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Close the gap: How can design of learning environments shape engineering students' professional identity and prepare them for workplace?

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***Abstract*— Engineering educators are under increasing pressure to provide university students with learning experiences that prepare them for the work after graduation. To understand how educational design can close the gap between engineering education and industry, we need to understand learners' professional identity practices. In particular, how these practices are shaped by the design of learning materials, learning spaces and learning events. Previous research provides little insight into such relations. We address this gap in two ways. First we propose a new concept of implied identity. Second, we illustrate and discuss implications of the proposed conceptualization of professional identity by drawing on a set of interviews conducted with engineering students in an Australian university with the aim of investigating their perceptions of engineering and unfolding aspects of their professional beliefs in relation to their experiences at two universities and industry.**

I. Introduction

ENGINEERING education has been framed as the development of students' professional identity by many educators and scholars in recent years [1] [2]. Preparing learners for requirements of workplace engineering practices is at the core of this perspective. While universities are expected to prepare students to become professional engineers, little is known on how to facilitate this learning process and close the gap between university formal education and what learners face after graduation.

To understand how we can close this gap, we need to unpack a) the process of learners' professional identity development in higher education and b) how this process relates to educational design. In other words, we need to investigate if and how the design of learning materials, learning environments and learning events can influence the process. A broad review of literature on professional identity development in higher education [3], illustrates a lack of a focused discussion that uncovers and explains such relations. Even more importantly, there is need to define more precisely what the term of professional identity means and to discuss its possible implications for higher education learning, teaching and assessment. In the following we propose a new conceptualization of professional identity and illustrate how it could be used in studies of professional identity development in higher education.

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II. Professional Identity Development and Educational Design

We use the term, professional identity, to refer to one's sense of belonging to a community of a profession due to positioning practices in relation to a profession including self- positioning and being positioned by others. Positioning theory is a theoretical framework from discursive psychology background that looks at how people position themselves and others in conversation [4]. "While positioning theory is more concerned with how people position themselves and others in a conversation and offers ways of looking at conversation to uncover different aspects of positioning, we suggest looking at educational designs as resources of positioning and professional identity among many different identity resources surrounding learners, including readings, learning spaces and conversations." [5] Furthermore, we apply the term implied identity to refer to aspects of professional identity suggested to learners in their experiences of learning situations [5][6]. We further distinguish implied, perceived, identities with intended identities. "We use the term intended to refer to all identity aspects that are either purposefully or implicitly included into the course design work by educators" [5]. Example of aspects of engineering identity often purposefully intended by engineering educators are the ability to design and conduct experiments and the ability to exercise critical decision making. While aspects of the professional identity

are intended by educational designers, they might be perceived and practiced differently by learners. This means, learners might experience intended identities in a different way according to their own interpretations of implied identities.

In the current paper, we take a holistic approach to the process of professional identity development by considering the relations between educational designers, educational design and learners' experiences of it in the form of implied identities.

III. RESEARCH DESIGN AND METHOD

We designed an empirical study to investigate implied identities, of being an engineer, as perceived by engineering students during their studies at two universities and as compared with their perceptions of workplace engineering practices. We were interested to get an insight into their beliefs about the discipline. Here we draw on the data from two participants who studied engineering in several universities and address the following research question: How do perceived implied identities from different universities differ among the two different participants?

A. Phenomenographic approach

Phenomenogrpahic approach provides an opportunity to identify similarities and differences in the way people experience and see the phenomena in their surrounding world [7]. Similar to our proposed definition of "Implied Identity", phenomenography has its philosophical underpinning in interpretivist paradigm and explores different ways that people think about and experience phenomena. Therefore we applied the phenomenographic methodological approach in this study.

We explored different ways that students think and talk about engineering experienced in two different universities and as compared with workplace. To this purpose, we conducted a set of interviews with undergraduate students of engineering at one of the Australian universities. Interview questions were designed based on the phenomenographic approach to understand how participants experience engineering through their formal experiences and more informal situations such as social interactions in society.

Each student was interviewed individually. The interviews were conducted in a semi- structured format and the interview questions were based on individual's reflection of their experiences.

B. Data analysis

In order to get a broader perspective about the influences of educational design on perceptions of engineering participants were selected among those who had experienced more than one university. Consequently, two interviews were selected purposefully from participants who were exchange students from Brazil. Interviews were transcribed and transcriptions were inductively analyzed using NVivo as a tool to find emerging categories of experiencing engineering in different contexts. In the following section we draw on the results from this analysis to compare the two cases.

IV. RESULTS

As summary of the results are shown in table 1, the two participants perceive different implied identities through their learning experiences at the two Australian and Brazilian universities. In other words, the Brazilian and Australian educational context have different suggestions of "becoming an engineer in the view of the two participants.

TABLEI

Implied Identity	Brazilian University	Australian University
Participant 1	Theory based engineering practices	Practical and project based engineering practices
Participant 2	Individual work and assessment	Group work

[a.] Preliminary Results

Participant 1 defines engineering as using resources to the welfare of people. In comparing engineering work at the two universities he thinks his experiences of engineering have "changed a little" since he has started his stay at the Australian university. He says:

"back home we have a lot of theory and very little projects, […] when I came here, I got my first projects"

In addition to perceiving the implied engineering identity, in his experience of the Australian educational life, as practical based, he thinks problems are tackled with different approaches in the Australian educational context. He explains:

"the difference [between the two universities] is that we have so much theory back home, while here they have this more technical approach. And you have certain freedom to approach a problem. In comparison, back home they give you the specific theory to solve that specific problem."

Furthermore Participant 1 continues that the way one experiences and perceives engineering "*depends on where you are learning, or what kind of activities you are doing."*

In his comparison of engineering practices at the university and workplace he thinks workplace environment requires getting involved as specialist and being focused on specific aspects of engineering. He mentions:

"in the workplace you will be focused on something, while in University you have this multiple things you have to deal with. So when you are working you start to become specialist or something. I guess that would be the biggest difference."

He further adds:

"Even though in the University we have team work, I think it's much stronger in industry, because the scale in industry is different, and in University you are achieving grades, meanwhile in industry you are achieving the final product, or final task, a final objective."

Despite the discussed differences between university and workplace engineering practices, he thinks the same competencies are required to work as engineers in both settings:

"you still need those same skills you had in University, how to achieve new knowledge, or how to achieve knowledge that you still don't have."

Participant 2 defines engineering as an important profession for the society because:

"it produces goods and products for society, including construction from civil engineering, and chemical products. So I think it's a very important field to get to society what they need in an economical way and sustainable way."

To compare engineering practices at the two Brazilian and Australian universities he thinks:

"*here [in Australia] you have a lot of group work. I think it's good, because engineering, if you do... in actual workplace you work in a group, you have a group for something. And in Brazil you have more individual work, more assignments, individual assignments, and a lot of exams.* "

As the quote shows, he perceives engineering as an individual work in the context of the Brazilian university as compared with his experiences of team working in the Australian educational setting. Meanwhile, he elaborates that the opportunities of team working are closely related to what he expects to experience at the workplace after graduation. He further continues comparing university with the workplace setting and says:

"*in the workplace you need to work with different opinions, cause sometimes you don't have these on a University field*."

V. Discussion and Conclusion

In our interpretation of the results we draw on the four dimensional model of engineering proposed by Figueiredo [8] where engineering is identified as consisting of four dimensions connected in a transdisciplinary relation. These include: 1) engineer as scientist, 2) engineer as designer, 3) engineer as doer, and 4) engineer as sociologist.

As it is shown, participant 1 perceives different suggestions of "becoming an engineer" in his experiences of the two educational settings in Brazil and in Australia. While the Brazilian higher educational context encourages him to practice engineering as science by focusing on theory, the Australian higher educational context provides him with opportunities of practicing engineering as practical realization.

Similarly participant 2 perceives different implied identities from the two universities. He sees engineering work as a more team oriented profession in the context of the Australian university as compared with his experiences at the Brazilian university. In his evaluation and comparison of the offered implied identities among the two universities, he finds the Australian way of engineering group work practices more relevant to what he expects to see at the workplace. Consequently he refuses practicing engineering as an individual work and accepts suggestions of "becoming an engineer who is involved in team work practices".

Result suggests that different educational designs have different suggestions of becoming an engineer for the two participants. In addition, the same identity resource may have different suggestions of becoming an engineer for different individuals as it depends on individual's reading and interpretations of it. While both "group work" and "project based" practices are considered as aspects of engineering professional identity in the Australian educational context, the two participants perceive only one of the two aspects through their responses.

We suggest that engineering educators consider the interaction between educational design and learners through perceived implied identities. This has practical implications for educators to have a holistic approach in engineering learning and even look at engineering assessment as learning situations where learners are encouraged to have the knowledge and methodology of thinking so they meet the requirements of each course [5]. Considering implied and intended identities is a step towards democratic practices of educational design. This can be achieved by designing educational materials that promote learners' reflection on the type of knowledge needed to tackle a problem and the different ways that knowledge can be integrated into action. It enhances creative engineering practices and problem solving and prepares learners for facing new and different situations at the workplace. In other words, closing the gap between formal higher education and workplace practices can be facilitated by providing learners with such opportunities.

Future research is needed to investigate how the design of learning environments and learning materials may influence learners' perception of what it means to be an engineer. In addition, individual differences in adapting different aspects of the profession can be studied.

Furthermore engineering students' beliefs about engineering can be studied in the context of Iranian universities to compare perceptions of engineering with the requirements of engineering practices in professional settings.

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