The teaching-research nexus in engineering education: A case study

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1 INTRODUCTION

1.1 The teaching-research nexus

The teaching-research nexus is a central feature of academic tradition and an ideal widely recognised, for instance as manifested in the *Magna Charta Universitatum* [1]. Originating from the ideas formulated by von Humboldt in the early 19th century [2] the teaching-research nexus is nowadays frequently emphasised in university policy documents. Advantages highlighted include that the students acquire an understanding of recent research, that curriculum is inspired by research conducted at the university and that the students are given the opportunity to conduct research on their own and thus become part of the scientific community [3]. These policies are in line with empirical findings of a wide spread belief within the academic community that there is a strong link between teaching and research that is mutually reinforcing. Faculty understand the link to operate on different levels. First, that teaching is an act of transmitting advanced knowledge generated by research; second, as the development of a specific approach and attitude among the students towards scientific knowledge which also promote a stimulating environment for the faculty;

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and third, that teaching and research interact on the departmental level in relation to the scientific discipline in a wider context [4]. Furthermore it is thought that doing research ensures a commitment to the subject and guarantees that the education is a jour with the international research frontier [5]. Beliefs in the linkage are however not unanimous, as it has been shown that university teachers' understanding of the teaching-research nexus range from seeing the two phenomena as a joint process to being substantially unrelated [6].

Inquiring in what ways teaching may be grounded in research, Griffiths [7] has presented a taxonomy, which has been further developed by Healey [8] and is illustrated in *Fig. 1*. Building on two dimensions, the model results in four categories with regard to whether the teaching setting is more focused on the students or the teacher and whether what is taught has an emphasis on research content rather than research processes and problems. An empirical investigation making use of the model was conducted by Elsen *et al.* [3] who conclude that the horizontal dimension is useful in practice but not the vertical one since it is hard to delineate what constitutes a focus on the students and the teacher respectively. They propose to alter the vertical dimension and instead use a measure of whether the students are only receiving knowledge or whether they also produce knowledge. A third possible dimension could be whether the research informing the teaching sessions are produced by the teacher or his/her department or if it is produced elsewhere.

While considering the teaching-research nexus one should not overlook the fact that teaching activities also may have an important impact on research. For instance, it has been suggested that teaching could be understood as an opportunity for the researcher to reflect on his/her results in relation to the students as representatives for the wider community, while the students learn from ongoing research [9]. Conceiving the nexus in this way depicts it as a symbiotic relationship, but does however clearly assume that the researcher is teaching his own research. As Angela Brew [10] has shown, academics' conception of knowledge is decisive in whether the teaching-research nexus may be enhanced or, as she fears, will deteriorate. While a traditional conception of knowledge as objective and transmittable is operating to distance research and teaching from each other, an understanding of knowledge as constructed within a socio-political context may instead create a more symbiotic relationship where students inform research in a similar way as research informs teaching. This may, as noted by Burke and Rau [11], make teaching "influence research by stimulating meaningful research questions, challeng[e] researchers'

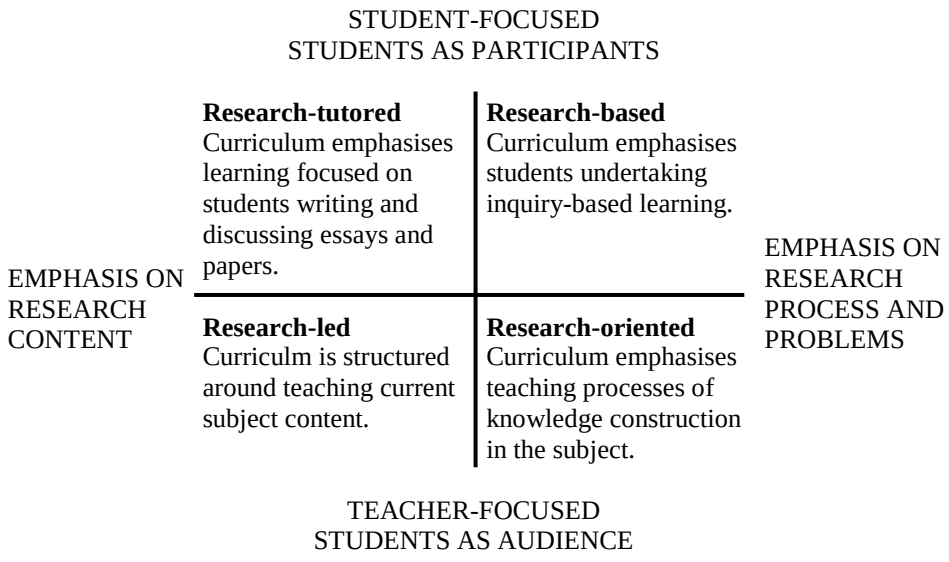

Fig. 1. Curriculum design and the research-teaching nexus. Source: [8].

thinking, and creat[e] excitement and energy around further research." Thus, the fact that teaching and students ideally could have a large influence on research should not be forgotten when studying the teaching-research nexus.

Despite the attempts made to explain the relationship between performance in research and teaching, empirical studies have failed to establish any firm relationship between research productivity and teaching quality [12, 13]. Part of the reason is presumably that the relationship is far more complex than the way it has been presented so far. At a structural level there are a number of factors influencing the preconditions for faculty to be able to uphold a close linkage between teaching and research. This include incentives in the form of both financing structures and career paths, as well as the strategic management of the academic milieu at all levels. These factors may operate by themselves or interactively. Regarding career paths and promotions for instance, experimental studies have shown that research activities are being rewarded far more than teaching and service activities [14]. Empirical evidence has shown that as individual incentives are encouraging faculty to invest their time in research, a pragmatic strategy is often used for the staffing of teaching activities. This has resulted in an evident division of labour among the ranks of faculty, where less research-active staff takes on the bulk of teaching activities and where the pattern is sustained year after year for efficiency reasons [15].

Other tensions are also operating in the relation between research and teaching, in particular within vocational education where labour market links historically have had a prominent role. In engineering education there has for instance been a discussion about 'academic drift', implying a shift of focus from industrial practice to esoteric bodies of knowledge. [16]. However, concerns have also been raised about a "curriculum creep" where industrial needs are taking priority over the research links in teaching [17]. Some of the studies conducted on the teaching-research nexus has explicitly intended to improve the links. The widely noted Boyer Commission report [18] proposed ten recommendations for improving undergraduate education at American research universities. They included among others using more research-based teaching; removing barriers to interdisciplinary education; creating a stronger integration between undergraduate students, graduate students and faculty; and changing faculty reward systems to value teaching as high as research. A consistent theme is the need for more unity and to cultivate a sense of community, both among students and faculty but also between disciplines. [19]

1.2 Research questions

It is apparent that the teaching-research nexus is a matter of quite some complexity with a number of factors influencing the outcome and with several tensions involved. But how are these tensions perceived and handled by faculty and managers? What factors do faculty think influence the teaching-research nexus? What incentives are there to promote and to thwart the nexus? Which of these are effective in influencing the behaviour of faculty? These are some of the questions we pose in our ongoing study. Hence, we will address the perceptions and behaviour of the faculty with regard to the issue of the teaching-research nexus. Our primary interest is to inquire how faculty and managers perceive the tension between academic ideals and countervailing forces such as industrial needs, promotion criteria or financing structures, and how this in turn influences their behaviour. This will be studied on a more general level as how time and responsibilities are managed by faculty but also closer to the practice of teaching and research, as in how these duties are carried out. In this paper, we will discuss some early findings, mainly from the management perspective.

1.3 Methodology

The overall aim of this project is (I) to examine how the link between research and teaching is realised in practice, (II) to map different stances and approaches to the teaching-research nexus among faculty and (III) to explain the occurrence of these. In this paper, the initial phase of the project and some tentative results are presented.

The study will have a sequential model mixed methods design [20] with in-depth interviews with key members of faculty, case-studies of two schools, and a survey to all faculty members. Additionally, the study will contain a comparison with technical universities in other countries and an analysis of policy documents. The following aspects will be covered during the project: leadership and management, funding structures, career paths and incentives, and pedagogical issues. Eventually, we will build our analytical model on developed taxonomies [3, 4, 6, 7, 8].

Regarding the case studies, the plan is to select two schools that have a strategy regarding the link between research and teaching, i.e., the School of Chemical Science and Engineering and the School of Electrical Engineering. The idea is to compare two departments in the same university to be able to hold institutional factors constant while allowing variety at the school level. The case studies will include documentary studies and interviews with faculty members.

Our case university, KTH Royal Institute of Technology, is a single faculty research intensive technical university, organised in ten different schools. [21]. In terms of ranking, KTH was in 2014 ranked as no. 126 on the Times Higher Education list of universities in the world, and as no. 18 among the engineering and technology universities in the world [22]. In 2014, KTH had a total turnover of 4,637 MSEK. 31% of the income is related to education in first and second cycle, and 69% is related to research and doctoral studies [23]. However, the different schools differ in a number of aspects, e.g. in terms of the division of incomes related to education and research [24].

2 FINDINGS

2.1 Documentary studies

In order to study the link between research and teaching in KTH policy documents, the following documents and evaluation reports were examined; KTH Strategic plan 2013-2016, Quality Policy for KTH 2011-2015, Vision 2027 KTH's long term strategy, and reports from the Education Assessment Exercise 2011 and the Research Assessment Exercises of 2008 and 2012.

In the *Strategic plan 2013-2016* [25], the link between research and teaching is conveyed. It is stated that educational programmes at KTH should be characterised by e.g. a solid research base and that contact with research should be established already in an early stage in the programmes. Additionally, it is established that research will have a positive influence on the educational programmes since all faculty members will be involved both in research and teaching. In the *Quality Policy for KTH 2011-2015* [26], the research-teaching nexus is emphasised whereas it is stipulated that research at KTH has an essential role in ensuring the scientific base of the educational programmes. It is also mentioned that research will be integrated in teaching since researchers will teach and teachers will do research. Additionally, the link between education, research and innovation is presented in *Vision 2027 KTH's long term strategy* [27]. In this document, it is stated that the three aspects of the knowledge triangle will be well implemented and integrated at KTH. Furthermore, the

vision stipulates that teaching and pedagogical skills will be more highly valued and there will be closer links to research in education at bachelor level.

In 2011, KTH conducted a comprehensive evaluation of the educational programmes, called the Education Assessment Exercise (EAE) [28], with the purpose to contribute to further quality enhancement of education at KTH. One of the strengths presented in the evaluation was the strong research base at KTH, even though this advantage was identified as a domain that, at least in some areas, could be improved even further. One issue raised in the EAE was the question of the value given to teaching and research respectively. It was concluded that '[m]any calls are made for according education the same high status as research' (p7). At KTH, two Research Assessment Exercises (RAE) have been performed, the first in 2008 [29] and the second in 2012 [30]. In the RAE 2012 report, the research-teaching link is not mentioned, while in the RAE 2008 report, the poor balance between research and education and particularly the fact that there are departments with a considerable teaching load is concluded to impair this link, which in turn is seen as 'a problem that needs attention in a university that aims to be one of the leading forces in technical research and higher education' (p 39). Thus, both EAE 2011 and RAE 2008 emphasise the need for being observant regarding the research-teaching link.

2.2 Interviews

After conducting a smaller number of interviews with top managers at the university's central administration our early findings highlight a number of themes. First, we can note that the general opinion is that all faculty should have considerable time dedicated to both research and teaching. To develop the skills necessary to perform research and teaching at a high level it is believed that one needs to dedicate a minimum amount of time to either activity. The amount of time for each activity may however differ between individuals; there is no value in strictly prescribing a certain proportion for all faculty. On the contrary, flexibility is held in high regard. Every individual cannot excel in research, teaching and third mission activities, but together, as a group or unit, it is possible. Furthermore, the possibility of being able to focus at one thing at a time is appreciated, even though this could risk creating a division between teaching and researching staff, which is regarded as highly undesirable. Additionally, the view that faculty should do both teaching and research is also confirmed by representatives from the Student Union.

Another major issue with relevance for the teaching-research nexus is funding. Some disciplines have large teaching loads but not so much research and vice versa. At a university as the case in point here where the faculty have to attract their own external funding for research it will always be hard to elevate the importance of teaching, according to our informants. An ideal would however be that all faculty should be funded by the university's direct state revenue and the external funds acquired would be used to hire researchers temporarily. As for now, faculty with permanent contracts are obliged to attract funding in order to cover their own salaries. Another issue on the same topic relates to the ability of the top management to act strategically. It is being increasingly common that external funding bodies demand a high degree of co-financing from the university. This means that the top management cannot make their own decisions on which areas to make strategic investments in since their resources are locked up to co-finance research projects selected by the external funding bodies.

Promotions and career tracks are themes frequently discussed in the literature on the teaching-research nexus. Among our informants there is a consensus that there is a widespread view among academics that merits in research is more prestigious and

valuable than in teaching, but also that there seem to be a misconception of what is being required for promotions today. The requirements for promotions at KTH were reformulated in 2008 and since then the pedagogical requirements are high. On the other hand, the view is also expressed that while teaching skills are highly appreciated, research skills are essential for anyone in an academic position. Without a wide understanding of the discipline and a close connection to the research frontiers the teaching is thought to become trivial and quickly outdated. While these statements may be understood as a confirmation of the wide spread belief that research skills are more valuable than teaching skills, it may also be understood as praise of the teaching-research nexus since what is expressed is essentially that research adds something vital to teaching, something that may be part of what constitutes higher education.

At a technical university such as KTH, it is impossible to discuss the teaching-research nexus without also discussing the links to industry. In both teaching and research the links to industry are strong and while it has been stated that this could cause a tension between purely scientific ambitions and practical industrial goals, our informants underline the possible reciprocity between the two ambitions. Even though they also attest to the existence of different cultures within the university with different emphasis on industry connections or scientific purity, there is also testimony of how this tension may be overcome.

3 SUMMARY

The topic of this paper has been teaching-research links at a Swedish Technical University. In summary, the policy documents analysed present the ideal of a close link between research and teaching. However, this link is presented at an overall level, thus not in detail how this link is expected to be accomplished and performed. Moreover, it is presumed that research will have a positive influence on education based solely on the fact that all faculty members will do both research and teaching. Another aspect worth noting is the fact that the link is assumed to be established already in first cycle.

The interviews with senior managers display a complex picture. Altogether, there are a number of factors acting as separating forces between teaching and research. Our informants highlight the fact that Swedish HEIs receive their state revenues as two separate grants, one for teaching and one for research, as formative in this sense. It affects the everyday actions of the faculty and creates a contrast between the two activities. This may however be handled differently by the HEIs and their subunits, but as we have seen this seems to be an exception rather than a rule. Our informants emphasise that in the long run it is essential for the university to maintain a high quality in both teaching and research and that the academics have enough time for both activities. This is understood as first and foremost a cultural issue that demands continuous efforts from the management in order to avoid that the easy decisions are taken. It is vital to foster an academic culture where it is natural for all faculty to conduct both activities. However, doing both teaching and research does not necessarily imply that there is a strong teaching-research nexus, but it is understood as a prerequisite. For the nexus to materialise, academics need to be convinced that there is an individual gain in actually adopting the ideal. Since research is still thought to be more valuable for promotions and also more profitable economically it will probably be hard work to enforce such a change of culture.

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