Recruiting engineering students from vocational schools

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ABSTRACT: By the consent of the Norwegian Ministry of Education and Research, Telemark University College (TUC), Porsgrunn, Norway, this fall semester started a pilot class in electrical engineering recruiting solely from vocational schools. Important changes in technology and society, including the educational system, began and nourished the work. The preparation process formally commenced in August 1995 and has included educational, psychological, tactical and organisational means to attain the goal. Results from tests given to 36 entering freshmen of this class are presented and discussed in the paper. Project organisation and test results indicate that today's vocational schools may represent a future sector for the recruitment of new students into the engineering profession.

INTRODUCTION

Like other industrialised countries, Norway has experienced important changes over the last 20-25 years. The national marketplace has been replaced by an environment that is much more focused on global competition, forcing major companies either out of business or into frequent processes of reorganisation.

With media focus on problems rather than visions, this situation may have generated frustration and a lack of confidence in the engineering profession. On the other hand, a growing industry dedicated to serving new needs in national and international markets now seeks engineers that can fill more broadly-scoped positions than before.

From an engineering schools' point of view, these past few years have seen a decline in student enrolments – some claim even in quality. Simultaneously, trade and vocational schools have, since about 1980, been constantly developed to serve the needs of a rapidly changing industry. In some trades, these changes have led to the issuing of trade certificates based on skills that resemble elementary engineering education. Most of these changes have gone unnoticed by engineering schools, which have stuck to former definitions of what engineering culture, quality and level are really about.

After more than six years of effort, the Faculty of Engineering at Telemark University College (TUC), Porsgrunn, Norway, succeeded this year in convincing the Norwegian Ministry of Education and Research that including a trade certificate in a vocational school's examination could be a future source for the recruitment of engineering students. As the country's only engineering school, TUC now has the Ministry's permission to run a test project in electrical engineering recruiting from vocational schools.

This paper will outline and discuss the evolving changes in the educational system, as well as in student enrolments, which have led to this pilot class, in which 100% of the students hold trade certificates related to electrical, electronic, control and process-technical engineering.

PAPER OVERVIEW

Important factors that have forced this project include:

- General issues underlying international debates.
- Many years of experience with students holding trade certificates.
- The results of local investigations.
- Several consequences from the Law of Training.
- Two major educational reforms at the turn of the century.

As well as a brief discussion of these elements and their consequences, the paper will conclude with a presentation of the pilot class's organisation and some test results ahead of the start of their first semester at TUC.

GENERAL ISSUES UNDERLYING INTERNATIONAL DEBATES

Almost all people today are subjected to technology in some form. Thus, it can be stated that technology, as a universal expression of culture, is now common to most civilisations. Thanks to rapid means of travelling and modern electronic communication systems, this means that changes in this common culture spread rapidly with major adverse consequences for those communities that do not respond adequately to these challenges.

One major consequence of a long period of technical development is the maturing of a series of *difficult* technologies

into an easily usable product. For engineering education at the fundamental bachelor level this irrevocably leads to a change of focus (paradigm shift) from teaching to learning. Consequences of this paradigm shift include:

- The need for vertical contact and cooperation in the educational system.
- State of the art *quality* debates will, for the bachelor level, concentrate on pedagogical and structural issues rather than cutting edge technology.

These elements are of paramount importance for the conception, planning and implementation of the vocational school recruitment project.

MANY YEARS OF EXPERIENCE WITH STUDENTS HOLDING TRADE CERTIFICATES

Historically, TUC is a continuation of an engineering school that was founded in 1884 to meet the educational requirements of that time. Like other schools, the present TUC has adjusted according to technological and political changes. For many years, elements of today's vocational schools were important parts of the educational programme.

More recently, TUC also helped to administrate some vocational classes, partly using its own faculty as teachers. Thus, several TUC professors know well today's vocational school and its student body.

THE RESULTS OF LOCAL INVESTIGATIONS

In 1995, TUC members of the Norwegian Society of Chartered Engineers (NIF) decided to prepare the College for experimenting with the rules of admission. As the Norwegian educational system is highly centralised, even at the university and college level, a long-lasting process was anticipated. For this reason, and spurred by the unique industrial structure of Lower Telemark, a local research programme was immediately started to provide background material for TUC's application to the Ministry.

This research programme included:

- The relationship between introductory mathematics and engineering mathematics used as tools to serve main technical courses [1].
- Local small and medium-sized industry's need for engineers and cooperative programmes with TUC [2][3].

The results indicated that relatively small level of coherence was found between introductory mathematics and mathematics as an engineering tool. These findings, among others, led to the assumption that the *new* vocational school might be a future source of recruitment, provided that a change of content, scope and pedagogy of introductory mathematics courses took place.

Local industry leaders were surprisingly unanimous in expressing an increasing demand for engineers holding one or more trade certificates. Furthermore, they described the engineer's role of tomorrow as partly technical (30-50%), partly organisational and partly leadership. These results were found to be in harmony with trends in the international debate on engineering education.

THE LAW OF TRAINING: INCREASED FOCUS

All secondary education in Norway is governed by the Law of Training, which states in Section 2 that it shall ... *promote scientific way of thinking and way of working*. As such, this injunction is also imposed on vocational schools.

Taking this seriously has been a major prerequisite for the political and practical preparation of the pilot class. This meant that TUC's attitude, educational programme and curriculum had to be redesigned and continuously adjusted through the four-year test period. The TUC educational goal of producing graduates at an internationally recognised quality standard, including preparation for advanced studies, remains the same. However, in addition, this new generation of engineers will also hold one or more relevant trade certificates.

THE LAW OF TRAINING: THE SILENT REVOLUTION

The first modern programme for vocational training in Norway dates back to 1979 with the new educational programme and trade certificate for chemical-process technicians. In form and content, this programme at the secondary level included elements such as laboratory work, a considerable amount of mathematics, languages, chemistry plus others. Similar programmes for the training of automation, electrical and electronics technicians, followed in the years after 1989.

To train these classes at the practical and academic level required by the internationally exposed parts of Norwegian industry, a new stock of teachers had to partly replace existing traditional vocational school teachers. Over about 25 years, the vocational school system engaged teachers with academic degrees in engineering, mathematics, physics and social sciences, in addition to the workers holding their trade certificates. A silent revolution has taken place, almost unnoticed by academia.

THE LAW OF TRAINING: EQUIVALENCE

An important consequence of the two preceding sections covering the impact of the Law of Training is the legal and conceptual equivalence of theoretical and practical training as a base of engineering education.

TUC now offers a three-year study programme for both types of candidates. Most of the material is identical but some introductory courses are not. For instance, fundamental DC and digital theory are taught at vocational school but *not* at theoretically oriented senior high schools. On the other side, the latter offers more mathematics than the former. Thus, by evaluating the content and quality of vocational school course material with respect to prerequisites set by TUC, it was possible to substitute traditional courses with new ones, change the course sequence and so on.

However, the fundamental principle was never at risk: A TUC *credit hour* represents an amount of student work, given on the premises of the engineering college. A *credit hour*, then, *does not* mean course content. Letting the content define what a *credit hour* really means would have jeopardised the project. Namely, this should have meant that TUC has *transferred* vocational school *credits* in electrical and digital engineering fundamentals. Neither the Ministry nor TUC would have accepted this. Instead, TUC's self-evident duty and ability as

being responsible for the design of a broad-scoped fundamental engineering education at the Bachelor level has been emphasised.

TWO MAJOR REFORMS AT THE TURN OF THE CENTURY

In cooperation with the national Labour Organization (LO) and the Confederation of Norwegian Business and Industry (NHO), the Government has worked on the *Competence Reform* [4]. The visions forcing this reform are the results of the open global economic system, of which Norway is a small part. Important elements of this reform are the citizens' legal right to continuous education, more independent and open universities and colleges and the use of modern electronic devices to access education independent of time and space. At present, this reform is at risk due to disagreements on how to finance the project. However, the philosophy underlying this proposed reform has fuelled the pilot work.

In 2001, the *Quality Reform* passed the Legislative Assembly, to be effective in universities and colleges from August 2003 [5]. In some respects, this reform amplifies elements of the *Competence Reform* by making these institutions responsible for doing research – even on educational methods and their results. At TUC, educational research is considered a prerequisite for the pilot project and has been an important element of the planning and approval process.

Most important, these reforms have represented a common platform for forming alliances between nationwide institutions, organisations and TUC.

BUILDING ALLIANCES

In a culture dominated by *quality-thinking* with regard to universities, recruiting engineering students from the vocational school system has been considered a *mission impossible*. Thus, moving people's conception of what *engineering culture*, *academic level*, etc, really means in an era when the paradigm shift is in focus, requires the following key elements:

- *Time*: As already stated, the process was initiated by NIF's group at TUC in 1995. The process of mental preparation started immediately with participation in debates, delivering speeches, making and giving interviews, writing editorials, etc. This process took place in national and regional arenas. Even an international conference on engineering education (*ICEE 2001*) was brought to Norway to speed up national debate on such issues [6].
- *Powerful alliances*: It was initially felt necessary to seek support from professional societies. The Norwegian Association of Electrical Engineers, Norwegian Society for Engineers and Norwegian Society for Chartered Engineers gave an early informal blessing to the work. In 1996, the Engineering College at TUC was formally involved; in 1998, members of the National Assembly were prompted to create political interest in the project. However, the Ministry was, at that time, not ready for the experiment, mainly due to conflicts with some superior national educational principles. Consequently, a 1999 application was turned down. Then, in the year 2000, the Confederation of Norwegian Business and Industry (NHO), through one of its sub-organisations, NELFO, became an active partner. This led to the invitation of TBL, another NHO organisation, to join the project. Through the TBL, the Norwegian Air Force was also linked to the project.

Early in the winter of 2002, the Ministry decided to permit the project to be carried out in electrical engineering, even with explicit financial support. In doing this, the Ministry simultaneously laid the groundwork for the formation of a representative Project Board.

PROJECT ORGANISATION

The pilot project has been organised with a Project Leader, who is also the secretary of the Project Board. Five to six TUC faculty members form the professional *core group*. Further, a Reference Group has been established to spread information to partners with an interest in the project; members of this group may, of course, also take initiatives to influence the work.

The Project Board consists of the TUC Pro-Rector and representatives from organisations contributing NOK 100,000 or more. Among these stakeholders are the NHO. Further, as an important industrial locomotive, the Norwegian Air Force has asked for a seat on the Board. Finally, the Telemark Superintendents for Schools and Training have been invited to establish and anchor two-way vertical contacts at the professional level in the educational system.

THE PILOT CLASS

The Ministry's letter of permission was issued on 9 April 2002 - too late to enable TUC to organise a recruitment offensive towards vocational schools' senior students. This meant that most of TUC's tentative *pilot students* had already made up their minds to pursue other educational or professional goals. Active professionals, working as certified electricians, technicians, operators, etc, were other sources of recruitment. However, these groups would need considerable time to make up their minds to return to school, make some kind of deal with their employer and organise their economic life for three years on loans/lack of income. Thus, even with this group in mind, the Ministry's decision was made unpleasantly late.

Nevertheless, well assisted by NELFO and TBL, TUC received 50 applications from people holding relevant trade certificates on order to organise this extra and relatively large class. Two months after semester start, 36 of these meet regularly in class; it is assumed that the missing 14 applicants were not able to make the necessary practical arrangements.

These 36 students have come from all over the country, representing 15 of 19 counties, holding 12 different certificates. Their average age is 24 years and 14 candidates average 41 months of professional experience. The remaining 22 come directly from vocational schools, signalling a significant possible source of future TUC recruitment.

Their vocational school average grades are listed in Table 1. The highest/lowest grade is 6/0, and the average good student will normally be awarded 4 (no decimals are applied). Mathematics 1 and Science are taught at vocational school freshman level, *Average, all other exams* at the junior level. The bottom row lists the results of a senior class examination, where materials from several courses have been integrated into one examination.

Table 1: Pilot class average senior high school grades.

	No. of Students	Average
Mathematics 1	31	4.5
Science	29	4.2
Average, all other exams	25	4.0
Interdisciplinary exam	34	4.1

Table 1 shows that the average student performed well in senior high school. The number of students in the different rows varies because school reforms over the last 10 years have prescribed different forms of evaluation. As such, the form and content of student transcripts vary slightly.

ENTRY TESTS FOR NEW STUDENTS

To verify the quality of the vocational school and prepare an adjusted engineering educational programme at TUC, the pilot students (Voc) and reference groups were given three unannounced tests during their first week.

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

Test 2 concerned digital engineering fundamentals. It made no sense here to use other freshman students as a reference group, since they had no background in digital theory. Instead, TUC's own sophomore class 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 (Soph) students as a reference, since Electrical Engineering fundamentals is a TUC freshman course. The results are shown in Table 2.

Table 2: Testing entering *vocational* students (average values).

Subject	Max	Voc	Pre	Fresh	Soph
Mathematics	23	9.1	7.5	12.3	
Digital fundamentals	50	7.8			23.4
EE fundamentals	50	28.6			24.2

Table 2 indicates that no group performed really well with respect to the maximum score (Max).

However, Test 1 in mathematics shows an interesting result in that the Voc-group scored better than the Pre-group, but lower than the Fresh-group, coming from the 3-year senior high school programme with a specialisation in mathematics and physics. The low Fresh-group average score of only 12.3 (53.5%) of a maximum of 23 may call for special attention.

In Test 2 (digital fundamentals), the TUC sophomores performed better than the Voc group. However, several Voc-respondents remarked that this course was taught early in vocational school, and many details had been forgotten since the material had not been practiced. Seen from TUC's viewpoint, the Soph average result of about 47 % of maximum score can hardly be labelled satisfactory.

Test 3 on EE fundamentals gave the surprising result that the Voc group performed better than the Soph group. Even this test may represent a TUC disappointment with respect to the attainment of specified learning goals.

However, it should be remembered that these tests came unprepared to *all* groups. Given this angle of view, none of the differences may be considered significant. Thus, at this early stage of the pilot project, it is impossible to predict the respondents' future success as engineering students - neither as individuals nor as groups.

Having secondary schools represented on the Project Board may open the way for future broad-scoped, vertical cooperation with secondary schools. The establishment of such cooperation at the professional level may represent a step forward in an integration process, which, over time, may yield increased competitiveness for Norwegian industry and business.

SUMMARY

After seven years of effort, Telemark University College semester started a pilot class this fall, with students recruited from vocational schools. The tests given to the entering freshmen of this class indicate that the vocational school's educational programme may represent an important means of recruitment into the engineering profession.

The project organisation and the educational research programme may provide the network and documentation necessary to confirm this assumption.

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