Engineering teachers' approaches to teaching and learning online

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This work in progress research reports on an ongoing study with the aim to explore engineering teachers' approaches of teaching and learning online. Digitalization of higher education is a fact and raises new challenges for academics when creating education of high quality. Adopting phenomenography as a qualitative research approach, the preliminary findings suggest that teachers from the technical and engineering sciences experience teaching and learning online in four qualitative different ways. Teachers experience teaching and learning online as: A) knowledge-building units, B) isolated learning, C) pathway for learning and D) enabling changes of teaching and learning activities.

Keywords—online teaching, phenomenography, teachers' experiences, higher education, approaches to learning

I. INTRODUCTION

Today, distance education and blended learning has become widespread ways of offering courses that higher education institutions need to respond to, in one way or another. Technology has the potential to transform higher education, but research has shown that university teachers have different motives and intentions with using digital technology in teaching [1]. The use of technology in education vary from aiming to increase efficiency, facilitate students' learning by engaging students to take more responsibility for their learning process, as well as redefined student and teacher roles [2]. A recent review presents similar findings, but concludes that the "potential of technology to transform teaching and learning practices does not appear to have achieved substantial uptake, as the majority of teachers focused on reproducing or reinforcing existing practices" [3].

It is well known that online teaching includes other demands on teachers in comparison to on-campus teaching [2]. For example, researchers have found that some teachers "viewed pedagogy as being dictated by technology" showing little insight into their own strategies when teaching online [4]. Englund et al. found that university teachers have different ways to approach and conceptualize the use of technology in education, where novice teachers developed their approaches and conceptions over time towards a more student-centered view, in contrast to experienced teachers [5]. Teachers' approaches to, and conceptions of teaching and learning, as well as, the relation between different teaching approaches and student learning, is a well investigated area [6-8]. However, little is known about engineering teachers' understanding of teaching and learning online. The transition to online teaching and learning may change expectations on students, as well as, add new tasks and change teachers' roles [2, 9]. Moreover, the shift from classroom to online teaching, can make teachers reflect on their teaching practice, such as their intentions and goals, course design and how to engage students [3]. Hence, teachers understanding of teaching and learning may change when they engage in delivering online education.

The scope of this contribution is beyond the discussion about the type of online learning (e.g. distance, blended) [10]. Rather, we take an interest in engineering teachers' approaches related to designing and delivering educational activities online, regardless if this is made via the university's local learning management systems or, platforms that enables more global settings, for example massive open online courses (MOOCs). However, we limit this study to teachers that are involved in delivering whole courses (such as minimum 5 weeks full study for students) and not just single online activities. The aim of the present study is to explore engineering teachers' approaches to teaching and learning online and thus capture the experiences of enactment. This means that we explore how the teachers' understanding is expressed in their doing.

Here we use the term teaching and learning online to refer to all teaching activities planned and conducted by teachers in digital environments, and all student activities undertaken in digital environments, or in relation to course material that is available in the digital course environment. With the term engineering teachers, we include teachers from various technical fields and study programs such as computer science and mechanical engineering.

A. Research about teachers' approaches to and conceptions of teaching and learning

Previous studies about teachers' conceptual understanding of teaching and learning have had a substantial impact on faculty and staff development activities [11]. Several studies point to a similar direction, namely that teachers' approaches to teaching and learning can be described in two contrasting orientations, and that those different orientations influence how teaching is planned, delivered and evaluated. The 'teacher-centered' view, which is *a combined focus on the teacher, the*

teaching strategies, and the transmission of knowledge from teacher to students. This approach is often connected with novice teachers, or teachers that have not reflected about how their students learn. The 'student-centered' view, which *is a combined focus on students, their learning and development and conceptual understanding*, is often practiced by teachers that have reflected on teaching and their students' learning. The student-centred approach is considered more sophisticated because the teachers' focus during a teaching and learning situation includes what is happening for both the teacher and the students. However, these views are not stable constructs but can change with teaching contexts. Thus, even teachers with sophisticated understandings (well reflected) about what learning and teaching means, may sometimes focus more on their own performance than their students' learning [6, 11].

The discussion about teacher-centered and student-centered approaches to teaching and learning has been discussed in the literature for the past two decades. Studies show that the way teachers understand teaching and learning affect how they conduct their teaching and what kind of learning activities they organize [12].

Mimirinis have studied academics' conceptions of e-assessment and found that academics approached e-assessment as a means of managing the assessment process, facilitating dialog and student engagement, enhancing student learning and as a mean to develop identity in the community [13]. Mimirinis focused on academics' *conceptions* about e-assessment rather than their understandings based on experiences, i.e. what e-assessment meant to them [13]. In this study we instead investigate the qualitative different ways to approach teaching and learning online with the starting point in the making of teaching and learning online.

Online learning and teaching are increasing [5], and this study aims to contribute to a deeper knowledge about teachers' approaches to teaching and learning,   Enacted practice goes beyond espoused views of a concept.

II. Methodological approach

We used phenomenography, which is a qualitative, research approach useful both for analysis of empirical data, and as a theory that describes how humans experience phenomenon in the world around them. Phenomenography is a well-used research approach that enables researchers to study how individuals approach a phenomenon [14]. A second order perspective is used in studies undertaking a phenomenographic approach, meaning than it is the relation between the phenomenon and the individual that is in focus [14], rahter than an attempt to describe the essence of the phenomenon as such.

Phenomenography is based on the fundamental assumption that people have qualitatively different ways of understanding phenomena, and these various understandings can be identified through analysis [15]. Phenomenography is explained extensively in the literature, and it is premised on the notion that individuals understand, interpret and experience phenomena in a number of qualitatively different ways. From a phenomenographic perspective, teachers' conceptions are not 'either or', but shows the depth of awareness, and can vary with different situations.

A study, undertaken with a phenomenographic perspective, search for the variation in awareness of a phenomenon [15]. Since the purpose is to maximize the variation of experiences, it is favorable to recruit respondents with different backgrounds, like age and so on [16-18]. The result from a phenomenographic study is referred to as the "outcome space" and represents a description of different categories of experiences, on a collective level [17].

III. Study design

The phenomenon in the present study is teachers' approaches to teaching and learning online in the context of engineering education. Engineering teachers include teachers from different disciplines within technical and engineering sciences (e.g. chemistry engineering, computer science mechanical engineering). The data was generated by semi-structured interviews conducted by all three authors, in pairs or individually, and was recorded and transcribed before the analysis was made.

In total, fifteen academics in technical and engineering sciences from two universities in Sweden (uni A: n=8 resp. uni B: n=7) were interviewed. The interviews lasted between 30 and 70 minutes. The participants were chosen based on their previous experiences of creating and delivering open online courses. The sample criteria was made to make sure that the informants had at least one experience of conducting online teaching, but all informants had additional experiences of online teaching. In order to ensure variation in approaches, teachers from different stages in their academic career as well as from different engineering disciplines were included in the sample. Of the fifteen academics, three had a position as lecturers (2 uni A and 1 uni B); one was a PhD student with extensive teaching experience; two were employed as researchers but frequently involved in teaching (1 uni A, 1 uni B); six were associate professors (3 uni A, 3 uni B); and three were full professors (1 uni A, 2 uni B). Both men (12) and women (3) were represented.

During the interviews, the informants were asked about how they conducted teaching and learning activities online, their intentions with different learning activities, and how they made use of online activities in regular engineering courses at the university. Questions about how teaching and learning was conducted online in relation and comparison to regular campus classes were also asked. The aim with the interviews was to let the informants, openly and freely, describe their work with teaching and learning online based on concrete examples. During the interviews, probing questions were used; all participants were asked to describe the work they had conduced when working with designing and delivering MOOCs. Follow-up questions such as "can you elaborate more on that" and "can you describe that deeper" were used in order to obtain clarifications and explanations. All informants were encouraged to, also describe, if, and how they made use of online learning in campus-based courses besides MOOCs.

A. Analysis

The analysis in a phenomenographic study follows a common procedure [see for example [13] or [19].

The analysis was made iteratively by following the procedure described and illustrated in table 1 [19]. The

familiarization of all the fifteen interviews was conducted by the first author in order to get an overall impression of the data but did not, to a lager extent, inform the analysis of the four transcripts that were analysed in depth for this work in progress paper. During the familiarization stage recurring perspectives on teaching and learning were noted after which four of the interviews (all from university B) were selected to be analyzed in more detail by a procedure following the steps in table 1.

The analysis was discussed among all the authors several times during the analysis in order to ensure intern validity.

Familiarization: reading through the interview transcripts to get a feel for how the interview proceeded; at this stage all data in the data set are given equal consideration
Condensation: identifying meaning units and marking these for the purpose of further scrutiny; the size of the meaning units can vary; different fragments of sentences can be associated with different ways of experiencing the phenomenon
Comparison: comparing the units with regard to similarities and differences
Grouping: allocating responses that express similar ways of understanding the phenomenon to the same category
Articulating: capturing the essential meaning of a certain category
Labelling: expressing the core meaning of the category; steps 3–6 are repeated in an iterative procedure to make sure that the similarities within and differences between categories are discerned and formulated in a distinct way
Contrasting: comparing the categories through a contrastive procedure whereby the categories are described in terms of their individual meanings as well as in terms of what they do not comprise

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Figure 1 - analysis procedures described [19]

IV. RESULTS

The preliminary findings show four qualitatively different ways that teachers approach teaching and learning online. These approaches were: online teaching-learning as: A) knowledge-building units, B) isolated learning, C) pathway for learning and D) enabling changes of on-campus teaching and learning activities. The different categories seem to be hierarchically ordered, with the most naïve way to understand teaching and learning online represented by the first two categories, A and B (parallelly ordered), followed by the categories C with D as more sophisticated ways to approach the phenomenon. We describe the four categories below, each illustrated by a quote from the interviews.

A. Knowledge-building units

This category entails the meaning that teaching and learning was taking place in solitary knowledge-building units. Teaching online is a matter of defining knowledge units and placing them into a context. The teacher viewed the course content as small knowledge packages that together can build up a larger understanding of the content (sum of pieces of specific knowledge). This understanding of teaching and learning online is expressed by one of the informants as:

"Movies, and so self-study. 'Have I understood'-quiz, video, have I understood"-quiz, etc. No texts, everything is filmed and in English. [...] these stand for themselves so if you want to go in and cherry pick, 'I want to know about that topic and that topic' then you can do that. And you can rewrite the order on them, they do not refer to each other but everyone is their own (entity)."

This way to approach teaching and learning on-line put an emphasis on subject matter focus meaning that the teacher most focus on package and deliver topic content in clear sections that can be learnt independently from each other. Students are invited to take part of knowledge-building units including different parts as videos, learning activities and assessment.

B. Isolated learning

In this approach teaching and learning online is understood as learning occasions isolated from any larger context. The digital solutions build up spaces where learning is taking place only through the material present at, for example, the platform without including other perspectives or previous learning experiences or knowledge of the students. This way of experiencing online teaching and learning is illustrated by following quote:

"I built my small modules in that way, clear strict terminology and constructive alignment by reusing the content as much as possible. I was thinking very hard, put in a lot of thought on having technical program examples that could follow and illustrate various concepts throughout the course."

This approach implies a content and a teacher focus. This means that the teacher designs and deliver course material and do not connect it to students' pervious knowledge, experiences, or activities outside the virtual learning space. Everything the teacher thinks the students' need in order to learn is provided in the virtual learning environment.

C. Pathway for learning

This more elaborated way of understanding teaching and learning online is characterized by the teachers´ willingness to support students learning by creating one well-designed path for the student to follow. The path is created through the teacher's work of sorting the subject matter and content, screening away disturbing elements, and putting the relevant part in direct focus in order to, in a strict and systematic manner, guide the learner. Defining and creating the path is a task for the teacher, the student engaging in the learning just follow the path. This approach emphasizes the teacher's role to keep track of the pieces and relate them to a bigger entirety. Following is an extract from the interview that illustrates this way of understanding teaching and learning online:

"To see the whole course and then go down to the building blocks and up again, it is a lot about to move up and down.[…] No, they (the students) don't have to ride the elevator, they follow my cut path, okay, and then they understand, and use that concept."

The teacher focuses on creating one (1) smooth and well-designed pathway, the students should follow in order

to learn. This approach to teaching and learning online means an emphasis on the learning process.

D. Enabling changes of teaching and learning activities

This category entailed the view that teaching and learning online is approached as an enabler to develop and implement improved teaching and learning activities, such as methods with focus on active learning. The focus for this approach is on students learning of the specific topic. The aim with these methods, that teaching and learning online cause, is expressed that they should lead to higher quality in student learning (deeper discussions for example). Development and use of teaching and learning online is understood to be an enabler for such improvement.

This way to experience online teaching and learning is illustrated by following quote from one of the interviews:

> "Our motives to [create a MOOC (authors note)] was that we could use it in our campus teaching and thereby upgrade our on-campus courses."

Teaching and learning online is approached as an enabler because of recourses available for the development of teaching and learning content, and also for the effect the process of rethinking teaching and learning for online purposes have on on-campus teaching. Teaching and learning online is approached as a new way to approach learning of the subject matter and this gives insight to how the subject matter should be taught online as well as on-campus.

V. DISCUSSION

Teachers' conceptions of teaching and learning are, from a phenomenographic perspective, not stable and fixed but are a matter of different perspectives of awareness that are dependent on the situation [15]. From this follows that teachers' conceptions of online teaching and learning can be different from conceptions of teaching and learning on-campus because of the different situations, even if the content is the same. The research on teachers' conceptions of teaching and learning is well known and the findings in this study are in line with previous results [2-5]. The first two categories (A – knowledge building units, and B – isolated learning) focus on how to organize and deliver the content. The teacher emphasis is on the subject matter and how it can be presented. In the other two categories (C - pathway for learning, and D – enabling changes of teaching and learning) the teacher has a broader awareness that also takes learning into account, although at different levels. A more sophisticated approach to teaching and learning is an approach that includes the perspectives of both the teacher and the students, of both teaching and learning [15].

Our results add and thus contribute to a more nuanced picture of how teachers approach teaching than the traditional studies in this area, as we look at how teaching is experienced in the online environment. Category A, B and C focus on the teachers work to create a structure and present the content that the students are supposed to learn. These different approaches to teaching and learning online are based on the teacher's perspective and his/her understanding of where the students' starting points and needs are. They do not take into account students different needs and perspectives; the students are approached as consumers of the delivered material.

The last, and here referred to as the most sophisticated way to experience teaching and learning, category D (enabling changes of on-campus teaching and learning activities) shows an understanding of teaching and learning online that takes the students' needs and perspectives into account. The category includes an understanding of teaching and learning online that learning online is not sufficiently enough in order for the student to develop more complex and high level of knowledge and skills. For this purpose, on-campus teaching has the dominate role. For example, for some teachers in our study the intention with engaging in online teaching was to develop material that also can be used in the ordinary on-campus courses.

Our findings, as well as previous research, show that teachers differ in their conceptions and approaches to teaching in online educational environments [3, 5]. Moving from on-campus teaching to online teaching can invoke new reflections on teaching and subsequently students' learning, as exemplified by the teacher in our study who talked about how he thought about the content as moving up and down in levels of abstraction when he designed his course. Our assumption is that it is not only the process of rethinking teaching and learning of a specific subject matter on-campus to on-line teaching that gives rise to how teachers approaches teaching and learning online. It is also affected by the platform providers' structure and functionalities, e.g. what is possible to do on platforms and how the virtual learning space is structured. The technology used for online teaching may cause limitations when teachers design their teaching [3]. However, whether this was an important aspect in the two more content-focused categories (A and B) in our findings is yet not clear and would benefit from more in-depth explorations. The full paper version of this study aims to provide more insight to this aspect.

Furthermore, it is of interest to understand, in more deepth, the different approaches teachers have when it comes to online teaching and learning in relation to their on-campus teaching and learning.

VI. IMPLICATION FOR PRACTICE

We are well aware of that reported findings are tentative but would still argue that the different ways to experience teaching and learning online has implications on how the teachers act when designing teaching and learning activities online. Future work with faculty development on institutional level as well individual teachers working with digitalization of teaching and learning may need to consider the implications of this study in order to create teaching and learning in the same (or higher quality) online in comparison to classroom teaching.

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