inter. Conf. on Engng. Educ.,* Cairns, Queensland, Australia (2003)