Vocational School Interdisciplinary As A Key To Success

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***Abstract* - Since 1977 the Law of Secondary Training has governed Norwegian secondary schools, regardless if they were offering theoretical or practical training. Through this quarter of a century, the practical training offered by the vocational school has changed significantly, thanks to tight links between the Ministry, the employers' confederations and the Labor Organization. These powerful partners have methodically changed the scope and content of the vocational schools in particular from traditional training to a theoretically based training resembling technical education. "Interdisciplinary" has been a keyword governing the transformation process. On the other hand, carrying out interdisciplinary has also contributed to concealing the value of the "new" vocational school as an important source of engineering school recruitment. Thus, the interdisciplinary learning program for the training of electricians is described and test results presented indicating why vocational school graduates are now considered attractive applicants for electrical engineering programs.**

Index Terms - Hands-on experience, Interdisciplinary, Systems thinking, Teacher role.

INDICATIONS OF FUTURE SUCCESS?

Telemark University College (TUC) has since Fall semester 2002 been running a pilot class on recruiting electricians from 3-year vocational schools, and holding a trade certificate to a redesigned three-year bachelor's program in electrical engineering.

This project is supported and partly governed by the Norwegian Ministry of Church, Education and Research, major employer's federations (electrical contractors, manufacturing industries, electricity manufacturing industry, process industry, offshore industry), the Norwegian Air Force and the superintendent of Telemark's primary and secondary schools.

As usual, the first year ended with a number of tests and exams [1]. In Norway the highest/lowest grades at the time were 1.0/6.0 with 4.0 as the lowest passing grade. Average class results are typically 2.5 - 3.0. In the following, "Voc" (vocational) will refer to the pilot class, while the ordinary student reference groups are denoted "Ord". These "ordinary students" are students recruited through the traditional channels. However, in Informatics technology and Theory of electricity, the Ord groups are sophomores of TUC. Three exams in new courses (Mathematics I and II plus Communication & Project) at an "equivalent level" referred to ordinary classes were given the pilot class. Average class grades were 2.39, 2.53 and 2.51, respectively. Thus, the results may be labelled as satisfactory to good. In addition, five final exams were specially designed to enable "ordinary" and "vocational" student group comparison. The results are listed in Table 1. In column 1, (I) means identical tests and (67% I) means that 2/3 of the test was identical, the remaining 1/3 was equivalent. (E) denotes equivalent level but different content. Care was taken to ensure that the censors could not know whether they were grading a Voc or an Ord student exam.

TABLE 1
COMPARISON OF PILOT CLASS RESULTS

Course	Class (size)	No show up/ /%	Fail, number /%	pass, number /%	Aver. grade
Programmable	Voc (36)	1/2.8	4/11.1	31/86.1	2.60
electronics (I)	Ord (38)	3/7.9	4/10.5	31/81.6	2.80
Chemistry/	Voc (36)	3/8.3	6/16.7	27/75.0	2.54
physics (67% I)	Ord (125)	7/5.6	28/22.4	77/72.0	2.86
Informatics	Voc (33)	2/6.1	4/12.1	27/81.8	1.81
technology (I)	Ord (117)	26/22.2	15/12.8	76/65.0	2.42
Business	Voc (34)	1/2.9	0/0	33/97.1	2.37
economics (I)	Ord (90)	6/6.7	0/0	84/93.3	2.45
Theory of elec-	Voc (32)	2/6.3	5/15.6	25/78.1	2.31
tricity (E)	Ord (45)	6/3.3	4/8.9	35/77.8	3.07

Starting with the "No show up" and "Fail" columns, no significant differences between the groups are noticed. However, the "Pass" column could indicate a slightly higher Voc group retention rate. Examination of the "Average grade" column reveals that the Voc group performs better than the Ord reference group in all tests.

In the courses Chemistry/physics, Information technology and Theory of electricity Table 1 may indicate that the Voc group *outperforms* the reference groups.

Thus, these early tests may indicate that Norwegian engineering schools *may* have overlooked an important recruitment source. There are reasons for this possible mistake, and in the following, the most important of these will be described and discussed.

ABOUT THE VOCATIONAL SCHOOL

The Law of Secondary Training has been effective since 1 January, 1977. In 1996 this law was incorporated in the Law of Training, comprising all public schools at the primary and secondary level in Norway. Thus, today even at the elementary school level, the legislators expect training in "..scientifically way of thinking and way of working…" to occur.

An important consequence of a common law including a mission statement, is that all schools at the secondary level should be considered *professionally different* but *academically equivalent.* This assumption has governed TUC thinking, planning and implementation of the pilot class program.

Concentrating on the secondary level, the first two modern vocational school training programs, both concerning operators for the newly established process industry, were launched 1979 in Telemark. Pushed by industry, this was a joint project between a vocational school and the process industry, heavily supported by the Director of Telemark vocational schools.

In contrast to all existing vocational training programs, these new programs introduced elements of the college form of organizing the learning process into vocational schools. Important elements of these new programs were laboratory work including preparations and reporting, introducing the "new teacher role" as an organizer and facilitator of learning, even outside the classroom, and systems thinking.

About ten years later, the basic ideas underlying these programs were adapted in the training of electrical, chemical, and mechanical personnel. However, since the scope of the training programs had moved from "doing by hand" to "*systems thinking*", the titles of the skilled workmen often had to be changed accordingly. For instance., a "craftsman" became an "operator", a "technician", and so on.

Thus, in an era of general inflation, these new titles are not just empty euphemisms for raising the status of people holding a trade certificate. The new generation of skilled workmen were still able to work by hand, even if some sacrifices with respect to level had to be done. On the other hand, industry quickly learned and appreciated the versatility of this personnel, which, in some cases, compete effectively with engineers, holding a bachelor's degree.

After 1994, this educational model has been made the national standard for vocational schools. The forces behind this development, were some branch confederations within The Confederation of Norwegian Business and Industry (NHO), the Labor Organization (LO), a few schools and county school superintendents, and the Ministry for Church, Education and Research (KUF).

A Steady Flow Of Educational Reforms

Norway is a highly industrialized country with a population expecting a relatively high material standard of living. Wages and, accordingly, costs of living are high. In an apparently shrinking world where low-cost country merchandises threaten to put domestic industry out of business KUF, LO and NHO early realized that the country's future could not rely on being successful on the mass production market. In stead, it was supposed that industry might survive, and even expand on the "niche product" market. It was assumed that going in such direction would depend heavily on changes in attitude, goals and knowledge of the population. Accordingly, a series of educational reforms were launched, often in revised versions, over the next twenty years - covering all levels of education in the country.

Seen from the viewpoint of engineering education, most interest has been concentrated on the developments of the traditional source of recruitment, most notably the secondary school's departments of sciences. These parts of the secondary school are considered the main recruitment source of almost any kind of higher education in the country. Consequently, there is a competition among universities and colleges to be "seen" by the secondary school students who are generally specializing in theoretical mathematics, physics and the basic sciences.

However, as indicated in Table 1, the "vocational school revolution" may call for, maybe, more future attention from Norwegian engineering colleges and universities.

Redesigning The Vocational School

The change of the vocational school training programs comprised these key elements:

- The three year's training program should, if possible, conclude with a practical final work, leading to the issue of a trade certificate.
- The first year should be taken at the school.
- The second year should be the joint responsibility of schools and relevant cooperative industry companies; *the school* had the formal educational responsibility.
- The third year should be the full responsibility of the outside cooperative industry partners with respect to learning the trade, with *the school* as the formal institution for student evaluation and assessment.
- In the periods when they were working outside the school, the students should have *student status*, and receive no pay.
- To enable such cooperative programs, interdisciplinary was considered a presupposition.

By inspecting these bullets, it may be noticed that making such cooperative programs effective, a new and hitherto unknown function was needed, namely the "new teacher".

The Role Of The "New Teacher"

In traditional schools, and the vocational schools were no exception, teachers expected to teach their professional specialties to the young generation. Thus, the goal was to teach a specific curriculum in a traditional way, interpreted and taught by the teacher - which meant the use of lectures and exercises in classrooms and workshops as sole teaching tools.

The new paradigm of 1979 introduced, above all, the teacher to the extra dimension of being *the organizer and leader* of complex learning situations, today often denoted *facilitator*.

This new situation required the successful teacher to master different tasks as:

- Build cooperative networks between the school and companies within particular branches,
- Involve relevant branch confederations as observers and advisers,
- In cooperation with the external partners and rector, design a program for learning,
- Plan and discuss learning objectives and content with craftsmen (the factual teachers of the trade) in the cooperating businesses
- Plan and carry out a scheme for appropriate contact and student following-up program during their periods outside the school, and
- Plan and carry out the student evaluation process.

To see the full effect of these changes and challenges, it had to take about 20 - 25 years, as one generation of teachers had to be gently replaced with a new. Typically, this new generation of vocational school teachers were engineers at the bachelor's level, simultaneously holding at least one relevant trade certificate. In addition, the new theoretical courses requirements attracted teachers holding bachelor's or even master's degrees in their fields of specialization.

INTERDISCIPLINARY - A SECRET RECIPE FOR SUCCESS?

It was a major challenge to convincing TUC and the Ministry that recruiting from vocational schools could be a solution to engineering school recruitment problems as well as an impetus for the development of new engineering education programs. The reason was the interdisciplinary structure of vocational school learning programs.

Inspecting the learning program, it appears that the vocational school offers too few engineering fundamentals courses. Estimated by number of weekly class hours, there is not much mathematics, physics, chemistry, organization, principles of leadership, Norwegian and English technical writing to be found. Consequently, the impression that the program might serve industry well but clearly fail as a preparation for future engineering education could easily be at hand.

But still Table 1 indicates that such a conclusion could be wrong. How could this happen? The answer is *interdisciplinary*, which serves as a tool for acquiring specific knowledge *and* an pedagogical instrument to enhance a broad student understanding for subject interconnection. Thus, interdisciplinary serves both as a goal and a tool.

A few examples may illustrate the composite learning obtained by interdisciplinary organized learning programs (course names are **boldfaced**):

Chemistry/environment: The course is taught in the classroom but also emphasizes the periods students are working outside the school. Students are expected to write and present in class reports on their experiences.

Social organization and behavior: 84 hours are taught in the classroom. In addition, a non-formal "embedded learning" process takes place in the periods the students are working inside the cooperating workshops and industry companies. The students are asked to plan their own work and learning program, notice work environment and work-time regulations, observe social and psychological processes, and discuss the observations and results by written reports, orally presented to their class.

Instrumentation: Basic knowledge in electrical, pneumatic, hydraulic and mechanical systems is required. In addition, by building systems integrating such technologies, the students are given hands-on experience as well as opportunities to detect how different systems may be integrated into even more complex new systems.

Analog technology: This fundamental course in electronics also contains important digital technology plus relevant mathematics and physics, used as tools. And since this is a vocational school course, hands-on experience at a high level is a requirement.

Digital technology: This course partly overlaps Analog technology but the adding of applied control technology makes the course transcendent with respect to high level hands-on experience and a more profound understanding of the material is obtained.

Electric power production, transmission and distribution: The course deals with most aspects of this large subject at the elementary level. In addition, the students get hands-on training in the building and maintenance of equipment, training in the use of a variety of measurement instruments and the interpretation of their results.

The course descriptions with comments above are short but indicate ambitious learning goals. As seen from TUC's admission office, however, this is not easy reading. A relatively deep professional insight from the admission's officer will be required to do a good job in the evaluation of the program. Another characteristics of interdisciplinary, as it is applied here, are the absence of appropriate evaluation and grading of embedded learning, caused by course integration. Thus, there are still problems to solve before the vocational school, tentatively, will represent a normal recruiting source for the country's engineering colleges and universities.

EQUIVALENCY

As already stated, TUC is running the pilot project under the assumption that all schools at the secondary level should be considered *professionally different* but *academically equivalent*.

In this case, equivalency means that entering freshman students, regardless which secondary school department they come from, will be offered a three year's program leading to a bachelor's degree in some engineering discipline.

This is in contrast to common practise, which imposes extra work on entering students without the normal background from a secondary school science-oriented department. This "extra work" could mean two extra summer semesters or a full year of preparatory courses in mathematics, physics, chemistry, Norwegian and English. These measures have been taken to ensure "equivalent academic level" of all entering students. This way of solving the equivalency problem can easily be translated to "let the students do the job so *we* don't have to change".

If the college or university *is* willing to change, then an interesting situation may be noticed:

The equivalency principle must mean that teachers in all branches of secondary schools do their work at an equivalent level within their fields of responsibility. If it is so, then the engineering schools' choice of courses should reflect this equivalency, which they do not. For example:

Today many courses are offered as compensation because secondary schools in general do not consider technology a major cultural force of our time and, accordingly, overlooking the necessity of conveying basic technological principles to their students. The engineering schools must compensate for this shortage when they design their programs.

On the other hand: the vocational schools may put too much emphasis on hands-on training and the understanding of basic technical principles and their applications. Based on vocational school transcripts, too little attention is given to classical subjects. In this case, the engineering schools may take advantage of the strong theoretical and practical background which is given to their graduates, and skip several courses which are offered the other group of students. Instead, even deeper insight into problems of leadership as, for instance, psychology, economy, negotiation principles, English and Norwegian technical writing, more and alternative mathematics and physics courses can be offered and so on.

LISTENING AND COOPERATION IS THE KEY

For more than thirty years, NHO, LO and others have accused engineering colleges for having been "poor listeners" to their signals. On the other hand, these two powerful and dominating forces of society have been blamed for wanting to control the free academia.

This uneasy situation may to a high degree be blamed on misunderstandings. The root of this problem could be academia's propensity to define "academic level" in terms of factual contents of courses. This attitude may make sense at the graduate and postgraduate university and college levels. However, engineering students are entering at the freshman level. Many engineering educators now agree that the good undergraduate "academic level" is characterized by its learning processes, academically and scientifically treated as if they were technical research items at the graduate level and beyond. With such attitude, there would have been few communication problems between NHO, LO and the engineering schools.

In the meantime, the almost always cooperating NHO/LO constellation have taken actions to have the vocational school modernized and improved. They consider jointly and proudly the revised vocational school their "baby".

Now TUC listens, and find NHO confederations ready to support. They have been invited to join the Project Board and yes, they could, maybe, feel tempted to take control over the school. But they don't. Discussing long range educational issues, strategies and tactics, is *not* interfering with TUC's learning processes. Thus, a relationship of mutual confidence has been established between confederations, other organizations and TUC.

Vocational school as a major engineering school recruitment source may come true in a near future. But if TUC will see success, the real explanation will probably be found in vocational school interdisciplinary and the constructive cooperative process which has been indicated above.

FINAL REMARKS

The real challenge of college teaching is not covering the material for *the students, it's uncovering the material* with *the students.* This condensed "teacher's credo" was formulated by David Johnson, Roger Johnson and Karl A. Smith in the early 1990's, and could serve as a guideline for the "new paradigm" implementation process in undergraduate engineering education.

TUC has since 1982 applied the principle of project or problem based learning, PBL. Acknowledging the close relationship between the vocational school's pedagogical approach and the "teacher's credo" quoted above, could open for most interesting TUC challenges in a future, where uncertainty appears to be the only certainty to be handled by engineering education schools.

REFERENCE

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