Diversity is a Necessity

Katriina Schrey-Niemenmaa[1] and Mervyn Jones[2]

[1] Katriina Schrey-Niemenmaa, Helsinki Metropolia University of Applied Sciences, Helsinki, Finland
Katriina.Schrey@metropolia.fi
[2] Mervyn Jones Imperial College London, London, SW7 2AZ, UK
m.jones@imperial.ac.uk

Abstract
We reflect on the need for diversity and the confusion that can exist between equality and excellence in educational missions. Examples are given of what can be done to improve the ability of an institution to fulfil these. Some of these issues, which it is felt have, and are still, challenging the profession and the education of engineers are explored. Perspectives from two different types of institutions in different counties are brought together. Some of the information about different aspects of identifying, benefiting from and supporting diversity originates from an ESR-research program OTE, where staff teaching engineering in ten Finnish HEIs are jointly studying these matters.

Key words:
diversity, appropriateness, orientation, learning styles, transparency, quality

1. Introduction

When considering the word diversity, its principal historic synonym might be given as variety. Zoologists and ecologists frequently use the term species diversity to indicate the range of natural species occurring in a location, its presence and importance valued and loss lamented. Currently in social and educational debates diversity is a word which can have somewhat more specific associations, be these with gender, ethnic, religious or political imbalances. In many countries there has been progress in achieving improved equality and a greater tolerance of gender or ethnicity; with the implication that diversity exists, is respected and should not be an issue. (The focus of a recent issue of the EEJE was exclusively on gender issues [1].) It gives some satisfaction that progress on all of these issues has been made, although not as far or as quick as one might have wished and much remains to be done. Such challenges, although important, are not the focus of this paper, which instead considers the issue of diversity within engineering education.

How should we consider broader diversity issues within the context of European Engineering Education? One of the drivers behind the Bologna process has been to encourage transparency and structural similarity in higher education and by so doing enhance workplace mobility. But in this sense the process should not be equated, either with equality or with the excellence of individual institutions; it is not related to

either. Transparency and structural similarity do not prevent diversity and in discussions about engineering education it is our view that insufficient attention has been given to the need to encourage and recognise diversity. In their professional life engineers undertake a myriad of different functions. Whereas historically a university might have had a single engineering department, today it might have many with different foci, be these Chemical, Civil, Electrical and so on. Within each of these students might be able to chart their own level of specialisation, which reflects their evolving professional interest and perhaps to some extent their individual life-style priorities. A diversity of approaches is desirable, but what is more important is their intrinsic quality or approach to excellence.

2. Changes in Educational Developments

Across Europe, the last 40 years have witnessed a massive increase in student numbers 'to meet the need for a more educated workforce'. This has always been on the basis that such a workforce will be needed to maintain European competitiveness. (In this context higher education is seen as being coupled directly to effective economic performance, the nature and effectiveness of such a coupling being an issue which in our view needs significant clarification.) However, there has been much less reflection how, with changes in design, manufacturing and servicing, it might be best to educate engineers for the future, recognising especially the very broad spectrum of jobs that can be undertaken on the basis of an engineering education.

Unfortunately teaching grants to a university more often than not are related to student numbers – to load – rather than a reflection of the success of the institution in meeting its qualitative aims or its impact, in whatever way that is to be measured. No two universities are the same and although there may be many similarities, each has its own set of unique characteristics, which might be determined a combination of several factors. These include (a) its location, in which country, in which city and why; (b) its historic background and why it was created, e.g. pre-1800, with perhaps religious origins; or mid 19th Century when there was a major expansion and the formation of many technical universities, or mid 20th or late 20th when there were growth spurts and large increases in student numbers, (c) the nature of how it is funded – locally, nationally, internationally (d) how it arrived in its present situation and its current mission and vision. With all these factors influencing an institution, it should be no surprise that there is a wide diversity of higher education institutions.

Given what we have just said, perhaps we should pause briefly to ask as reflecting engineers and educators what value should we place on the single figure that emerges from the reduction of the diverse characteristics to a single quantified figure and less so the use of this figure to compare very diverse institutions in ranking tables, which ignore or of these differences. Also we should question the use of such information to influence or guide the policies of an institution. The presence of diversity is self evident. While excellence, which has to be a reflection of achievements within the specific mission of an institution, is something to be sought, it makes direct institutional comparisons challenging.

As highlighted above. There are many different forms of engineering and many different ways in which engineers can usefully contribute to society. This applies not only to the discipline of the engineer, but to a complete portfolio of competences, extending from calculation and simulation to creativity, costing, project management and marketing. Even just linking together in a few words this range and diversity should surely start to lead us towards the clear recognition that a diversity of engineering skills are needed to meet a broad range of different functions. Individuals are varied, institutions are varied, and the different engineering skills required are varied. Surely, should not also the educational opportunities that are offered need to be varied? Buy, is sufficient recognition given to this [2]?

One additional aspect to highlight and that needs to be considered is that the role of universities and engineering education is to a greater or lesser extent changing. Whereas in the past universities used to have a working mode of independent academies, which generated knowledge and knowledgeable people for society, albeit not necessarily according to the needs of the society; today there is an increasing tendency for society to see itself in the role of customer and stakeholder, trying to play a stronger role in setting the requirements and dictating the outcomes of universities. This development has changed the role of students, who are now sometimes viewed as 'customers' whose needs must be considered – whereas perhaps historically they used to be passive receivers of the knowledge delivered by the university. This development and the imposition of student fees in some countries has forced the universities to reflect more on the varying needs of different students. If an institution aspires to higher quality and through this gain appreciation and financing, it may need to develop services to support and benefit from diversity.

3. Diversity in Approaches

One concrete and interesting source of information about different aspects of identifying, benefiting from and supporting diversity originates from an ESR-research program OTE. In this programme, staff teaching engineering in ten Finnish HEIs are jointly studying issues in diversity. Those involved are five science universities and five universities of applied sciences. The focus is on how to get a good start for the studies, remove bottlenecks, guide thesis work, find different learning styles and have clear definitions of the expected learning outcomes. Some additional aspects of that project will be introduced in another paper in this conference [3].

The OTE project is divided into 6 different sub-projects, and in addition to these a development programme for the staff in universities is being created. Each of the sub-projects is chaired by a science university, with the universities of applied sciences participating and contributing to several of these. Conclusions are made and knowledge as well as good practices is shared in joint meetings and seminars throughout the whole duration of the 30 month project. We describe here the six sub-projects, while at the same time including comments from a wider non-Finnish perspective.

In the first sub-project the focus is on achieving a good start for students new in the university. As in the beginning students' backgrounds and expectations are seen to

vary strongly – special attention needs to be given to finding best learning methods and what is most appropriate to meet individual needs. The main driver behind this is to try to avoid unnecessary drop-outs when entering university life after the more regulated studies at a pre-university level. In addition this is an excellent time to gather new ideas for the developing different ways of treating students, as the students have not yet "learned the habits of the university".

According to the first experiences of the project, this kind of tutoring is supporting many of the new students in finding their personal learning styles. Additionally, several students have realised that at university level engineering education there is a need for self study, as many of the students perhaps have had a "too easy" time in high school – they have learned by listening during the lessons, without the need to invest too much of their own time and effort.

Achieving a good start for students is a challenge everywhere. As a phrase it encompasses several facets, from changes of teaching and learning styles, to being in a different environment and developing self responsibility for learning, understanding and time management. Student drop-outs are a source of several concerns. Is it that the motivation to become an engineer declines as the subject as delivered is not as they expected, or that an entry selection process would have inhibited such students even from starting? Whatever is the case, this is certainly an issue that needs to be addressed and is a challenge also to institutions such as Imperial College London where, while the drop-out rate is low, the number of students who subsequently follow engineering careers is lower than we would like to see.

In the second sub-project the focus is on the bottlenecks that occur after starting studies. Typically these bottlenecks' have been found in mathematically challenging subjects as some engineering students are more orientated towards practical issues. The motivation to subjects, which are developing scientific thinking and analysis to give a deeper background understanding for further creative work as an engineer, might need additional and different effort to be conveyed in an effective manner. A special tool called "snail" has been developed to help recognise and analyse the bottlenecks. Typically in these courses there are more students from senior classes, who have failed previously to pass the examinations and are therefore repeating the course. In addition, the exam results from these courses tend to show a lower average score than for other courses. This new tool for detecting the bottlenecks has proved quite effective and adoptable. By investing more resources in those courses showing greater problems the flow into follow-on courses has been smoother, as the required basic skills and methods have been learned.

As a profession we should be concerned about our effectiveness in communicating ideas and concepts which are essential for a professional understanding. Effectiveness can be improved by ensuring that all teaching staff have an appreciation of these issues. Larger classes remove the student from the more intimate environment of the school room and this is an important transition, but addressing such issues is vital for the effectiveness of teaching.

The focus of the third sub-project is on the supervision and tutoring of thesis work. In Finland most of the master and bachelor level thesis works is undertaken as projects, which have been suggested by external stakeholders of the institution. Often their views are from the 'customer's side' and also there is a "project owner" guiding and setting demands for the work. To meet the requirements of the customer the thesis work has to be conducted to a planned schedule and naturally also has to fulfil the necessary academic requirements. For this process to be effective universities have to create a process and then communicate this process effectively to all supervisors and students. In this OTE project a special seminar-series has been developed to support students in this phase. Following the seminar-series the time used for theses work has been found to be more effective, with improved ease to keep within the expected quality and frame.

The aim of the fourth sub-project is to define clear method for setting learning outcomes for each of the course. The summation of these learning outcomes jointly creates the expected outcomes of the whole study program, and thus gives a comprehensive picture for the students about their future skills. In addition to this **the fifth sub-project** is creating materials for supporting and tutoring several different learning styles to help reach the defined learning outcomes. As an example learning of mathematics is taken as a focus. Learning outcomes have been defined in cooperation with the different stakeholders in industry, society, teachers and students, although obviously the responsibility must stay in the university.

Finally, the focus of the sixth sub-project is on the diverse and different needs of students as they are located in different places around the world for family, for work or other reasons. Blended learning, flexibility in participation, virtual approaches to exams and flexibility in planning the flow of studies, especially in the final phase, are some of the varied approaches to support different learners to finalise their degree successfully. The main purpose is to make studies more attractive, and make it easier for different kinds of students to meet the requirements of the degree and furthermore to avoid drop outs. The challenge here is to achieve this while not sacrificing the integrity of the learning, nor compromising the degree standard. This is easier to claim than it is to verify.

The results from all of these six sub-projects will be generated by cooperation across the institutions, while continuously discussing, developing and sharing ideas. Several seminars for handling the results of the project have been organized already and some of these have been put into practice immediately, resulting in good experiences from the other universities or units. The main event for sharing the results will be held in December 2010 in Espoo. That will be a symposium where the outcomes of the project will be introduced [3].

In addition the outcomes of the project will be shared by organising a development programme for teachers. This programme is jointly created and is credited by 5 ECT units. Teachers can use it as a part of their own continuous professional development or even as a part of further studies as the accreditation is done by Aalto University.

4. Evaluation criteria for diversity in the context of the quality of engineering education

Funding and evaluation are key issues when thinking about the development of engineering education. The base of funding can be used pro-actively to encourage the development of reflective practices – or it can address outcomes without reflection. The evaluation criteria might even lead to inappropriate developments, if the criteria do not to some degree reflect the needs of society. This fact was noted in US – when in the 1980s, the accreditation criteria had become increasingly prescriptive, inhibiting development of innovative programs to reflect the changing needs of engineering practice. In response, ABET (formerly Accreditation Board for Engineering and Technology) and its stakeholders developed revised criteria, Engineering Criteria 2000 (EC2000), which emphasised learning outcomes, assessment, and continuous improvement, rather than detailed curricular specifications [4].

Another attempt to develop engineering education towards more diversity, understanding and applicable form is the CDIO initiative, created with wide international cooperation and coordinated by MIT [5]. There are current attempts to adopt these criteria in both American and European quality systems. An evaluation process based on a rating scale, such as the CDIO self-evaluation model, is more useful for continuous improvement than a threshold value scale, such as used in a EUR-ACE accreditation [6].

Currently it is suggested that academic funding may change in many countries, including Finland, in a way such that qualitative criteria are introduced in addition to the current quantitative funding criteria. A cooperation group of Finnish HEIs in technical engineering education has defined possible criteria for good engineering education at university level. The results included criteria to support diversity and social responsibility: “Universities and polytechnics must collaborate in developing professional societal communication to various target groups, such as the youth and the political decision makers. The key role and significance of the engineering skills and competencies must be emphasised when creating well-being for the people and the environment. And moreover, each institution needs to communicate widely their chosen profile as a higher education institute in the field of technology.” [7] While laudable, it is a source of concern that unless appropriate care is taken, meeting such targeted criteria can also become unnecessarily prescriptive in setting the engineering educational agenda.

A survey about how well these criteria have been met in Helsinki Metropolia University of Applied Sciences has been made [8]. The UAS has many development areas, but several of those devoted to diversity had already be seriously considered and successfully implemented.

In these many national, European and international quality approaches the tendency has been towards learning outcomes and an appreciation of different learning styles, as well as flexibility according to the needs of the different stakeholders. This

tendency is very challenging for academia, as results have to be reached in a very cost effective way while at the same time trying to maintain standards.

Conclusions

The solutions to many of society's current challenges lie in the work and application of engineering knowledge. As the challenges are huge, no resources should be wasted, but all the different available skills used. This requires attracting different people to engineering, educating them well, taking care of their continuous professional development and creating and sharing new knowledge for the needs of society.

In this task Universities have an endless work field – to define society's needs pro-actively, offer education by not just accepting the diversity, but also encouraging and getting the benefit from it – and thus creating an innovative and productive environment, where all involved are learners and developers of our future world. The 'joy of learning' can create good, even unexpected results and effective diversity can support this well.

Such work needs resources and tools for management – tools for continuous development and evidence; evidence for those, who are deciding where to study; evidence for those who are making decision on educational financing; and evidence for the political decision makers, who are deciding how to best to address the challenges which we all face.

References

[1] European Journal of Engineering Education (2009), Vol. 34, No.5, pp 409-464
[2] Schrey-Niemenmaa, K & Jones M E: (2009) '*Challenges in re-thinking engineering education'*, Proc. SEFI Annual Conference, Rotterdam (July 2009)
[3] Huvinen, O, Myller, E, Kairamo A-K, '*Networking Opportunities And Challenges In Developing Teaching And Counselling In EE'*, SEFI Annual Conference, Trnava (September 2010)
[4] http://opetuki2.tkk.fi/p/reflektori2010/index.en.php
[5] Prados John W., Peterson George D., Lattuca Lisa R. '*Quality Assurance of Engineering Education through Accreditation: 'The Impact of Engineering Criteria 2000 and Its Global Influence'*, Journal of Engineering Education (January 2005)
[6] Crawley E, Malmquist J, Ostlund S & Brodeur D: (2007), '*Rethinking engineering education, the CDIO approach*', Springer (2007)
[7] Malmquist, Johan, '*A Comparison of The CDIO and EUR-ACE Quality Assurance Systems Proceedings of the 5th International CDIO Conference'*, Singapore Polytechnic, Singapore, (June 2009)
[8] Tekniikan yhteistyöryhmä: Teknillisen koulutuksen kansallinen profiilikartta, ISBN-10 952-5633-32-2 Helsinki, Finland (May 2009)
[9] Pekko, T: '*Quality examination in Metropolia University of Applied Sciences on ground of the criteria for the good engineering education for a functioning campus'*, Bachelor of Engineering thesis work, Espoo, Finland (May 2010)