Educating Generalists versus Specialists - A Comparative Analysis on National Framework Plans for Engineering Education in Norway before and after 2003

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Abstract *— Engineering education in Norway is in a rapidly changing process and paradigm shifting for the last decade. The Norwegian Ministry of Education and Research has initiated a number of reforms and restructures for higher education, including engineering education. The initiative was a national merging process to integrating over 130 local and district colleges into 26 regional university colleges. The merging process also intended to strengthen the potential future aspects, such as internationalization, research based teaching methods, quality assurance for teaching and learning activities, just to mention few.*

National Framework is a basic document to formulate criteria and guidelines for engineering education in Norway. For the last decade, this national framework has been changed twice, in 1996 and 2003 respectively. The current study focuses on the major changes in this national framework between 1996 version and 2003 version. The study compares the two versions and their similarities and differences. The comparison is undertaking in both versions' details, such as requirements, goals, expectations, technical specifications, structures, organizing, teaching methods and evaluations. The significant changes between these two versions are noticed almost for every detail. This raises a fundamental question for engineering education: Are going to educating generalists or specialists for our future engineers?

A parallel analysis for changes in quality international standards is introduced to compare with current study. It seems the quality concepts, the quality standards and their contents have been changed for two decades ago. The modern quality philosophy focuses on customers' satisfaction, need assessment, and documentation processing (dynamic aspects), while the traditional quality systems emphasized rather technical definition and specifications (static aspects). The similar trend and changes (dynamic vs. static aspects) are observed between these two versions of framework for engineering education. Perhaps, the modern quality philosophy has catalyzed the paradigm shifting for the modern engineering education and formulated a future profile for engineers?

Index Terms *— Comparative analysis, national framework, quality standards, an engineer's future profile.*

HIGHER EDUCATION IN NORWAY – AN OVERVIEW FOR THE PAST AND STRATEGIES FOR THE FUTURE

The education system in Norway is relatively well-developed, compared to many other countries of the world. The facts indicate the Norwegian education sector has relatively adequate budget (6.9% GDP compared with 5.7% average OECD level), large population of educated people (94% of people in 25-34 years of age with upper secondary education) and various offers of vacation or on job training [5].

TABLE I
FACTS ABOUT NORWEGIAN EDUCATION AND TRAINING (1998)

Population	Category
590,000	Pupils in compulsory education
164,000	Pupils in upper secondary education
174,000	Students in higher education
1,000,000	Adults in various full time or evening courses
85,000	Teachers in compulsory education
23,000	Teachers in upper secondary education
11,300	Academic staff (full time equivalents)

The basic principles and priorities of Norwegian education policies have been focused on these elements:

- A high general level of education in the entire population
- Equal opportunity for all in access to education
- Decentralisation of educational administration

- Meeting long-term and short-term qualification requirements of the labour market
- Emphasis on a broad and general initial education, leaving specialisation to later stages and further training at work
- Lifelong learning (based on a "cradle to grave" definition)
- A comprehensive education system with easy transition between levels and courses

It is also a general and political belief in Norway that high and widespread competence is also a means to prevent unemployment. It is therefore not only an ideology, but also a common practice that most people shall be able to receive education. This practice also reflects fundamental basis for the concept of educational industry [9].

For higher education in Norway, these principles and priorities are implemented through universities or colleges. For example, higher education offered by the state in Norway is tuition free and most students are able get state financial supports and study loan as well. Aside of 4 universities, there are 26 state university colleges to offer the higher education. The intention of these 26 state university colleges is to make higher education more widely accessible while increasing the amount of academic expertise available to the different regions of Norway. These colleges thus make an important contribution to the decentralisation of higher education. Primarily they offer shorter courses of a more vocational orientation than those offered by the universities. In addition to teacher training and courses in engineering, health and social work and other courses of two to four years' duration, the colleges also offer undergraduate courses interchangeable with those offered by the universities.

The Norwegian government has also introduced essential curricula for the learners in order to meet the future demands [5], most are quoted below:

- Abilities of being creative
- Ability to define and solve problems (ability to think analytically and scientifically)
- Ability to cooperate and participate actively
- Ability to use ICT and a variety of methods in the education and training process
- Ability to select information from huge amounts of sources and references
- Ability to play an important part in the ordinary running of the school or working place through democratic participation
- Ability to be enterprising
- Ability to communicate openly and a high degree of communicative competence
- Ability to acquire, evaluate, integrate and make use of knowledge leading to competence
- Ability to promote ethical values and appreciate multi-cultural respect

It is a clear indication that above curricula focused on abilities and skills, rather than pure knowledge only. This strategic change of focus was made on basis of Norwegian educational reforms in the 1990s. The backgrounds were social changes at that time, so our society became more knowledge based, technology depended, multicultural related and multimedia focused. Also, teaching students requires pedagogical understanding and efficient communication, as pedagogical content knowledge becomes more essential [10]. There is a need for paradigm shifting, as well as reforms to follow up the changing philosophy into practice. It has also suggested a number of detailed steps for reform processes, such as degree structure, encouraging of international cooperation and student mobility, increasing freedom to improve quality, etc. [6].

NATIONAL FRAMEWORK PLANS FOR ENGINEERING EDUCATION IN NORWAY

The higher education in Norway is highly regulated. The Ministry of Education determines which degrees, vocational training or other educational programmes each institution may offer and the requirements in terms of breadth, scope and specialisation. Other the other hand, there is no specific requirements imposed on the institution as the teaching content of instruction, the content of research or the content of subject-oriented development work. Hence, each educational institution has their freedom to develop their own offers. The combination of regulation and freedom is an essential element for quality assurance of higher education.

One important document of this process is national framework plan, determined and revised by the Ministry of Education. The framework plans are for certain types of training, including engineering education. These plans determine at a general level which main and subordinate topics the training programme should include. Thus, a framework plan tells a rough direction and emphasis of the particular education this plan belongs to. The national framework for engineering education also assured the same quality and levels of subordinate topics for all institutions of engineering education in Norway. The current framework plan for engineering education was revised by the Ministry on December 2003 [7]. The former framework plan was approved by the Ministry on November 1996 [8].

Table II summarizes a comparison of the overall goal and few partial goals for national framework plan in current (2003) and former (1996) version. The changes in the 2003 plan indicate a direction of education philosophy, rather in extensive

learning than in-depth training. Moreover, the individuals (learners) are expected to take more responsibilities for own. Another noticeable change is more focusing on pro-active abilities rather than attitudes creating only.

TABLE II
NATIONAL FRAMEWORK PLANS FOR ENGINEERING EDUCATION IN NORWAY, A COMPARISON OF 2003 AGAINST 1996 IN OVERALL AND PARTIAL GOALS

Content	2003 Plan	1996 Plan	Changes in 2003 Plan
Overall goal	Educating theoretical, technical knowledge with practical skills. Interacting between technology, environment, individuals and society. Understanding of innovation and entrepreneurship. Meeting society's current and future demands.	Educating theoretical, technical knowledge with practical skills. Educating professions. Interacting between technology, environment and society.	Educating engineers. Individuals are involved and integrated into interaction between technology, environment and society. Understanding of innovation and entrepreneurship. Meeting society's current and future demands.
Partial goal	Balancing of science and technology courses.	Balancing of basic mathematic, theoretical and technological courses.	More general science courses focused rather than purely mathematic courses focused.
Partial goal	Not taking this element into 2003 plan.	Acquiring sufficient knowledge on new technology for company's innovation process.	Not taking this element into 2003 plan.
Partial goal	Developing of abilities for innovation and entrepreneurship.	Creating positive attitudes toward knowledge and entrepreneurship.	Focusing on pro-active abilities rather than attitude creating only.

The 2003 plan also targets the requirements and expectations toward learners than institutions, compared with the 1996 plan. While the former (1996) plan used the term "engineering education (ingeniørutdanningen)" as the target group for requirements and expectations, the newer (2003) plan uses the term "candidates (kandidatene)" as the target group. This means the learner (candidates), as the end users of engineering education, will get more attention and focusing from the 2003 plan. The newer plan has listed up a number of essential requirements and expectations for the future engineers:

- Implementing knowledge of mathematics, sciences and technology
- Identifying, formulating, planning and solving technical problems in a systematic approach within one speciality/area
- Specifying solution requirements in a systematic approach
- Planning and conducting experiments, as well as analyzing, interpreting and utilizing the experiments' outcomes
- Constructing a component, a system or a process to reach and obtain specific results
- Using modern instruments, techniques and appropriate skills in daily work/tasks
- Cross-section cooperating to solve the complicated problems
- Communicating efficiently with others experts in other specialities/areas
- Understanding and practicing professional and ethical responsibility
- Undertaking quality concepts and implementations in every relevant area
- Participating in innovation and entrepreneurship processes
- Balancing technological solutions with economic, organizational and environmental aspects

The above list has mentioned many skill-based requirements, such as implementing, identifying, formulating, systematizing, analyzing, cooperating, communicating, participating and balancing of different aspects, etc. This skill-based focus indicates a current expectation for the future engineer of being able to perform different tasks and working in many fields, thus, a generalist.

Noticeably, both plans consider quality concepts as a vital value of engineering work. The 1996 plan has a separate section to describe this issue. The 2003 plan also requires an educated engineer will be able to undertaking quality concepts and implementations into every relevant area. There are naturally debates, arguments and different opinions toward the former and newer plan. The quality issue is often settled as the focus. The 2003 plan has updated and assured this issue in an appropriate and active way.

Another remarkable updating is the focus on participating in innovation and entrepreneurship processes. The Norwegian government has predicted a need of 800 000 jobs in the future, in order to keep the current living standard. These jobs are not available or existing in the current industries, and they need to be created. The future engineers in Norway need therefore to participate in innovation and entrepreneurship processes, or even create their own jobs.

Table III demonstrated another comparison of the 2003 plan and the1996 plan, in course compositions. There are two noticeable changes in the table: 1) The compulsory and basic courses in mathematics and other scientific subjects have been increased 5-15 ECTS (European Credit Transfer Systems); 2) There is no longer distinction between speciality and major in definitions for technical courses, but there is possible or space for reduction (upon to 15 ECTS). Both changes indicate a

trend of more basic courses or less technical (usually within one particular speciality/area) courses. This indicates, again, a direction of educating a generalist.

TABLE III
NATIONAL FRAMEWORK PLANS FOR ENGINEERING EDUCATION IN NORWAY, A COMPARISON OF 2003 AGAINST 1996 IN COURSE COMPOSITIONS

Content	2003 Plan (accounted in ECTS)	1996 Plan (accounted in ECTS)	Changes in 2003 Plan
Course type	Basic Courses 50-60 including (minimum): Mathematics 25, Physics 10, Chemistry and Environment 10, Computer Techniques 5	Basic Courses 45 including these: Mathematics 24, Physics 6, Chemistry and Environment 9, Computer Techniques 6	Increasing Mathematics and Sciences Basic Courses in 5-15 ECTS (Compulsory)
	Social Science Courses 15-20	Social Science Courses 15-18	No specific changes
	Technical Courses 75-90	Technical Courses 90 (Speciality 30, Major courses 60)	No longer distinction between speciality and major courses, possibly 15 less ECTS
	Optional/voluntary Courses 10-20	Optional/voluntary Courses 12-18	No specific changes
	Final Project Work 10-20	Final Project Work 12-18	No specific changes
Total ECTS	180	180	No specific changes

Further comparative analysis of the 2003 plan and the1996 plan has summarized similarities and difference of these two plans in degree, quality assurance, working and teaching methods, as well as evaluations. See details in table IV. The overall structures of both plans are most likely the same. The awareness of quality requirements for teaching work in both plans is highly appreciated. The differences and changes in the 2003 plan are:

- Integrating degree with international systems (converting to bachelor)
- Decentralizing of course plan settlement to the institution level
- Focusing on learners' interactive abilities, such as cooperation, communication, cross-section skills
- Appraising practice as a more important step of teaching activities.
- More focusing on the learners and their competence upgrading after learning

TABLE IV
NATIONAL FRAMEWORK PLANS FOR ENGINEERING EDUCATION IN NORWAY, A COMPARISON OF 2003 AGAINST 1996 IN WORKING AND TEACHING METHODS

Content	2003 Plan	1996 Plan	Changes in 2003 Plan
Degree	Bachelor of engineering (bachelor i ingeniørfag)	College engineer (høgskoleingeniør)	Integrating with international degree systems
Quality assurance	Course plan settled by the institution level, including learning goal, teaching methods, evaluating process and relevant requirements.	Quality control and evaluation for course's learning goal, teaching content, methods, organizing, syllabus, R&D relevance, etc.	Decentralizing of course plan settlement to the institution level.
Working & teaching methods	Focusing on learners' abilities of cooperation, communication and practical problem solving skills, focusing on cross-section issues, implementing practice training, integrating final project with external companies or organizations.	Following the pedagogical principles, focusing on learners' abilities to seeking knowledge, learning skills, self-engagement, introducing institution for first year students, opportunities for practice arrangements, teaching information analysis skills.	More focusing on interactive abilities, such as cooperation, communication, cross-section skills. The practice became a more important step of teaching activities.
Evaluation	Assuring engineering students have learned and implemented knowledge and competence which satisfy the overall and partial goals.	Evaluating learning effect, developing and improving teaching methods, and evaluating institution's teaching levels.	More focusing on the learners and their competence upgrading after learning.

Reviewing both framework plans, there are noticeable similarities such as structures, outlines and awareness of quality requirements for teaching work. The general policy and philosophy for engineering education in Norway remain the same. However, there are few differences and changes noticed in the 2003 plan. The changes are mainly focused on the plan's extensiveness, the descriptive content, terminologies or definitions, requirements or expectations, and targeting of the end beneficiaries/users. Below is a summary of changes:

- The 2003 plan is a short and concise plan (the 2003 plan contains 10 pages while the 1996 plan has 68 pages)

- The 2003 plan has removed the definitions of traditional engineering disciplines, so there is no detailed criteria and requirements for each discipline (the 1996 plan has defined 5 traditional disciplines, as construction engineering, computer engineering, electronic engineering, chemical engineering and mechanical engineering)
- The 2003 plan has decentralized the course content and descriptions, so that each education institution has their freedom and space to develop and define these courses (the 1996 plan used 6 pages to define/describe basic courses, 10 pages to define/describe speciality courses)
- The 2003 plan focuses on the learners/students, thus the end users of engineering education, while the 1996 plan considered institutions are the targeting groups for requirement and expectations
- The 2003 plan has defined and expected skill-based requirements as learning outcomes, such as an engineer's abilities of systematizing, analyzing, cooperating, communicating, participating and balancing of different aspects
- The 2003 plan seems to be a more dynamic and flexible guide for engineering education, so there is freedom and space to implementing for each institution, while the 1996 plan seems to be rigid in definitions of each discipline, major, speciality and even course content
- The 2003 plan expects a future engineer will be able to perform different tasks in different situations and environments, thus a generalist of engineering, while the 1996 plan seems to consider an engineer rather as a specialist with in-depth knowledge of technical specialities/areas
- The 2003 plan has integrated the Norwegian engineering degree (høgskoleingeniør) system into an international standard (Bachelor of engineering)

Compared with the essential curricula introduced by the Norwegian government [2], these changes are indeed made for meeting the future demands. The remaining question is: What makes future demands end up this way?

A REFLECTION ON MODERN QUALITY PHILOSOPHY VERSUS TRADITIONAL QUALITY SYSTEM

For two decades ago, the quality management was a top agenda and a popular topic in Norway, including engineering education. It seemed then the quality concepts, the quality standards and their contents had been changed considerably from the traditional quality system. The modern quality philosophy focuses on customers' satisfaction, need assessment, and documentation processing (dynamic aspects), while the traditional quality systems emphasized rather technical definition and specifications (static aspects).

Upon to now, the modern concepts on quality in the industrial societies seem to have agreed with one common understanding: Quality is fitness for use [4]. This means that the users or the customers will have the first priority to decide what criteria should be for the quality.

The users and customers are apparently human beings and they have own cultures, values and criteria about certain thing, including concepts of quality. It is also nature that their basic cultures, values and criteria are different since these elements were already programmed in their minds in an early age [2]. Such differences may possibly influence their working attitudes, behaviour and outcomes. As a result, the standards or evaluations of "good quality" or "doing a good job" may also vary differently from one culture to another. The good quality of a meal dish in Norway probably includes the elements of proper nutrition, originality of the taste and colour. These criteria are not necessarily equal valued in everywhere else. For instance, a good meal dish in China may probably focus on the style of sauces, taste, complexity or even the symbolic meanings of the meal. Thus, customer satisfaction is not a single dimension issue.

The historical development of quality and quality management had a strong connection with the changing need and requirements from users and customers. The earliest activities about quality in our human society that we know about can be tracked back to ca. 1450 B.C. where the Egyptian people executed their huge Pyramid projects. It was noticed that they had quality controller who had responsibility for the quality of work [1]. The need and requirements at that time were more or less based on technical reliability, the performance of objective measurement and the character of eternity was considered as the first priority.

This was presumably the basic philosophy and criteria for the classical quality definitions also, though there is definitely a distinction among different customers' preferences. Some may perhaps consider less degree on eternity since their needs for changing models or new fashions are more frequent. Others may appreciate reliability and firmness as their quality criteria. The character of eternity is also important for people whom are considering on prices and lasting time. This consuming behaviour again, is depending on the consumers' economic abilities. Apparently, such consuming behaviour may not be the same for developing countries, compared with developed countries. .

The modern quality study focuses also much on the competitions in the consume markets. Consumerism is the key element for the criteria of the quality. The customers' preferences are the driving force for the change of markets and products. The need of customers provides legislative approaches and changing laws for the improvement of quality and quality management [3].

The modern quality philosophy therefore belongs to subjective and people related issues, thus in dynamic aspects. It requires motivation and people engagement for operative actions, such as undertaking total quality management (TQM), implementing of ISO9000s or ISO14000 systems. Furthermore, different people might have different needs, and each organization has their own necessity for documentation. It is therefore impossible to define customers' satisfaction, need assessment, and documentation processing, rigidly or generally.

The traditional quality systems, such as NS5801 (a Norwegian Industrial Standard) was based on objective and technical definitions and specifications. The essential elements in these quality systems are usually metrics, dimensions and other physical measurements or indicators. Naturally, these definitions and specifications are rather related to static aspects. For these quality systems, good quality means a satisfaction to specific metrics, dimensions and other physical measurements or indicators.

THE MODERN ENGINEERING EDUCATION AND A FUTURE PROFILE FOR ENGINEERS

It has now believed that consuming and marketing economy was the driving force of this quality conception changes. Both varieties of consuming behaviour and marketing globalization result changing expectations of consumers, shorter product life cycles, integrated production. There is no longer fixed parameters to guarantee the quality. It is necessary to "compose" the appropriate quality for the right customers. Philosophically, this process shall be dynamic and updated continually.

For the comparison of two framework plans for engineering education in Norway, it has also been observed and noticed the similar trend and changes (dynamic vs. static aspects) between these two plans. As the current analysis indicates, the 2003 plan seems to be short and concise, general and flexible, free and spatial for further developing, learner focused and skill related, as well as holism and international.

As a result, the modern engineering education in Norway will bear the above characters and our future engineers will be educated in this way. Like quality debates for decades ago, not everyone is comfortable with this approach. The most common opposite arguments are fear of missing technical content in engineering education. However, the modern quality philosophy has demonstrated a good example for the engineering education and a future profile for engineers. There has already been a common understanding of modern quality philosophy nowadays, that customer satisfaction and need assessment are more important quality issue.

When the modern quality philosophy was developed from the traditional quality systems, it was mostly focused on a physical product or a service. The customers are the end users of this product or service. It was a traditional philosophy to consider the industry or society as the end users for engineering education. However, with changing factors, such as rapid developing of new industries, changing society and globalizing processes, it will be better to educate a future engineer into as a quick learner or a good survivor. In this respect, the modern quality philosophy may provide us a good lecture.

Perhaps, the modern quality philosophy has catalyzed the paradigm shifting for the modern engineering education and formulated a future profile for engineers?

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