COMPETENCES DEVELOPED IN A DOUBLE DEGREE PROGRAMME: MASTER OF SCIENCE IN ENGINEERING AND IN EDUCATION

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Abstract

Since 2002 there has been a double degree programme in Stockholm, Sweden thanks to a joint venture between KTH Royal Institute of Technology and Stockholm University. After five years of studying, which is the stipulated time for the teacher programme and engineering programmes in general, the graduates become engineers *and* teachers. By choosing this programme the graduates have the option of two professions during their careers. At present Sweden is in desperate need of more teachers in maths, science, and technology. These career options also offer flexibility when the number of teenagers decreases, or companies have to downsize.

Sceptics might fear that this programme could lead to less competence, due to less time spent on specialising within the subjects of engineering, but according to Trevelyan most engineers spend more time on human interaction than on design and calculus [1]. Thus, studies in education can provide engineers with additional useful competence. Previous studies on double degree programmes have mainly focused on organizational problems, except for Wimshurst & Manning who mapped students' ongoing experiences when they combined a degree in criminology with degrees in other disciplines. These students complained about disjoint courses instead of joint discourses [2].

The aim of our study is to map and analyse:
(1) how alumni evaluate this programme in retrospect, and
(2) how they describe their present competences.

Accordingly, 49 alumni answered a questionnaire in June 2016; and 15 of these respondents were selected for a tape recorded interview face to face. These alumni graduated from the programme 2-9 years ago. The data were coded according to principles of Grounded Theory [3].

In retrospect these alumni do appreciate the programme. Most respondents comment on the merits of maths learnt at KTH, though only a minority of engineers use higher maths as a practical tool. On the other hand, maths serves as a prototype for problem solving in general. Studies and training in leadership, learning theories and communication offer important tools for most engineers. Alumni employed as teachers claim that they are more well-prepared to teach maths, science, and technology than other teachers, partly because they can illustrate phenomena by giving examples from other realities than the school context.

Alumni's descriptions of their present competence illuminate various combinations of engineering and educational skills. When data were coded three main categories emerged: material, processual and functional. Finally, the core category was formulated as follows: *The programme matches new needs in present working life, i.e. that expertise knowledge is communicated to various kinds of recipients. The programme does not primarily reproduce labour, but rather support alumni in creating niches for themselves by pushing, widening and going beyond previous professional roles in working life.*

Conclusion:
The double degree programme provides labour market with competent teachers and with communicative engineers. This is important in our era, when working life is partly transforming from standardized production into flexible knowledge processing.

Keywords: Competences, Double degree programme, Education, Engineering, Grounded Theory

1 INTRODUCTION

Since 2002 there has been a double degree programme in Stockholm, Sweden, called “Master of Science in Engineering and in Education”. This programme is a joint venture between KTH Royal Institute of Technology and Stockholm University (SU). After five years of studying, which is the stipulated time for the teacher programme and engineering programmes in general, the graduates become engineers *and* teachers. A large part of the courses in educational sciences are given by SU, while the teaching subjects and some educational courses are given by KTH in an engineering context. All students study much Mathematics, which is also the primary teaching subject. The students in this study have also chosen a second teaching subject: Physics, Chemistry, or Computer Science.

By choosing this programme the graduates have the option of two professions during their career. At present Sweden is in desperate need of more teachers in Maths, Science, and Technology. These career options offer also flexibility when the number of teenagers decreases, or companies have to downsize.

Sceptics might fear that this programme could lead to less competence, due to less time spent on specialising within the subjects of engineering, but according to Trevelyan most engineers spend more time on human interaction than on design and calculus [1]. Thus, studies in education can provide engineers with additional useful competence. Previous studies on double degree programmes have mainly focused on organizational problems, except for Wimshurst & Manning who mapped students’ on-going experiences when they combined a degree in criminology with degrees in other disciplines. These students complained about disjoint courses instead of joint discourses [2].

Thus, a double degree programme could render possibilities as well as problems. This paper will illuminate that both by focusing on graduated alumni’s opinions and on their experiences in retrospect.

The aim of our study is to map and analyse (1) how alumni evaluate this programme in retrospect, and (2) how they describe their present competences.

2 METHODOLOGY

A questionnaire consisting of twelve questions was sent to 133 graduated alumni and was answered by 49 of them in June 2016. In the questionnaire, we asked the respondents to indicate if they were willing to participate in an interview. Fourteen of these respondents were selected for a recorded interview face to face. The interviewees were graduated from the programme 2-9 years ago and represented a rich variation in relation to courses studied, gender, employments, and answers in the questionnaire. Each of them is quoted or referred to once or twice in Sections 3.1 and 3.2.

The first research issue, i.e. alumni’s evaluation of the programme in retrospect, is mainly illuminated by alumni’s open-ended answers to questions of the questionnaire. The second research issue, viz., meanings of joint competences, is based on interviews processed and coded according to the principles of Grounded Theory [3]. Thus, twelve concepts were constructed and clustered into three main categories. Finally, the emerging pattern, the core category, was formulated in propositional form.

3 RESULTS

3.1 Alumni’s evaluation of the programme in retrospect

Many alumni reported tensions between a tough culture at KTH characterized by high demands, high workload and to a large extent traditional teaching, versus a smooth and reflective culture at SU. Due to tough demands in e.g. Mathematics at KTH, and being unfamiliar with expectations and demands in Educational Sciences, several students spent little time on studies in educational subjects at SU. The latter put too much emphasis on theory and too little on practical applications, according to several students. Educational Sciences were also too school-and-child-centred, instead of company- and adult-centred, according to alumni who were not employed at schools. Some cohorts of students seemed to have suffered from ups and downs in work load, due to lack of sufficient planning coordination between KTH and SU, as mentioned by Wimshurst & Manning [2]. However, many alumni modified their judgements in the long run.

Only alumni employed as teachers of Mathematics and a minority of engineers had use for higher maths as a daily practical tool, but on the other hand, many students expressed their opinion that studies in Maths enhanced their problem-solving skills and attitudes in general.

In a similar way, alumni seemed to refresh knowledge and insights from Educational Sciences when they encountered challenges related to learning, leadership and communication in practical situations.

> *During a meeting, an engineer tried to explain a problem, and after fifteen minutes I realised that nobody understood what she was talking about. Her presentation included too much irrelevant information for the other participants. I had caught most of the message, but I needed to double-check it. I summarised her presentation and asked if I had got it right. My interpretation was correct and now the meeting participants understood her intention, too. (Comment in questionnaire, female alumna, industrial enterprise)*

> *I use pedagogical tricks every time I am going to speak in public, during marketing, lectures, seminars, reporting, or customer meetings. I often have use for mathematics in BI (Business Intelligence) missions and generally in financial management. In the latter case when working with economists, it is a great advantage to not be formula dependent, but to be able to derive all I need. (Comment in questionnaire, male alumnus, consulting company)*

Several alumni refer to the impact of ”significant others”, i.e. persons who supported their studies or their personal development. Learning from fellow students' approaches to mathematical problems and supervisors' support in school practicum were mentioned several times.

Positive outcomes of double degrees were mentioned more frequently than negative effects.

> *I have had very much use of studying this programme, especially when I was employed in a technical industry. In dealings with pedagogical issues, and as a teacher in upper secondary school my technological knowledge made me feel secure. My ten-year old industrial experience could easily be refreshed and I invented strategies to let my students make significant discoveries. (Comment in questionnaire, female alumna, mixed experiences from industry and schools)*

> *I have wide competence, as I do understand technology as well as humanities.* […] *I am not restricted to one single world. Varying perspectives make me a better problem solver, too. I am a secure leader and I can see the development of groups and individuals. My technical competence is good enough. (Comment in questionnaire, male alumnus, business company)*

However, disadvantages are reported, too. Width in competence is sometimes achieved at expense of technological specialisation.

> *Advantage: Flexibility in working life*
>
> *Disadvantage: Jack of all trades, master of none.*
>
> *(Comment in questionnaire, male alumnus, business company)*

> *The fact that I chose this programme hinders me from accessing jobs I desire. My real competence within nuclear technology is not sufficient; and my lack of formal ICT competence prevents me from getting an employment related to programming. (Comment in interview, male alumnus, organisation)*

3.2 Meanings of joint competences in alumni's practices

Two significant patterns related to self-assessed professional qualities among these alumni emerge in questionnaires. The respondents consider themselves to (1) be more socially competent than engineers in general, and (2) have more solid competence in the school subjects taught, not least in Maths.

Thanks to the interviews a detailed account of joint competences in various contexts is possible. When these narratives were processed step by step the following emerging pattern was formulated:

The programme matches new needs in present working life, i.e. that expertise knowledge is communicated to various kinds of recipients. The programme does not merely reproduce labour, but

rather support alumni in creating niches for themselves by pushing, widening and going beyond previous professional roles in working life.

As mentioned before, this condensed summary in propositional form was grounded by coding into three main categories based on twelve underlying concepts. These are as follows:

Table 1. Three main categories describing the alumni's competences and twelve underlying concepts.

	Material	Processual	Functional
Engineers	Catalyst Blocks Laminate Alloy	Interpretation Individualisation	Coordinator Innovator Hybrid
Teachers		Transfer Model	Exemplar

3.2.1 The material dimension

The material dimension refers to how integrated and how solid different elements of knowledge/skills appear to be, according to alumni's narratives.

Catalyst: An alumnus claims that he has learnt much more from experiences outside the courses at KTH and SU. Nevertheless, his assignments as well as interaction with like-minded students made him qualified to work with IT and communication with others; and thanks to his degrees he got the entrance ticket to professional challenges, which made him even more qualified, Thus, his studies had an indirect effect and could be called a catalyst, as they facilitated his progress and access to an interesting and enhanced position.

Blocks: Building blocks are selected or rejected depending on the specific task and situation at hand. This is a predominant pattern noted with a couple of alumni having a mixed repertoire of knowledge and interests related to Science as well as Humanities. They can use relevant skills in a number of different situations. These alumni are successful in their companies and may be open-minded for switching over to a school career.

Laminate: Laminate is an adequate name for a combination of actions, implying that competences related to engineering and education are involved. Thus, an alumnus employed in a finance company solves his analytical tasks by means of mathematical skills learnt at KTH; and the next step is to present his conclusions to the executive and clients in a pedagogical way.

Alloy: Alloy was introduced as a metaphor in the questionnaire, to convey how a new material with unique properties may be obtained from a mixture of quite different raw materials. An example was given by referring to steel, viz., iron plus carbon constitute an alloy (steel) which has unique qualities, different from its two original components. A self-employed alumna exclaimed ”steel” when she was asked to describe her competence. In solving her work tasks she used chemistry studied at KTH; and thanks to her studies in education she could do it so well.

3.2.2 The processual dimension

The processual dimension refers to what alumni do and how they perform their tasks.

Interpretation: A successful alumnus oriented towards ICT formulated his interpretive ambitions in relation to executives, subordinated colleagues, other departments, and customers. By experience he has learnt that it is necessary to explain problems and solutions profoundly, as making solutions without insights only leads to new questions over and over again.

Individualisation: A newly graduated alumna who is employed at a purchasing department of an industrial company neither feels like a complete technician, nor a complete educational expert, but

something in between. By support from specialists, she comprehends technical details, and tries to speak like an engineer with technicians and like a communicative expert with other people. She adapts her message to the specific individual or group.

Transfer: Transfer is a learning concept referring to the fact that practice in one domain, e.g. playing badminton, could have an impact on another activity, playing tennis. Thus, an alumna developed a theoretical mind thanks to her studies at KTH; and as a teacher of Maths and Chemistry this analytical approach is practised when she supervises teacher students in their school-based practicum. By expecting the teacher students to build classroom practices on learning theories and educational philosophy, she tries to transform teaching from a technical into a professional activity.

Model: Instructional videos in Maths, distributed by YouTube, made a future teacher a well-known pedagogical model before she graduated. By introducing mathematical topics in public, her colleagues and pupils recognised her from the very start. These contributions constituted the empirical base of her master's thesis, and several teachers used her videos in their teaching practises.

3.2.3 The functional dimension

The functional dimension refers to various kinds of impact related to qualities of the programme.

Coordinator: Alumni may also serve as coordinators. An alumnus describes how he coordinates a group of five technicians who are responsible for producing a significant component within a complex technological construction. In order to build a well-organized and well-informed team he introduced established routines, e.g. weekly letters to his staff and nearby groups. In order to prevent incidents his team participates also in staff meetings organized by the nearby groups, and the other way around. As a positive spin-off effect these routines have generated a constructive team spirit. Another alumnus describes how he serves as a bridge between engineers and co-workers with different background. His familiarity with engineering contexts and engineering education is of crucial value for coordination of their activities.

Innovator: The label innovator fits the task performance of another alumna. By practising boundary pushing, and even sometimes boundary breaking, she often transcends traditional ways of acting in working life. These innovations are neither expected nor hindered by her employer; it is just her un-conventional way of doing things. According to her narrative these transformations could be interpreted as an effect of her double competence.

Hybrid: An alumna claims that a person with her profile was wanted by her company before they even knew her. In fact, they had formulated the competence profile needed for a position held by Mr/Miss Somebody. But they could not find this hybrid person in real life. Consequently, the position was vacant for months until she did appear. Thanks to her double degrees, i.e. her combination of engineering and communication, she was found suitable for the job.

Exemplar: Alumni working as teachers may serve as exemplars. By choosing to work as teachers with their double degrees, they may contribute to raising the status of teaching.

4 CONCLUSIONS

Due to dropping-offs in relation to questionnaires the results from this study are not representative according to statistical requirements. However, the open-ended answers and narratives from interviews offer interesting insights into various contexts. Thus, according to qualitative criteria we consider the results to be valid.

Double degrees facilitate developing of alumni's mixed competences as generalists, as well in business companies as in schools. They seem to enhance their competences in dynamic spiralling, rather than deepening their knowledge in specific/narrow technological fields. However, generalist roles may have different profiles, and competition with a more well-known generalist programme, Industrial Management, could turn out to be a challenge.

In retrospect these alumni do appreciate the programme. Many respondents comment on the merits of Maths learnt at KTH, though only a minority of engineers use higher maths as a practical tool. On the other hand, maths serves as a prototype for problem solving in general. Studies and training in leadership, learning theories and communication offer important tools for most engineers. Alumni employed as teachers claim that they are more well-prepared to teach Maths, Science and Technology than other teachers, partly because they can illustrate phenomena by giving examples from other realities than the school context.

The main purpose of establishing this programme was to facilitate recruitment of future engineering students, by supplying schools with competent teachers of Maths, Science, and Technology. This aim seems to be partly satisfied, as a significant number of alumni work as teachers, but the other noticeable consequence seems to be that working life outside schools became enriched with engineers who are good at leadership, communication, and learning. Trevelyan's findings that contemporary engineers are more involved in human interaction than expected is confirmed and illuminated in our study by several cases [1]. That is illustrated by the following dialogue:

> *Researcher: In the questionnaire you have written: 'We became academic chameleons'. What do you mean by that?*
>
> *Alumnus: We can adapt to a context populated by Communication officers; but also to IT specialists, as we do understand their conceptual framework.*

That phenomenon could be interpreted as a changed relationship between technology and the present society. Originally, engineers were trained in military academies. In modern society they became civil servants to support and revise procedures in factories. However, in the postmodern society knowledge is decentralised to a great number of individuals. This is the case not least in relation to information and communication technology. So, taking a double degree in higher education is not only a safety strategy that enables alumni to change professions during their lives' span, but it could also turn out be a career advantage to combine competences from different domains.

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Conflict of interests: Cronhjort is the present Programme Director of 'Master of Science in Engineering and in Education'. However, he was not involved in the programme when our respondents were students. Naeslund and Nyberg belong to Departments involved in the programme, but they have not been involved in the programme before this study.

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