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Published in: Conference Proceedings - Frontiers in Education Conference
DOI: 10.1109/FIE44824.2020.9274073

Available online: 2020

Citation:
Szynkiewicz, J., Lundberg, G. M. & Daniels, M. (2020). Students' professional competencies in computing project courses in the Norwegian context. 2020 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2020. doi: 10.1109/FIE44824.2020.9274073

Students’ professional competencies in computing project courses in the Norwegian context

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***Abstract*—In this Research Full Paper we look at IT students’ experiences from collaborative project-based courses at two Norwegian universities through the lens of “Curtin graduate attributes”. Many universities use lists of graduate attributes, sometimes referred to as competencies, generic skills, or capabilities that graduates should acquire during their studies. For the time being, these two Norwegian higher education institutions have not implemented graduate attributes into their curricula, though there are several ongoing initiatives that promote students’ employability and development of professional competencies. Through interviews, observations, and thematic analysis with overtones of grounded theory, we aim to identify Norwegian IT students' perceptions of professional competencies acquired at project-based learning courses. The findings are analysed through the use of the identity and employability frameworks, taking into consideration the cultural context. This paper answers two research questions: 1) What professional competencies do students acquire in project-based learning settings? 2) How do project-based learning courses support the development of employability and identity? We have identified that putting more emphasis on graduate attributes can help to legitimise diverse ways of participation in the computing discipline and at the same time broaden its identity.**

Keywords—*Employability, Identity, PBL, Professional Competencies*

I. Introduction

Competencies such as problem-solving and project experience [1], communication [2], and working in interdisciplinary and multicultural teams are in high demand in times of globalisation and when facing global challenges such as pandemics and climate change. We have, for example, seen a sharp uptake in online collaboration as a result of COVID-19.

Computing degree programs to a large extent focus on delivering technical knowledge and developing students’ cognitive skills [3], [4] while so-called soft skills and personal attributes play a marginal role or are not addressed at all. The widespread understanding of computing is quite narrow, 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].

The needs of the IT sector today go far beyond those of core software development. Employers require graduates who can integrate knowledge from a variety of disciplines and address complex problems with creative problem-solving and innovative thinking [6]. Hence, IT students need to develop computational thinking, critical thinking, and creativity skills through “real-life” experiences [7]. These skills will lead them to attain the required competencies, such as project management, teambuilding, software estimation and planning, progress monitoring, and communication [8].

In 2013 the Institute of Electrical and Electronics Engineers (IEEE Computer Society) and the Association for Computing Machinery (ACM) joined forces and developed guidelines for Computing Curricula. The CS2013 report states: “the education that undergraduates in computer science receive must adequately prepare them for the workforce in a more holistic way than simply conveying technical facts” [7]. The report from 2017 on Information Technology Curricula 2017 (IT2017) identifies “soft”, communication, and teamwork skills as “fundamental for those in the IT profession” [9] and states that IT student must have “familiarity with the methods of science, a sense of how to apply computing in practice, and preparation for being a well-rounded and effective member of society” [9]. It aligns well with the Bildung tradition [10] where education is regarded as a process of becoming a citizen with a strong ethical approach.

Becoming a computing professional often requires participation from students in project-based learning courses, where they can develop competencies critical for the workplace. This active way of learning, based on constructivist pedagogical approaches [11] is implemented to develop students’ 21st century skills: creativity, collaboration, cooperation, and critical thinking. Students gain these skills through group work, additionally supported by industry involvement and real or fake customers, as well as multicultural teams. It is important to understand what kind of computing identity is created through these practices.

Computing identity is an increasingly interesting field of research with its focus on agent-centred development, a sense of belonging and recognition, and engagement in learning. The longitudinal study by Peters [12] identified that university environments can perceive some forms of computing as more legitimate than others.

The main goal of this paper is to analyse students’ professional competencies through the use of identity and employability frameworks in the context of project courses. Gaining a more holistic view of student 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.

We believe that efforts to increase student employability by including professional competencies in computing curricula [13] should be supported by efforts to promote diverse IT identity development.

II. Context

A. Norway

The demand for computing professionals in Norway is increasing [14], [15]. Almost all IT students graduating in 2018 had found a job within 6 months of graduation (26% without applying for a position) [16] and many of them came into contact with industry during their studies [17].

In a study by Lauvås and Raaen [18], 10 industry representatives suggested that "an inner drive and interest in the computer programming field is the most important [candidate'] quality (…) Furthermore, the candidate should be a good match for the team, as well as the company culture."

Employers specifically look for candidates with well-developed 21st-century skills, and students having a hobby within their discipline confirms for the employers that students have these skills [19].

The Norwegian education system is quite progressive; education institutions in Norway are legally obliged to provide education based on the foremost research, academic, and artistic development work, alongside experiential knowledge [4].

Projects are an essential part of the information technology (IT) profession due to the fact that project-based learning is a pedagogical approach often used in IT education. This learning settings allow students to gain not only content knowledge, but also competencies. Project-based learning can be applied in many ways [20].

In this study we are interested in project courses where students create artefacts, and how they support competency and identity development. Aspects of Piaget's constructivist theory of learning and Papert's theory of constructionism [11] are theoretical pillars of project courses with elements of artefact creation. During computing project courses, students develop digital artefacts like apps, websites, and digital games [21], as well as investigating societal questions [22].

B. GameLab

For the purpose of this article we use data collected during two project courses at Norwegian University of Science and Technology (NTNU) and Nord University. GameLab at Nord University is an obligatory course run each semester for the whole 3-year bachelor study program Games and Entertainment Technology. It is small bachelor program with around 30 students recruited each year. The GameLab course is a company simulator that gives students a real-world job experience. The project was designed to shed light on the realities of working in industry settings, to activate all students and to delimit the possibility of "free-riding". Work during the project is structured, and students' daily commitment and consistency is important.

In the beginning of the semester the teams are formed, preferably with less than 7 members in each team. Firstly, students volunteer to become group leaders. Secondly, the leader chooses group members based on skills that candidates identify. During the semester a team can trade working hours with other team for the skills that students lack.

One day of the week is a GameLab day when all team members need to be at the campus and work on game development; between the 3rd and 6th semesters, GameLab days increase to two days each week. During weekly meetings with group leaders called *executives' meetings*, teachers look at students' projects and give them guidance, moreover students receive external input (given online) from active professionals that students trust and value. *Weekly team meetings*, where all team members and teachers meet are an opportunity for the whole group to resolve any possible conflicts within the group.

Deliverables of the course includes students' logs, peer assessments, a design document, the completed project, a team report describing the project, a short personal performance report outlining the work the team member has done, and a comprehensive self-reflection document (when applicable).

During projects, students use knowledge, skills, and social abilities (attitudes and dispositions) in a study situation. Munkvold [21] indicates that GameLab increases engagement and motivation among the majority of students. Kolås et al. [23] has identified that projects with elements of constructing artefacts at NTNU and Nord University hardly ever span more than one course, and the deliverables are mostly well-defined during the two first years of study. Students gain more freedom concerning what to deliver later in the study program.

C. Concurrent Design

The second course, Concurrent Design (CCD) at NTNU is taught in the sixth semester at the bachelor in Computer Engineering (3 years) in a one-day version as part of a semester-long course in Systems Engineering with Economy. The longer, one-semester version of the course is taught in the Digital Collaboration (2 years) master study program in the second semester.

CCD is a project management method for multidisciplinary design in which a multidisciplinary team follows a process including a set of CCD-sessions [24] to solve a problem. The method is based on real-time interaction in an organised collaboration room. There are three essential elements of this method: process, people and tools [25]. Establishing a project team with the necessary expertise within the various disciplines is crucial and allows for decisions to be made in real time during CCD sessions.

The CCD course at XX starts with students learning a theoretical basis of the method and trying it out during practical training session, before the main project. The aim of the project for external stakeholders could be to create a design document for an online introductory course in digitalisation in which the four focus areas of expertise are: subject matter experts, educators, technology, finance. and administration.

Teachers provide a description of the various expertise needed and the tasks for the various expert roles. Based on the description students sign up for expert roles in specific areas and, based on their choice, are placed in teams of 2-4 students. There are five collaboration sessions: situation analysis, feasibility study, solution selection, and solution design. The teacher plays the role of a facilitator who manages the sessions. It is important that experts from each of the above areas are present in the class and participate in the sessions so that decisions are approved by experts from every area.

Both GameLab and CCD are courses that imitate industry settings, aim to developing students' professional competencies, and require students to create a product in a learning environment. As mentioned earlier there are increasingly more project-based learning courses and active learning practices at Norwegian higher education institutions. Nevertheless, to this day both NTNU and Nord University have not yet implemented into their curricula institution-wide learning outcomes other than disciplinary content knowledge.

We believe it is interesting to look at the experiences of students from the project courses through the lens of graduate attributes developed and implemented by another institution, namely Curtin University. We use "Curtin's graduate attributes" as a lens to see what students think they have learned beyond content knowledge in GameLab and CCD course.

III. Theoretical Background

Improving the quality of computing education is vital for ensuring that our graduates have the knowledge, skills, and attitudes required to become competent employers and good citizens. Higher education institutions have launched many initiatives to draw 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 the focus on graduate's employability. Terms like graduate attributes, learning outcomes, and employability have recently begun to be used almost interchangeably [26]. Nevertheless, in this paper employability and graduate attributes are not synonyms. To make our reader understand the differences between the aforementioned concepts, we present the concepts of 1) employability, 2) identity, and 3) graduate attributes below.

1) Employability

Employability is defined by [27] as "a set of achievements – skills, understandings and personal attributes – that makes graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy". This focus on skills, knowledge, and personal attributes is the most common way of looking into employability and can be seen as the possession perspective [28]. However, this definition is broad – taken into account both the micro, meso, and macro level. When researching employability within a country, all participants do have the same demand factors and access to resources [29], which might indicate that the macro level is not the best perspective. In this paper we will use the micro perspective, focusing on individuals and their competencies.

Even though there is much research on which skills, knowledge and personal attributes a person should have to gain or attain a job, there is no agreement on what specific skills a person needs; even within a company there can be disagreement over the importance of different skills [30]. A study on the employability of computer programmers in Norway showed that all companies interviewed valued non-technical skills highly, with enthusiasm, curiosity, teamwork, and cultural fit being the most important [18].

There are several initiatives to combine employability and identity, often called pre-professional identity [31] or professional identity [32]. Jackson [31] re-conceptualised employability, calling it pre-professional identity, which "relates to an understanding of and connection with the skills, qualities, conduct, culture and ideology of a student's intended profession". There are four aspects that affect the development of professional identity: 1) Professional development opportunities - when students participate in conferences, do research about their discipline, or do internships; 2) Informal activities - hobbies like participating in Hackathons, coding clubs, or personal projects; 3) People - a student's social network can help influence their career and their choices; 4) Coursework - having CS courses has led some students to pursue or not to pursue a career within CS [32].

2) Identity

Identity-based research is concerned with agent-centred development, sense of belonging, and affiliation. It focuses on questions such as: *Who do I want to become? Who do I think I need to be to engage in science? Do I belong here? Am I recognised as part of this community? What do I think/feel/do in relation to this discipline?*

In this work we look at identity from a sociological standpoint as the collective property of people engaged in social interaction. Identity as a social construct is always in the process of being constructed, negotiated, and reconstructed [33]. Identity is not something that one possesses, but it is rather constructed in everyday practices to make sense of the cultural and social context and a way of being recognised and accepted as a legitimate member in that context [34]–[36]. "Identities are constructed through practice—practice that requires knowledge, skills, and ways of thinking that characterise the discipline in which one is engaging". [37] Computing identity, from that standpoint, is negotiated and constructed by students, teachers, faculties, politics, and different ways of learning and teaching.

Computing identity influences, informs and forms the *identity work* of an individual. Barton et. al define *identity work* as "the actions that individuals take and the relationships they form (…) at any given moment and as constrained by the historically, culturally, and socially legitimised norms, rules, and expectations that operate within the spaces in which such work takes place" [37]. *Identity work* is understood as individuals' interpretive efforts to construct a coherent sense of self in relation to others [38]. Such work is done both with and against the norms of the computing discipline.

The major reason for students dropping out from CS courses was "loss of interest in the computing field and career" followed by "feelings of not belonging and a notion that a non-CS career would be more fulfilling" [39]. Fisher and Margolis identified that low diversity in CS education is caused by the exclusionary nature of computing culture, nor a lack of interest or inability among diverse learners [40]. Due to challenges like dropping out, low engagement and lack of diversity in science education, identity has become an increasingly important field of study.

3) Graduate attributes and professional competencies

Development of professional identity is strongly connected to the development of occupational competence [41]. Frezza et al. define competencies as “state of being able, or the generic capability which is a necessary requirement to perform, or the set of characteristics which enable performance” [13]. In the model presented by Frezza and others:

- “Knowledge, or "know-that", is predominantly cognitive or intellectual qualities that refer to mastery of core concepts and content knowledge;
- Skills, or “know-how”, are more practical qualities that people develop and learn over time with practice and through interactions with others;
- Dispositions, or "know-why" and "know-yourself", are affective or dispositional qualities encompassing attitudinal, behavioural, and socio-emotional qualities of how disposed people are to apply knowledge and skills to solve problems or address issues of personal, social, or workplace-related interest;
- Context represents relevant and authentic situations related to problems/issues and aspects of work in which competencies manifest” [13].

Similar elements can be found in the Barrie [42] definition of graduate attributes which he defines as “the skills, knowledge and abilities of university graduates, beyond disciplinary content knowledge, which are applicable to a range of contexts”. The Graduate Attributes must be contextualised, embedded, and assessed as learning outcomes in subjects and achieved across the degree program [43].

Graduate attributes are often called learning outcomes, qualities, capabilities and competencies [26]. In Australia, Curtin’s Curriculum 2010 project [44] specified nine attributes that graduate students should possess. One of them, entitled *professional skills*, includes the ability to work independently and in teams and to demonstrate leadership, professional behaviour, and ethical practices.

A recent work by Oliver and Jorre [26] identified attributes that should be emphasised to better equip those who graduate from 2020 onwards. The authors recommend continuing to emphasise attributes such as global citizenship, teamwork, and communication, also emphasising independence, problem-solving, and critical thinking, as well as the skills of written and spoken communication.

IV. Methodology

This study is guided by the constructivist version of Grounded Theory [45]. It is a rigorous yet flexible type of qualitative data-driven analysis [46] which allows for deep engagement in the search for the meaning created by people. It focuses on situations, contexts, processes, and interactions. Identity development is a complex, ongoing process to which factors such as social environment, experiences, beliefs, and expectations are essential. The methodology allows one to listen to students’ stories and investigate what they are experiencing on project courses and how they are affected by those experiences.

Analytical tools such as codes, concepts, categories, and memos are used for interaction with the data, while the analysis engages in constant comparison between data, codes, concepts, and categories.

The analysis is based on nine interviews with computing students that participated in project-based learning courses. Between June 2018 and April 2019, the first author observed three project courses: GameLab at Nord University and Concurrent Design (CCD) at the master and at bachelor level at NTNU. These are quite small courses where the number of students ranges from 9 to around 30. The courses were chosen based on innovative approaches that aim to imitate industry environments.

Participants were recruited during the university courses. During the GameLab course, after presenting the project, the first author asked students for volunteer participation in interviews. Six students expressed their interest, four were interviewed. Realising that the volunteers might be the most engaged and courageous students, the first author decided to switch to more purposeful sampling. During the CCD courses observation, the first author identified verbally active and passive students and aimed to achieve a balanced female-to-male ratio. The time spent for each interview varies from 30 minutes to a little over an hour. NVivo software was used for transcribing and analysing the data.

Findings presented in this study are based on a larger ongoing study on computing students’ identity development [47]. The first author conducted 3 additional interviews and concluded that they do not enrich empirical findings presented in this paper therefore we have a rationale to claim that the study has reached an interim end-point in other words the theoretical saturation.

Interview Participants’ Demographics

Total	9
Gender (female)	5 (56%)
Course name and study program	
GameLab, Games and Entertainment Technology	4
Concurrent Design, Computing Engineering	2
Concurrent Design, Digital Collaboration	3
Form of participation[a]	
Active verbally	2
Passive verbally	3

[a] Identification of active and passive students begun with the recruitment for the 5th interview.

V. Data Collection and Analysis

The first author conducted, analysed and anonymised all the interviews. The initial interview guide consisted of 35 open-ended questions. During the first four interviews, conducted with students from GameLab, the interview guide was quite closely followed, and the questions asked were very alike. It was then induced that better results could be achieved by allowing participants to speak more freely. Therefore, during the interviews with Concurrent Design students many questions were omitted and the first author focused on topics that emerged which were interesting or surprising. This flexible approach to interviewing resulted in more insight and allowed participants to feel more comfortable opening up.

Each interview was open coded, with the codes then compared in the search for similarities and differences. Emerging categories from the interviews with GameLab students were, for example, *experience prior to university*, *experience at university* and *envisioned future* [47]. Analysis of the interviews with Concurrent Design students resulted in codes that were grouped into three main categories: *computing ethos*, *project course*, and *necessary skills*.

VI. Findings

In this section we present empirical findings from nine interviews with students. We are particularly interested in students' perception of acquiring professional competencies during project courses at university and its relation to disciplinary identity development.

The image of the computing discipline seen from the perspective of students participating in project courses is characterised by the need for communication skills and teamwork, followed by leadership skills, work ethics, exchanging ideas, facing uncertainty, possessing discipline knowledge, as well as self-study and research.

A. Communication

"Anyone can learn knowledge about programming languages and development (...) ability to work with others and communicate and like being a human being with others is so much more important and fundamental (...) almost all software development projects are done in teams." (Mark)

Participation in project courses make students aware of the high value of communication skills while doing computing. The importance of communication is necessary for smooth processes throughout the development pipeline. Firstly, students must understand the needs of a client and communicate their opinions on the project:

Maybe they [some computer engineers] are super smart, but you can't talk to them, you can't communicate, you can't know if he or she will produce what you want. (Tina)

Later, students brainstorm ideas and, while explaining ideas to others and somewhat assuming the role of a teacher, they deepen their own understanding: *"You're forced to explain your ideas and make yourself understood in a way that can help you learn more about that idea itself."* (Mark)

Participation in projects makes Tina' aware of her communication skills: "*[students I helped to learn] could get a better grade than me because I can't formulate what I know"* and she can practice these skills*: "I can learn how to communicate what I know (...) to tell everyone else: 'I know how to do this. We can do it like this'"*

Students identified lacking or bad communication as one of the main reasons for teams to fail.

B. Team work

"I've learned a lot from the study but when it comes to specific knowledge about a frameworks or a language, people could have just learned by themselves (...)[what] you don't learn doing your research on the internet are personal skills required to work, to develop software, the social skills, the communication, and yet somewhat, the team roles, the leader role and being a part of team in an efficient way, working with others" (Mark)

Students interviewed stressed that becoming a computing professional requires ability to work in teams where they need to perform roles and contribute to a team effort. Students are convinced that to build a good system/product, a group of people is needed who function well in a team.

Toni sees the "*willingness to admit you are wrong (...) adaptability and ability to change your approach*" as an important aspect of teamwork. He also adds that team composition changes the experience: "*when you are with good people, it's great*."

Project work also improves the social skills of students who quite often refer to themselves as shy or introverted:

"I feel it's easier to work in a group, after I've been work in groups for such a long time (...) I feel it's easier to socialise" (Oliver)

Another positive aspect of the teamwork is collective achievement: *"It's great, to be able to work together and get results together"* (Erik)

C. Leadership

Project courses require students to perform roles: *"(...) in teamwork you can find your place (...) try a lot of different things, find what you like."* (Tina)

One of the possible roles for students to take on is the position of leader. This role, according to students, requires a good overview of and control over project progress, time management skills, and good organisation and structure. This is followed by the ability to listen and make everyone feel included, understanding individuals' unique styles of work ('not everyone is working as I do') and adaptation to the situation.

Being a leader is a challenging task for a student, the challenges and mistakes made performing the role are reflected upon, and their behaviour can be modified over time since there are multiple projects and students have the chance to carry out that role again.

"I was a leader unable to prioritise the right things and assign the right tasks, (...) I also slightly mismanage my time (...) and another problem was that only programmer (...) disappeared for a week, and I should probably have been way harsher (...) I should have fired him from the team before the mid-terms." (Martin)

Fulfilling the role of a leader increases self-awareness of one preferable style of working*: "The team lead is the organiser (...) I'm not suited for it (...) I am not that organised, I work in a mess"* (Toni) and personal characteristics such as lifting the team spirit*: "If the team is feeling down or just tired, I can somehow manage to turn it around, push up people's spirits a bit."* (Sara)

Some students' predispositions, such as being extroverted, makes them fall into the leader category. Nevertheless, Erik, who considered himself 'not a leader type' changed his view about leadership over time:

"*Before, it was the extrovert or person who made a lot of themselves, talked a lot, who was the typical leader. And that's probably why I didn't see myself as a typical leader or person to coach others. (...) They [employers] want us, those who can make other people better at what they do. (...)*

Because I didn't see or know that I could excel at that, or be better at that, or be good."

The image of an extroverted, talkative leader has now been replaced. Erik understands that he can be a good leader by supporting others to improve how they work.

D. Work Ethics

One aspect of the real-life environment of the projects is a work schedule. Working with others can stimulate the feeling of responsibility, Mark said: *"It often can be more motivating to work together (...) in the way that if we don't show up on time today, it's bad for the team."*

Students also face challenges related to inability to find a common working schedule and compromise: *"We were just fighting, the boys wanted to come to university after lunch, the girls want to work early in the morning."* (Anne)

Another professional competency is the ability to adapt to the situation: "*If you're in a group with people who you don't work so well with, I think it's important to just focus on the results."* (Elin)

From the perspective of the study participants, the successful student, beyond the passion for and interest in what they are doing, needs *"the ability to work hard and step out of the comfort zone (...) the certain amount of willpower (...) the ones who don't have it, they drop out."* (Martin)

E. Exchanging ideas

In open-ended projects there are many ways to design products, solve problems and many tools to be used. In a group, students learn from each other by being exposed to different perspectives, ideas, and skills. Brainstorming and the exchanging of ideas are a crucial part of the students' learning experience; students need to consider others' opinions:

"Take your opinions and then hear his opinion, build on each other, I get a lot from it (...) it makes you think things through, the thought process is also part of the learning. You have to consider a different angle of what you're trying to do and then it makes sense, what you're trying to learn" (Erik)

The exchange of ideas can lead to conflicts; the goal of the project experience is to learn how to be objective:

"It can easily get heated if you have people with different opinions (...) how a game should be. It is best to be open to others' ideas, and also hope that they're open to yours, so you can have a proper intellectual discussion about those ideas that would objectively be best for the game." (Oliver)

Project experience makes them realise the group dynamics and that the ability to speak up is important:

"The negative thing is [that] you probably have a good idea (...) but then another person comes with another idea and then we're going to do his (...) it's often the person who talks the most" (Tina)

F. Facing uncertainty

Open-ended problems are complex and characterised by uncertainty: *"we're always going to face some challenge that we, we haven't been prepared to face, which also often involves having to find an alternative solution."* (Mark) Students have the opportunity to experience this in a learning environment before facing the work life.

G. Disciplinary knowledge

Content knowledge is gained in theoretical courses "*the natural first part of learning something, [is to] get the fundamentals and the theory behind something and then (...) experiment with it and use those theories and practice during, for example, group work*." (Mark)

Student have also reflected on knowledge retention. According to Tina: *"in a theoretical course you learn a lot in one hour, but maybe you don't remember it."*

The computing discipline is changing very rapidly, meaning content knowledge becomes outdated fast: "*new technologies, new frameworks come every year."* (Tina)

H. Self study and research

Students experience that with every new project they learn something new. Open-ended problems that students try to solve require from them to use knowledge and skills they gained previously in a new context. Students also search, often using the internet, for new knowledge which suits the specific problem they are working on.

"You're almost always being forced to (...) doing the research, this self-study research during project (...) how can I make this work in using this framework or this language or in this setting" (Mark)

Projects focus on developing teamwork skills, nevertheless there are also opportunities for self-study, some students said that it is easier and more efficient for them to learn alone.

VII. Discussion

The process of becoming a computing professional through participation in project courses is a process of employability and identity development. In this section we present our empirical findings through the lenses of employability and identity. Moreover, we present the implications of our findings for the classroom.

A. Employability lens

There has been much focus on developing employability in higher education and several initiatives have been set up to make sure that students develop necessary skills sought after in the employment market; these have been shown to educate students with the competencies needed in the industry [48].

Lauvås and Raaen found that the employers' value the non-technical skills highly in Norway [18]. Our findings show that students do understand the importance of the non-technical skills and argues that these skills might be hard to learn elsewhere. The students Tina and Mark argue that communication skill is a much-needed competency for making teams work. However, communication skills are often found lacking when hiring graduates [2]. It is therefore important that the university provides students with opportunities to develop communication skills so that they can effectively communicate their problems and solutions to others [1].

Project experience is highly valued in the industry. Students who do not have project experience and problem-solving abilities will have a harder time gaining employment [1]. The student Oliver argues that after working in a group over a longer period it become easier. Teamwork skill and cultural fit was also one of the most important considerations for employers, according to Lauvås and Raaen [18].

Another interesting finding is that students talk about having an interest in the computing discipline, and this could be the determining factor when hiring someone [19]. Employers think graduates could manage to learn what is needed to become good at their work as long as they have an interest within their discipline [18]. Mark comments that everyone can learn programming skills, but the ability to work with others is much more fundamental.

B. *Identity lens*

What is recognised as "real IT" is a social construct that counts some practices as legitimate and others as not. In contrast to common preconceptions of computing as a very technical discipline as identified by Peters [12] our findings show that students participating in project courses develop identity that goes beyond the "technical". Professional identity developed in the projects has a strong collaborative and communicative component. The students participating in project courses perceive professional competencies such as communication and teamwork as crucial.

Through participation in projects, students learn that they will need to face uncertainty in their future profession, that there are many ways of solving problems, and that new tools are constantly being developed and used in a rapidly changing computing discipline.

Practices related to the development of systems, games, and other digital artefacts at university allow students to perform different roles and, in that way, explore and identify what kind of profession would fit them. Through projects, students come to realise that there are different valid ways of being recognised and accepted as a legitimate member in computing culture. Similarly to Holmegaard et al. [35], we identified that project courses are engaging and align with students interest and ideas.

Students' computing identity is always in the process of being constructed, negotiated, and reconstructed. In the example of Erik, who did not consider himself a 'leader person', after having several leadership experiences (*identity work*) both at the university and as a volunteer, he came to find his quality of caring about other people's development to be the most important quality that a leader should possess.

Identity that is constructed during project-based learning is aligned with the identity constructed by employers, who in particular value and expect that professionals are passionate about what they are doing, are a good team fit, and are able to communicate [18].

C. *Implications for the classroom (recommendations)*

We need to encourage teachers and students to take professional competence development seriously. We need to continue efforts that broaden narrow views of the computing discipline. Unfortunately, computing degree programs that offer extensive programming classes in the first year give the impression that computing is only about programming. Such an identity of computing is not aligned with the identity that the industry presents and can discourage students looking for more active, social, and hands-on learning experiences.

We recommend exposing students to project work early in their academic career, after they master the ability for self-study, which should mean in their second or third semester. We agree with Kolmos et al. that project courses have great potential but need to be implemented carefully, considering many parameters [20]; one of them is a process of professional identity development.

We identified that project courses develop not only students' professional skills such as work ethics and communication skills, but also their feeling of belonging to the discipline. Our recommendation is to pay closer attention to the identity development processes that happen throughout project courses and design those courses with these aspects in mind.

We believe that well-designed project courses not only equip students with skills and knowledge, but also help them to become well-rounded and effective members of society. We agree with Mahadeo et al. [49] that "we need to keep technology's constant evolution in mind and improve our understanding of how people build strong affinities with computing so as to motivate the development of new solutions that help meet the needs of our diverse society and the growing sustainability concerns of the future."

VIII. FUTURE WORK

This grounded theory study is based on a relatively small group of participants from two project-based learning courses at two Norwegian universities. In the future it will be important to get a better understanding of students' professional competencies, employability, and identity development in a larger study taking into consideration different computing degree programs and larger students' population. It will be as well interesting to see in more detail how our findings differ from previously reported results in the field.

IX. CONCLUSION

We have identified that putting more emphasis on graduate attributes helps to legitimise diverse ways of participation in the computing discipline, and at the same time broaden the narrow and technical computing identity as identified by Peters [12].

Our findings show that there is a strong emphasis on professional skills development in the courses analysed. The findings align with recommendations several computing curriculum development documents [7], [9], [50] provide. Students participating in project courses acknowledge that being open to different perspectives of their team members is important. Moreover, students develop an image of competent computing professional as a person that effectively communicate, work in teams, and solve problems creatively. By participating in project courses, students have an arena to develop these professional skills and gain project experiences which increases their employability, makes them become ready for a future profession and face global uncertainties.

We presented theoretical perspectives in a structured manner and provided a consistent vocabulary to discuss important issues regarding change of education based on identity, employability and professional competencies perspective.

Aiming at creating a mutual understanding and 'opening up' computing education, we provided a theoretical base that is needed for further implementation and redesign of curriculum. We argue that we need to have a holistic, university-level initiative regarding the implementation of professional competencies and identity into computing education.

We hope our findings will increase motivation for curriculum reform and the implementation of graduate attributes in Norwegian higher education curricula.

ACKNOWLEDGMENT

We would like to express our appreciation for reviewers' engagement and constructive feedback. We would also like to thank our colleagues for fruitful discussions, and to all participants that took part in the study and enabled this research to be possible.

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