Professional Competencies in Computing Education: Are They Important?

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***Abstract*— In this Work in Progress paper, we discuss why including professional competencies into computing education curricula is important. We are particularly interested in competencies that students could and, we believe, should acquire during collaborative learning experiences in project-based IT courses. In the age of globalisation and technological advancement, there is a need for competencies such as collaboration, communication, and working in interdisciplinary and multicultural teams, including online ones. Computing education, however, tends to focus on content knowledge and technical skills, which is contrary to the emphasis companies place on soft skills in a hiring situation. This discussion and reflection paper discuss how employability, and identity frameworks can be used to analyse professional competencies in a project course environment in Norway? This paper focuses on how professional competencies should be implemented in the curriculum of computing degree programs and courses in the Norwegian university system. We use Curtin's graduate attributes" framework used by an Australian university as an example of learning outcomes that emphasise professional competencies. In this conceptual paper we discuss how placing more emphasis on graduate attributes, employability and identity can help to legitimise diverse ways of participation in the computing discipline and at the same time broadening the identity of the computing discipline.**

Keywords*— *Higher Education, Identity, Employability, Professional Competencies

I. Introduction

The role of Higher Education institutions is to advance students' knowledge of the discipline and to help them develop professional competencies. In the age of globalisation and technological advancement, and not least the sharp uptake on online collaboration in the wake of the COVID-19 pandemic, there is a strong need for competencies such as problem-solving and project experience [1], communication [2], and working in interdisciplinary and multicultural teams, nevertheless, the computing degree programs typically have a heavy focus on delivering technical knowledge and developing students' cognitive skills [3], [4].

The common understanding of computing is quite narrow; for many, the discipline is about programming, meaning "many students still feel that studying computer science is equated with working as a "programmer," which in turn raises negative and incorrect stereotypes of isolated and rote work" [5, p. 47]. There is increasing interest in researching into disciplinary identity [6]–[10] and computing identity [11]–[13], with a focus on social structures in computing culture, identity negotiations, and different ways of participation in the discipline. Research indicates that university environments can perceive some forms of computing as more legitimate than others [14].

University course designers inspired by the constructivist learning paradigm [15] are implementing active learning practices based on real-life, hands-on experiences in order to prepare students for employment. This often realised in the form of project courses. It is important to understand what kind of computing identity is created through these practices.

Our work is motivated by the need to design project courses that promote diverse computing identity development. Integrating professional competencies and other graduate attributes into the curriculum could be one way to broaden the view of the discipline and acknowledge different types of participation. Moreover, it may enhance students' likelihood of finding or creating meaningful work.

II. Context

There is an increasing need for computing professionals in Norway [16], [17]. In 2018, almost all students had found a job within 6 months of graduation (26% without even applying for a position) [18] and many of them came into contact with industry during their studies [19]. Employers are particularly looking for candidates with well-developed 21st-century skills [20], [21]. Norwegian education institutions are obliged by law to offer an education that is based on the foremost research, academic and artistic development work and experiential knowledge [4]. There are several initiatives undertaken at the universities in Norway (e.g. Center for Excellent IT Education [22], Center for Computing in Science Education [23], and a project: Technology Studies of the Future [24]) to improve computing education so that students are ready to face an uncertain, multicultural, interdisciplinary reality and become critical thinkers able to collaborate.

By offering students collaborative and real-life experience at university, educators hope to improve students' competencies and make the learning experience more engaging. Project-based learning is inspired by constructivist learning paradigm [25], this student-centered pedagogy aims to reflect real-life experiences at university and is in particular relevant to engineering because projects are representative of the way engineers work [26]. Projects at university quite often involve group work, collaboration with industry, solving open-ended problems, and designing digital artefacts. There are several strategies for implementing projects, they could be part of a course, the entire course, or spam trough several courses. Among 19 study programs within IT at Norwegian University of Science and Technology and Nord University there are more than 70 courses, which mainly or partly involve project-based learning with hands-on and relevant industry experience where the students, often in teams, are required to design a product [27].

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In this paper we are focusing on collaborative ways of learning, such as project courses. Traditional computing courses usually prioritise teaching the subject content in a small, and controlled environment. Project courses, on the other hand, are characterised by ambiguity, and better reflect real life.

III. Theoretical Background

Improving the quality of engineering education is vital for ensuring that our graduates have the knowledge, skills and attitudes required to conceive, design, implement and operate complex products, processes, and systems in a team-based environment [28] with the awareness of their impact on society and the planet.

Many initiatives have been launched to bring more attention to developing personal and interpersonal skills and there is a need to continue these efforts. Efforts to develop graduate attributes have emerged from a focus on graduate's employability. Currently terms like *graduate attributes*, *learning outcomes* and *employability* have begun to be used almost interchangeably [29]. Nevertheless, in this paper *employability* and *graduate attributes* are not synonyms and to make our reader understand the differences between these concepts, we are presenting the concepts of 1) employability, 2) identity, and 3) graduate attributes below.

Employability is a term used to describe the skills, knowledge and personal attributes a student needs to get employed [30]. This way of seeing employability is the possession perspective and is commonly used contrary to the position perspective and the process perspective of employability [31]. There is not a common definition of what should be included within this term, and even within a company, there may be disagreement about the importance of qualifications for applicants [32].

There are different frameworks used to describe what graduates should possess in terms of their *employability* view. Research on employability might be either narrow, only focusing on the skills needed find employment in one distinct job position [20], or wide, including external factors such as labour market forces and macroeconomy [33].

Like employability, there are many ways to define *identity*. For the purpose of this work we consider identity as a social construct, that is negotiated in interactions, and is always in the process of being constructed, negotiated, and reconstructed [34]. It is not something which an individual possesses, but it is constructed in everyday practices to make sense of the cultural and social context and is a way of being recognised and accepted as a legitimate member in that context [35]–[37]. Disciplinary identity such as computing identity is negotiated and constructed by students, teachers, faculties and politics. Students *identity work* is a process of integrating their educational experiences with perception of who they are and who they want to be. *Identity work* is understood as individuals' interpretive efforts to construct a coherent sense of self in relation to others [38]. The individual is conditioned by disciplinary identity and can choose to question or reinforce it.

Graduate attributes are generic outcomes of the educational experiences beyond the content knowledge that is taught at university. They can be referred to as generic skills, generic graduate attributes, capabilities or competencies that graduates should acquire during their studies. These skills may be understood as part of the term *employability*. There are several lists of Graduate Attributes such as Attributes of Engineers in 2020 by National Academy of Engineering [39]. Because of its simplicity and clearness, we use Curtin's Graduate Attributes as an example of attributes framework. The cultural and ethnic differences between Australian and Norwegian context exist and it is important to understand these differences when implementing professional competencies into curriculum. Nevertheless, discussing these differences is not in the scope of this work but should be closer investigated in the future work.

Curtin's Curriculum 2010 project [40] aimed to enhance the university teaching and learning practices by embedding nine attributes that graduate students should possess (see figure 1, which is a picture of a bookmark that was distributed to students enrolling at Curtain University) into the course- and semester-length learning experience. Attributes in the literature can be referred to in various ways as learning outcomes, qualities, capabilities or competencies and are a mixture of knowledge outcomes, generic skills, and employment capabilities [29]. Barrie [41, p. 440] defines attributes as "the skills, knowledge and abilities of university graduates, beyond disciplinary content knowledge, which are applicable to a range of contexts". These Graduate Attributes must be contextualised, embedded, and assessed as learning outcomes in subjects, and achieved across the degree program [42]. Curtin's list of professional competencies includes the ability to work independently and in teams, demonstration of leadership, professional behaviour, and ethical practices.

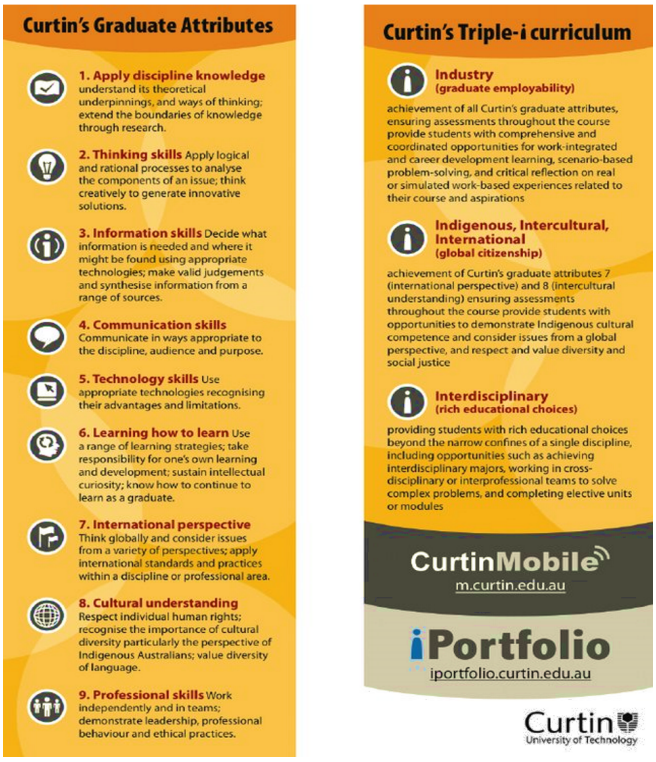

Figure 1 Curtin's Graduate Attributes

Recent work of Oliver and Jorre [29] has identified attributes which ought to be emphasised in order to equip those who graduate from 2020 onwards . The authors recommend continuing to emphasise attributes such as global citizenship, teamwork, and communication; in addition to increasing emphasis on independence, problem-solving, and

critical thinking, as well as the skills of written and spoken communication.

The research shows that students and teachers tend to focus on technical skills and knowledge, while the bulk of the graduate attributes, often referred to as *soft skills*, can end up marginalised. In spite of the significant focus on graduate attributes there has been, to some degree, a lack of acceptance of and willingness to actively support graduate attributes on the part of academic staff in Australia [42]. They placed emphasis on and were most willing to and confident about teaching and assessing the attributes that are considered as conventional to the discipline such as problem-solving, critical thinking, and written communication. Attributes less traditional to universities but perceived as important by industry such as teamwork and information literacy were identified by teachers as less important. They expressed less desire to tech and asess them and were less sure about doing so. Oral communication, ethical practice, and independent learning took the middle ground [42].

IV. Method

This conceptual paper [43] synthesises knowledge from previous work on identity, employability and professional competencies. We focus on integration and proposing new relationships between existing theories and identifying how they can be used to analyse professional competencies in a project course environment in computing.

Adding the identity perspective to graduate attributes means acknowledging students' navigation in the social structure and the process of negotiation of their place in the discipline. Through participation in computing courses they learn what it means to be a computer scientist. Students may challenge the existing values of computing culture or conform to them.

We have chosen to add an identity perspective because mainstream employability theories do not cover it. "Curtin's graduate attributes" were developed and implemented to increase student's employability but did omit the identity perspective. Employability theory is mainly focused on possessing skills and knowledge, but does not take into consideration motivation factors or values. There is therefore a need to broaden the term *employability* term [6], so that not only skills, knowledge and soft skills are taken into account by universities when planning their curriculum.

We see becoming a computer scientists as a social process in which students are gaining new competencies (knowledge, professional skills, and interpersonal skills) and also negotiate identity and develop employability. We believe that students need to acquire more than technical knowledge, which is why we chose to use "Curtin's graduate attributes" as a lens to see what students think they learn beyond hard skills (content knowledge). Our discussion serves as a foundation for further empirical work which will analyse qualitative data gathered by observation and interviews.

V. Discussion

The main goal of our work is to discuss the importance of implementing professional competencies into computing education. In this section we discuss how employability and identity frameworks can be used to analyse a project course environment in Norway. We introduce identity and employability frameworks as lenses to look at the project courses environment in the Norwegian context.

Employability has often been referred to as knowledge, skills, and personal attributes a graduate should possess to become employable now and, in the future [30]. During higher education it is important for students to develop professional skills, so that they have competencies employers seek for. As previously written, computing education often focuses on the development of knowledge and domain specific skills [44]. This is a narrow view of employability and does not take into consideration the perspective of disciplinary culture and the process of students' identity development within their field.

Adding the identity framework to employability lets us see students project course participation in a new way. For instance, leading to not only seeing it as developing employability factors, but also as an opportunity to let students develop and negotiate their identity through course participation.

A project course is a space for developing professional competencies such as teamwork, leadership, professional etiquette, and ethical behaviour. In this space, students construct their sense of self (*identity work*) in relation to: other students, often their team members; teachers; and, in some cases, industry representatives. To fit into the computing discipline, students adapt to the disciplinary identity. Peters [14] identified that computing students need to perform an identity as a problem solver (technical). Team-based projects require different forms of contributions and allow different ways of participation in the discipline. We believe that such courses support diversity, not only in terms of gender and ethnicity but also in terms of different values. These values could for example be caring about issues like global warming, ethics, social injustice, and well-being of our society and planet. Creating artefacts like games and apps, which is often part of a project work, was identified as a valid way of participation in the computing discipline [14]. By including students' interest and by designing courses around global issues mention above, we could change the narrow focus of computing discipline.

Students' unique skills and knowledge are used to solve problems or create artefacts both in projects at university and in the workplace. We believe that students, in the process of becoming a computing professionals have the right to learn how to critically examine the products and services they create, which includes the impact of their work on the planet and on other people's lives. In addition, aspects such as values and visions are also important in the job seeking phase [45]. These aspects may affect graduates' choices of electives, and how they self-promote (writing their CV), which again affects their employability.

By combining employability and identity (as [6], [31] has done), we argue that we cover all the competencies and attributes required to gain or create a meaningful job and find employment. In addition, both student and the teachers should understand the importance of developing professional skills. By making teachers understand how important these skills are, as well as the importance of being aware that one has these skills, we could make students more confident and aware of their competencies they possess. Teachers should know what skills they are teaching (such as teamwork, problem-solving, communication), know how they present the skills for the students, and be able to express why it is important for students to learn those skills. Graduates will, because of this transparency presented by the teachers, be better equipped for

the hiring process, and probably have less tendency to choose a job which does not match their identity.

As mentioned earlier, there are more and more active learning practices and project-based learning courses at Norwegian universities. Unfortunately, without embedding the graduate attributes into the curriculum, these efforts are fragmented. Since there is no national graduate attributes framework, developing students' professional competencies falls on teachers' shoulders. Research shows that teaching and assessing attributes less traditional to universities like teamwork and information literacy is difficult [39]. We need to learn how to assess these skills and clearly state them as a learning objective. Assessment practices need to be updated, formal measures of achievement or grades are poor representation of students' performance [46]. Other challenges faced on project courses like conflicts between team members, and "free riders", need to be addressed as well.

VI. Future Work

Gaining a more holistic view of students' acquisition of professional competencies on project courses requires empirical investigation using the lenses of identity and employability theories. These frameworks can be used to look at the qualitative data gathered from project courses by interviewing students. Such a study should lead to concrete recommendations for curriculum and course designers as well as teachers on how to implement graduates' attributes into higher education curriculum with acknowledgment of diverse ways of participation in the computing discipline.

VII. Conclusion

In this paper we combine frameworks of employability, identity and graduate attributes in order to obtain a more holistic view on educational goals. By combining these frameworks, we have put more emphasis on students' computing identity negotiation in higher education, rather than the traditional strong focus on developing skills and knowledge. We argue that combining these perspectives and taking them in consideration while designing computing curricula can support legitimisation of different ways of participation in the discipline.

Project curses are suitable for developing professional competencies as well as disciplinary identity and students sense of belonging. Increased emphasis on professional competencies, in our opinion, may be beneficial for students and increase their chances of performing more meaningful work during their academic journey and their professional career. We argue that this emphasis on professional competencies ought to be an institution-wide initiative.

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