Engagement in Computer Science and IT – What! A Matter of Identity?

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***Abstract*—In this paper, we develop and illustrate the use of a new theoretical framework to systematically investigate the development of student identity in Computer Science and IT. Identity has been identified as a critical issue in the endeavour to increase students' engagement in Computer Science and related areas. Findings from earlier studies indicate that students' doubts about future engagement are often due to an unfortunate perception of the discipline, that it lacks meaning, which leads to a tendency to dissociate themselves from IT and Computer Science as an area of further study. To understand different ways of experiencing engagement in the discipline as personally meaningful, we have integrated aspects of Lave and Wenger's social theory of learning, especially Wenger's notion of meaning, with a model developed by Entwistle that describes how conceptions of learning and knowledge expand and evolve in the context of the educational experience. We explore the use of this theoretical framework on reflections that we collected from all novice students of the Computer Science and IT engineering programme at Uppsala University, in which the students reflect on their choice of study program, goals, and expectations for education. The theoretical framework is furthermore discussed with respect to our broader research project to study students' identity development in Computer Science and IT as well as the role of education, how it supports or hinders students and how this can be used to inform educational development.**

***Index Terms*—engagement, identity, meaning and perception of the discipline, Computer Science, IT.**

I. Introduction

> "When you are a programmer, I think, you work with problem solving [...]. It's not that complex. You write this code and it's not like you have to think of [...] society and economy and things like that."

This statement was made by a student in the Sociotechnical Systems Engineering degree programme at the end of an introductory course in Computer Science (CS) [1], [2], explaining why he will probably not choose CS as an area for further study. Unfortunately the student's utterance paints a relatively narrow picture of what a computer scientist is, and, apparently, one that the student cannot identify with. This is one of many examples of student reasoning we have collected in our research on trajectories leading to future engagement in CS and IT.

Low engagement and high dropout rates in CS and IT degrees continue to cause concern in Western countries [3]. Two major advocates for engineering and computing, the Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM), continue to champion initiatives to enhance engagement among school and university students [3]. Recent research in science, technology, engineering and math (STEM) education suggests that students' ability to identify with their chosen area of study is a critical aspect affecting retention and recruitment [4], [5]. An aspect broached by these studies is that many novice students now seem to relate to STEM disciplines as being cross-disciplinary and innovative. This view is often not confirmed by early university experiences which leads to disillusionment and doubt. As a conclusion, research on how identity formation can be supported in university education is recommended. However, what should be the focus when investigating students' identity formation in CS-related areas?

Results of our pilot study [2] as well as of our preliminary data analysis of novice students' reflections indicate that students in different CS-related study programs reason, engage, and define themselves in relation to the knowledge content of the discipline. In the introductory example, the student is interested in complex problems, that relate to society. He can see engineers working on such problems, but not computer scientists, programmers, that in his understanding only do coding.

Based on these observations, we wish to describe and explore identity formation as students pursue their studies. In this paper, we suggest a theoretical framework to study identity formation in relation to students' conceptions of a discipline and its meaning. Furthermore, we explore how to utilise this framework in the context of empirical analysis of reflective texts, and interview data. Our aim is to develop and demonstrate the power of a system within which it is possible to qualitatively describe the evolution of conceptions of discipline and identity at the cohort and individual level.

We commence with the specification of our research aim and questions. The description of the theoretical framework follows. Subsequently, we describe our data collection and analysis methodology. Then, we describe the results of our data analysis with a focus on how the theoretical framework helps to reason about students' identity development. After that, we discuss the results of our analysis in relation to related results and to emerging research questions. A summary of the study outcomes and directions for future work is the focus of

the concluding section.

II. Research Framework and Questions

This paper presents a theoretical framework for our research project on students' identity formation in CS and IT. We will follow students from the beginning of their studies over a period of two to three years. Furthermore, we want to compare different ways of identifying with the discipline, by investigating students from three different study programs: Computer Science (CS), and two engineering programs, Information Technology (IT) and Sociotechnical Systems Engineering (STS).

Our objective is to inform educational development, e.g. curriculum design. This, in addition to investigating different student identities, necessitates an understanding of how education supports or hinders students in perceiving their education as relevant.

In this paper, we describe and discuss a first version of a theoretical framework specifically developed to study identity formation. We combine aspects of Lave and Wenger's social theory of learning as well as aspects of Wenger's theory of Community of Practice with a model on learner's development proposed by Entwistle. We explore its application based on reflections we collected of all novice students of the CS and IT engineering program. We aim to answer the following questions:

R1: What aspects of Lave and Wenger's theory appear to be relevant to understand students' identity formation in CS and IT?

R2: In what ways can Entwistle's theory complement the notion of identity we describe in R1?

R3: How do the answers of R1 and R2 inform our endeavour to understand students' identity formation and the effect of the university education experience?

Figure 1 gives an overview of the study design. We will study and compare identity development of students of three different study programs – CS, IT, and STS. We are interested in the students' ability to relate to the discipline, which is presented by the vertical axis. The graphs illustrate the development of identity, at this time generalized speculations. As research indicates that students in CS struggle to identify with the discipline due to educational experiences, we have illustrated this through a descending graph. For the STS students, we assume rather growth of their identity in CS and IT as the students have not chosen IT and CS in the beginning. The image in the circle illustrates the theoretical framework for the investigation of students' identity formation.

III. Theoretical Framework

Investigating development of identity is a complex undertaking. It has been pointed out as a critical aspect in recent research [2], [4], [5], but it has hardly been explored in higher education research so far [6], [7]. How should identity be understood so that research on identity development addresses problems such as low engagement in CS and IT? In his recent thesis on attrition and retention in physics, Johannsen argues

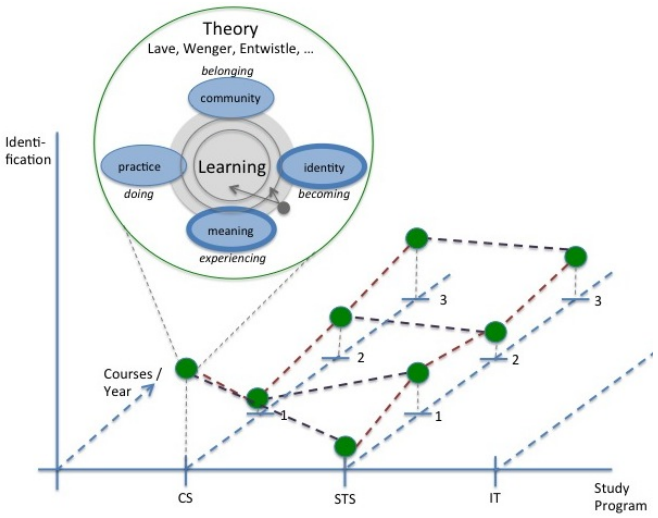

Fig. 1. Illustration of the Broader Research Framework

that it is necessary to "operationalize a socio-cultural and cultural-historical perspective on identity" [7, p. 24].

A socio-cultural perspective is also incorporated in theories of community of practice [8], [9]. Lave and Wenger develop a view of learning as being situated in a community of practice. The epistemology of the group, that is to say, their beliefs regarding knowledge and meaning are defined by and through the members of that community. Accordingly, the main purpose of learning is to work towards acceptance as a member of a community, as opposed to the traditional view of learning as being apprenticeship. Lave and Wenger then define identity as a long-term, living relationship between a person and his or her place and participation in a community of practice [8, p.53]. Consequently, identity formation can be understood as establishing such a relation and place in a community of practice, and thus is a major focus of learning activity.

Wenger's social theory of learning [9] gives concrete support for investigation of identity development. It integrates four components: Identity, Meaning, Practice, and Community [9, p. 5]. Wenger argues that identity is formed through the negotiation of meaning, through practice, in the context of a community. Hence, all of the four components can be seen as linked through meaning. Meaning is central to Wenger's theory as he stresses that "human engagement in the world is first and foremost a process of negotiation of meaning" (p. 53). Wenger describes meaning as the interaction of two constituent processes, which he calls "reification" and "participation" [9, p. 55-62].

The term participation refers to two aspects, to taking part in something, and to the reflection this arouses from interaction with others. Hence, participation and the meaning thereby construed, always have a social character. Even if the activity is carried out in isolation, it is given meaning through social participation. As an implication, Wenger argues, participation cannot be turned on and off erratically. Furthermore, partici-

pation involves the whole person – body, mind, emotions, and social relations as well as doing, talking, thinking, feeling and belonging.

Reification refers to both, the process and the product "of giving form to our experiences by producing objects that coalesce experience into thingness" [9, p. 58]. It attributes substance to abstractions, such as "justice" or "economy". Through reification, we "project construed meaning into the world". Reification is central to every practice, and expresses itself through tools, symbols, formulas, stories, terms, and concepts. As much as we produce reification based on our experiences, reification also influences our experience of the world as well as our ability to act, and our identity.

In addition to Wenger's components of meaning, Wenger reasons that patterns of engagement are also a means to understand negotiation of meaning and thus formation of identity. Patterns are activities that we engage in more or less regularly, e.g. a conversation during lunch with our colleagues. Producing these patterns anew gives rise to meaning since we "extend, redirect, dismiss, reinterpret, modify or confirm - negotiate anew - histories of meanings" [9, p. 52-53]. This history of meanings mirrors a learning trajectory, and is another aspect of identity formation.

The aspects of Lave and Wenger's theories presented here provide a structure to reason about students' identity formation and how they experience engagement as meaningful. However, the application of Lave and Wenger's ideas and concepts to our problem is not straightforward for several reasons. Wenger illustrates his theory with examples of an ethnographic study in a medical claims processing center operated by an insurance company in the US, which is a very different context to that of an academic learning environment in CS and IT. Furthermore, he uses the theory foremost to describe the characteristics of a community of claim processors.

Lave and Wenger's theories provide a context with which to describe becoming a member of a community in a way that appears meaningful, and developing a relation to the knowledge content of the discipline. This is complemented by Entwistle's theory of learner development [10] as it describes students' development of conceptions of knowledge and learning (see Figure 2). In both dimensions, development leads to "changing as a person", and developing a "sense of identity".

Development proceeds as the learner recognizes different forms of knowledge and learning processes. Entwistle draws on work of Perry [11] to describe the development of conceptions of knowledge, i.e. students' epistemological development, until they reach the ways of thinking characteristic for academic discourse. The main threshold that has to be overcome is the change from "Dualism" to "Relativism". Thereby, the students refrain from thinking in terms of knowledge as right or wrong but instead accept uncertainty in knowledge and values and reason based on evidence and testing alternative explanations. This opens up the subject in new ways, but also the learning.

To describe the development of conceptions of learning, Entwistle integrates results from research by Säljö [12]. There, a threshold is described between the conceptions of learning as "Reproducing knowledge" and "Seeking meaning", which entails monitoring the learning progress towards an own understanding, in which knowledge takes on personal meaning. Hence, the learner in these mature stages tries to understand the meaning of what he is learning, thereby relating to what he has learnt so far, and sees things in different ways as he is learning.

As the two dimensions of conceptions of knowledge and learning are seen in parallel, the potential of Entwistle's theory is to help to develop an understanding of how students come to perceive and construct knowledge in a way that is personally meaningful to them and how they choose to go about learning. This adds another perspective to the notion of meaning as described by Wenger. Concluding, we argue that Lave and Wenger's theory together with Entwistle's theory provide an interesting initial theoretical framework with which to explore students' identity formation and their conception of the discipline and its meaning.

IV. Data Collection

In order to explore ways to apply the theoretical framework, we collected empirical data.

A. Instrument

To answer the research questions stated in section II, we developed three open questions for a reflection. All of the questions had sub questions that were meant to inspire the students in their reflections, not to be answered one by one.

In the first question, we asked the students to reflect on their choice of study program: How have their experiences, their interests, and what they think is exciting and challenging influenced their choice. Have others, like friends, family or school, influenced them? In the second part, we asked the students to reflect on their prospects of their future work. In which situation or context can they see themselves? What do they want to work on, and with whom? What do they want their work to result in? In the third part, we asked the students for their expectations on their education. What do they expect to learn? What is needed to reach their goals described in the second part? How can the university support them in that?

B. Collection Procedure

For this explorative application of the framework, we focused on the novice CS and IT students, that entered their study program at the start of the Autumn term of 2012. The questions for reflection were given to the students in the beginning of an introductory course, which introduces the students to different aspects of the discipline and studying. The students received the assignment to do the reflection in the second week of the course and semester.

V. Data Analysis

In the following section, we aim to describe how the theoretical framework (section III) helps to understand different ways of identifying with the discipline, in particular how engagement in CS and IT is perceived as meaningful.

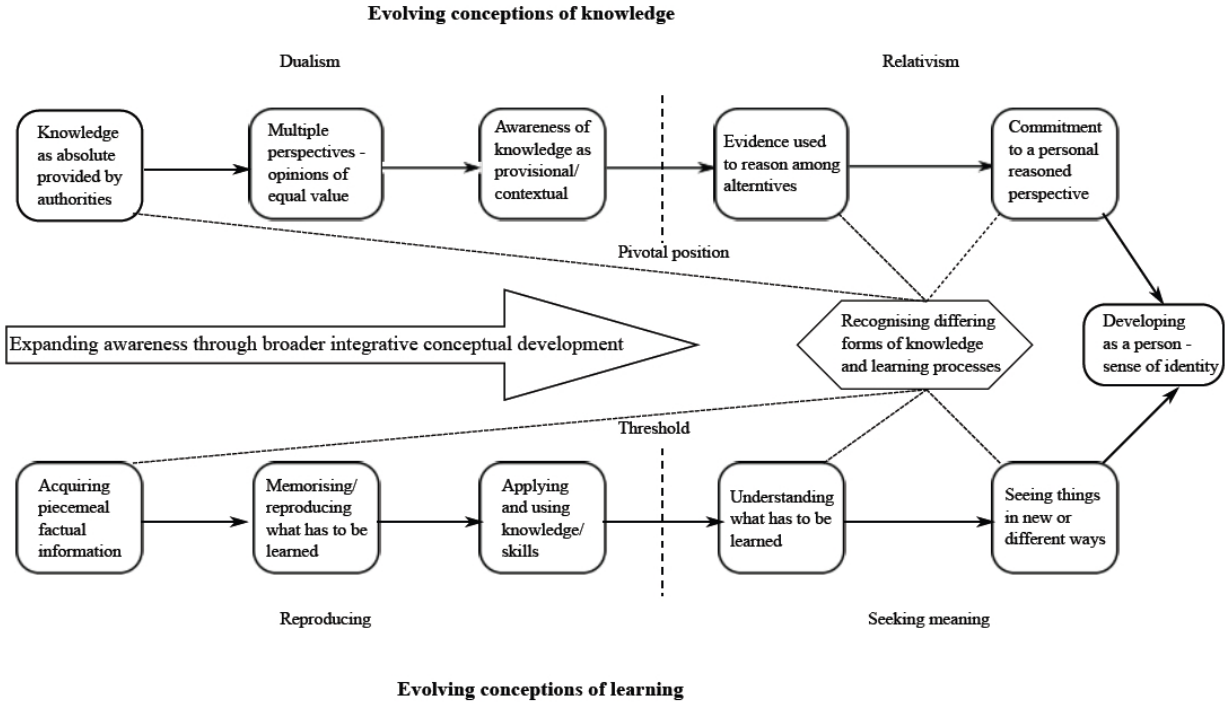

Fig. 2. Slightly Adapted Version of Entwistle's Theory of Learner's Development [10]

A. Methods

We collected 123 reflections in Swedish from 149 registered students in the study programs IT and CS. The lengths of the reflections vary a lot, between a couple of paragraphs to two pages. The average number of words per reflection (that might contain the questions also) is 380 words. To get an overview of the data, we did a thematic analysis [13] of 30 randomly chosen reflections (25 male, 5 female). From that, we developed ideas on how to use Lave and Wenger's theory to understand students' relation to the discipline, i.e. as described in section III, how they perceive their engagement as meaningful, how they identify with it. We developed tentative categories that relate to Wengers' four components of learning, identity, meaning, practice, community, and coded the chosen reflections, using these tentative categories and subcategories, that we identified while we were doing the coding. This coding was done in several iterations. Furthermore, we did an explorative deductive analysis [14] based on the conceptions that Entwistle describes in his model of learner development (section III, Figure 2).

As we are aiming at testing and discussing the use of this framework rather than making claims about students' identity formation, the analysis has been explorative, preliminary. However, further more rigid analysis of this data will be worked on after the framework and its actualization has been discussed.

B. Results

The results of our explorative data analysis are presented in three parts: first, in respect to Wenger's theory of Communities of Practice, then based on Entwistle's model of learners' development. In the third part, we integrate the results. The quotes given are translated from Swedish to English, as much as possible preserving the students' connotation.

1) Using Wenger to Explore Student Identity: Aspects of identity are common in students' reflections on their engagement in CS and IT.

> "Computer Science is that which lies closest to me." (student in CS, male)

Identity, according to Wenger, develops through (re)negotiation of meaning during a trajectory of learning. Further, meaning can be studied through its two constituent processes reification and participation. In the following, we explore ways to concretize this theory with empirical data.

> "My computer interest was the reason for my choice of study program. Everything began with my father who works as a consultant [...] and thus has a 'computer oriented' work. Like for many other young people, my father was the first ideal to strive for, he was my hero. One day, he took with him, an installationdisk for a programming language and asked if I was interested. The answer was of course yes. Ever since then, my computer interest has escalated." (student in IT, male)

Many reflections invoke "interest in the computer" as a reason for the choice of study program. In fact, as it is the case here, many reflections begin with a statement of that nature. We find many stories, such as the one above, that describe computer-related activities with friends and family, such as playing games, maintaining the computer, or programming. In these stories, the computer seems to be *the* object that the students base their stories on. Hence, we suggest that the

computer can be seen as an object of reification.

Meaning in connection to the computer is construed in different ways:

> "The choice was quite obvious- I like to work in a computer environment, where I feel home." (student in CS, male)

Feeling home in a computer environment hints to everyday activities with computers. Indeed, later on in the students' reflection, the student writes that "of course", a dream is to work in the computer game industry, which indicates that this student enjoys playing games which has led to the feeling of home when dealing with computers. In fact, many students that write that they like to play games write that they are interested in game development.

Furthermore, we find statements that express fascination over what computers can "do":

> "It has always puzzled me how things, such as computers, can 'think' when you can not see anything special with the naked eye." (student in IT, male)

Similarly, we find other students that express fascination over what one can create with code, e.g. in relation to computer games. This hints to computer programs and programming.

> "I chose IT because I have always been interested in computer, have sat much in front of the computer, and have done things like programming." (student in IT, male)

This student talks about how he has later chosen the "technical line" (program) at high school that has reinforced his orientation towards IT. In fact, when students write about their interest in computer, we often find stories about programming, in many cases in relation to programming websites, which is for example done with PHP.

> "I began early with PHP and am quite good at it now but I don't do any larger things with it for the moment. The reason for why I want to become better at programming is that I have two friends through the internet that are working on a very big project, and to fully understand how the project works would be a big challenge. The fun of programming is when you get it to work, according to me." (student in CS, male)

In this case, early experiences in programming have let to a kind of participation in what the student perceives as a big project. As the student mainly reflects on programming and why it is fun, it is presumably the aspect of the project that he has in mind, that he thinks is a challenge to fully understand, and that he wants to become better in. As emotions, mutual recognition, social interaction and reflection are involved, we can interpret this as participation in Wenger's sense, more specifically "partial participation", and envisioned "full participation". The student writes that he wants his future work to be challenging, and that he wants to learn programming. Hence, previous experiences and ideas for future work as well as education appear well aligned.

We also find rather hardware-related experiences:

> "Since I was small, I have always been very technological, I have always loved to fiddle with electronic and learnt how they function. I have also used at least a pair of headsets per year, but when they are broken, I want to take them apart, only to see what they look like inside. I have always been a 'gadget geek' who wants to read about new things, at the same time as I have had friends who were interested and could do more than me, so it was just to ask them." (student in CS, female)

The computer is of special interest, fascination for this student as she starts the section on what she is interested to learn with:

> "One of my goals in live is to build a whole computer on my own." (student in CS, female)

Consistently, she says that she can imagine to work within the field of computer architecture in the future. She chose CS instead of IT because:

> "CS is more hardware and in depth of a Computer." (student in CS, female)

In summary, this student also negotiates meaning in relation to computer. Her story of earlier engagement indicates experiences of participation, as emotions and mutual recognition are included. Her experiences in taking apart devices thereby relates to her goal to build a computer (put together parts to a whole).

We have argued that one example of reification is the computer. In relation to that, we find experiences that can be interpreted as participation as they involve activities, feelings and emotions, as they are carried out in a social group, with friends and family in mutual recognition, and as meaning is construed through these experiences. These experiences of participation have been meaningful to these students, as they are described to explain engagement in CS and IT and as they determine future trajectories of engagement.

Another way meaning is construed is with a broader focus on technology, often in relation to society:

> "I chose Computer Science because my whole life, I have been interested in IT and ways computer have been integrated in our society." (student in CS, male)

This student also uses the term computer, but in a broader social context. In the rest of his reflection, he does not write "computer" or any other computer-related term, such as "programming", "application" etc.. Instead, he writes about "IT-solutions" and "technological development". He states that he wants to work as a consultant. He does not write about any previous experiences or activities that relate to that.

Another quote that relates to this way of meaning making:

> "I hope and believe that my work will lead to a better world where technology and society interact in a more effective and gentle way." (student in IT, male)

This student sees technology embedded in society and wants to contribute to improving this interplay. How does this goal relate to earlier experiences, possibly participation in a social environment? The student begins his reflection by stating that he has been interested in technology, everything in his environment from a TV to a microwave, and in how these things work. He states that he has friends that are similarly technology interested and that are like him well-informed about technological development.

> "And that has shown me that the world of technology is fantastic and not driven of limits, but free for speculation and imagination." (student in IT, male)

Reading and talking about technology with friends could be seen as a kind of participation, as it includes emotions, mutual recognition and as it has had an influence on the students' engagement. In his future job, the student hopes to be creative, to solve problems, or to develop new technology that does not yet exist, together with innovative people with similar interests. In line with this, he wishes to learn how things work and how to solve problems with "IT-structures". In regard to development of IT-systems, he does not state experiences. He seems to have a relation to programming though:

> "Maybe I do not want to program things for the rest of my life, because that seems to be quite boring." (student in IT, male)

It is unclear how this view relates to earlier experiences.

The following quote is taken from the reflection on the choice of study program:

> "The biggest obstacle to continue is that I do not like to program, but I still want to have a deeper understanding of our technology in society." (student in IT, male)

Unfortunately, the student does not write about why he does not like programming and where he got his experiences from. In his reflection, he does not write about other earlier CS and IT related experiences but that he dropped out of the engineering physics program. He writes that he has done a lot of thinking before he chose IT, he sat down with the catalogue of study programs and crossed out everything he wasn't interested in – IT and Multi Media remained. He envisions his future engagement in the following:

> "My dream is to lead an own company that works on some kind of IT solution. If I may dream freely, I would like to become an inventor, I want to develop a product from the beginning to the end. [...] If I choose a role model, then it would be Steve Jobs and his development of Apple." (student in IT, male)

This student writes about who he wants to become. As he uses "dream" and "dream freely", this appears to be quite detached from experiences he has had so far. Indeed, he does not state any earlier experiences. His expectations for education relate to his future ideas:

> "From my studies, I want to carry with me knowledge that I can compete with on an international level, and that lies on the edge of what technology has to offer." (student in IT, male)

The previous quotes illustrate negotiation of meaning with a broader focus on technology, often in relation to society and innovation. This can be seen as another object of reification. It has become visible in the students' stories and it appears to be a projection of construed meaning, as it is used to explain engagement in CS and IT.

Wenger states that reification refers to giving form to our experiences. The students' experiences related to the two objects of reification, "computer" and "technology in society", appear to be very different. The students with a focus on computer have often experienced a kind of participation as the computer is relatively accessible. Further, they have often experienced development, e.g. computer programming. The students that focus on technology in society have less likely had hands-on experiences. Hence, their envisioned future participation (e.g. consulting, development) and their expectations for their education do less likely relate to previous experiences of participation and concrete activities. As meaning, according to Wenger, is the interaction of reification and participation, this observed difference between the two different ways of negotiating meaning is remarkable.

Also, we find students with a broader focus on technology that have a "striking" relation to programming. Maybe they have experienced programming in a way that does not relate to what they perceive is meaningful? This could be the case as early programming probably relates to programming applications for computers.

2) Conceptions of Knowledge and Learning Based on Entwistle: Analyzing student discourses using an adapted version of Entwistle's model of learner development allows us to gain insight into students conceptual maturity as they negotiate their professional identity in a broader social framework. Overall, we find expressions that indicate lower conceptions. The following quote is an example for knowledge being dualistic:

> "First of all, I hope to learn to program correctly." (student in CS, female)

This statement indicates a dualistic conception as the student assumes that there is a right way to program and that she will be told what that is, which is directly related to knowledge as provided by authorities. Further evidence of this conception can be found in statements such as:

> "I believe, that the university will teach me what is required for a career as a programmer, computer scientist. [...] First and foremost to program, both programming language and how to organize a project with programming, including how a computer works." (student in CS, male)

> "I hope to be able to learn everything that is needed to be active in the labor market. To reach that, I will finish all my courses." (student in IT, male)

We surmise that students with this type of conception also fall, presumably, into the lowest conception of learning "acquiring factual information".

The higher conceptions of Entwistle are not so easy to identify at this stage, as the students are mostly not so experienced. Quite some students appreciate the developing character of the discipline: faster technology, new programming languages etc.. This suggests a conception of the discipline as being provisional. Furthermore, we find very few statements that indicate a conception of learning as seeking meaning, e.g. by one student that hopes to learn how programming languages are built up to be able to learn new programming languages.

3) Integration of the Results: So far, we have explored the use of Wenger's theory to better understand how students experience their engagement in CS and IT as meaningful. We gave two examples of reification and in relation to that interpreted students' experiences, in some cases in terms of participation. In our analysis based on Entwistle, we found overall lower conceptions of learning, especially the expectation to "be provided" from the university with what is needed

for the career. Based on these results, we can give a possible explanation of the following quote:

> "In the first week, it suddenly struck me: Computer Science is perhaps not what I expected and if I did right or wrong when I chose the program. [...] During the weekend, I just sat and read deeper about CS, what it actually is and what future it has."(student in CS, female)

The student might have been confronted with CS and IT in a way that does not match what she perceives is meaningful. This leads to strong doubts about her choice of study program as she expects to learn what she will need and use after her studies. Furthermore, her meaning making may be relatively weak, as she does not have earlier experiences of participation.

Previous examples of students with broader interests in "technology in society" indicate problems in relating programming to students' negotiation of meaning. We found one example of a student, male, enrolled in the CS study program, that seems to be more successful in that: After the student had thought about studying medicine, microbiology and politics, he finally decided that:

> "Computer Science is that which lies closest to me. I have always been interested in technology, even if I have not always understood how it worked. [...] Looking into the future, I know, that our world needs more computer scientists and developers." (student in CS, male)

This indicates a rather broad perspective in his negotiation of meaning. He does also state an interest in computer, "especially in gaming". Furthermore, he says:

> "I have always been interested and fascinated over what one can create with code." (student in CS, male)

Through his friends, that have studied the same study program at the same university, he knows about the versatility of different jobs for computer scientists, which leads to a positive view of the future:

> "A future, that can involve another great interest I have, namely in an international perspective and in security. Therefor I hope to work in security related programming. That which I also hope for is an international work, that I will be involved in a project [...] that leads to global development." (student in CS, male)

The student relates programming to global development, which the other students with a broader reification don't do. This however is not based on the students' own experiences, but maybe partly on his friends' stories of participation. Furthermore, the student has a high conception of learning, that has presumably supported him also:

> "I know that the education will be useful. Maybe not that I will learn exactly what my dream job comprises, but what I will learn is a way of working and thinking that will be useful to me." (student in CS, male)

Although the student states that he knows this from his friends that are already working in the field, we can assume that he himself has such a view and does not expect to be provided with exactly what is needed for him. One argument that supports this assumption is that he is able to link programming to his broader interests.

Concluding, the two examples above summarize how the theoretical framework presented in this paper could help to better understand students' negotiation of meaning in CS and IT. The examples above furthermore show how the components of the framework add on to each other, i.e. Lave and Wenger's theory of social learning, especially Wenger's concepts "reification" and "participation" to study meaning, and Entwistle's model of learner's development.

C. Discussion and Questions for Future Research

Our results are related to Schulte and Knobelsdorf's research on novice students' attitudes towards CS [15], [16]. According to them, trajectories of experiences that lead to engagement in CS often begin with usage of computer. Furthermore, they describe an important shift from usage to creation and development (programming) that leads to future engagement in CS. They collected data through "computer biographies", in which they explicitly asked the students to reflect on their experiences related to the computer. As computers are so prevalent nowadays, Schulte and Knobelsdorf assume that those have the biggest affect on students' attitudes towards CS. Our work suggests that students also construct meaning with a broader perspective on technology in society and innovation.

Ulriksen et. al. [4], [5] investigated drop out in STEM. They find that students that are interested in innovation and interdisciplinary work are often confronted with a different image in their education. This throws light on the student group in CS and IT that negotiates meaning with a broader perspective on technology. We have found possible problems as some of the students express a conspicuous relationship to programming. The way the students learn programming in the beginning of their education presumably addresses a rather narrow perspective on computer (applications).

Concluding, it is important to understand students' negotian of meaning and its development during education. Are there other focuses in student's negotiation of meaning? How do students' negotiation of meaning relate to earlier experiences? How do participation and reification develop during their studies? Are students' conceptions of learning and knowledge developing and how does that influence students' negotiation of meaning? What is the role of education in all these aspects?

VI. Summary, Conclusion, and Future Work

In this paper, we described and explored the application of a framework that provides a theoretical basis with which to study students' identity formation in order to understand how student perceive learning CS and IT as meaningful, and how they are supported or hindered by their education. In order to study personal development, we combine Lave and Wenger's theory, which provides a way to understand becoming a member of a community and negotiation of meaning, with Entwistle's theory of learners' development that describes growing conceptions of knowledge and learning. Based on data gathered from novice students, we tested the use of this theoretical framework to illustrate how students' reflective utterances can be used to chart identity formation in CS and IT.

We find Lave and Wenger's concept of meaning useful when trying to understand students' relationship to the discipline, and how they envision their future participation and learning. The concepts reification and participation have been particularly useful in helping to reach an understanding of students' trajectories in this respect. Analyzing the data based on an adaptation of the developmental model proposed by Entwistle, we find (not unexpectedly) that students in our study express collectively conceptions of knowledge, as being absolute and provided by the university, which implies a less sophisticated conception of learning, i.e. reproducing of facts.

There appear to be two student groups with different negotiation of meaning that could be valuable to follow. One group of students makes meaning with a focuses on computer and applications. Such students often have participated in programming and envision their future participation in alignment with their earlier experiences of participation. They expect to learn more in this respect. The second student group focuses on bigger systems and technology in society. These students have often not participated in development and envision their future participation differently from the first student group, and it appears unlikely that their stance is based on previous experiences of participation.

As the students now have overall low conceptions of learning and knowledge, they often expect to be equipped with what they need for their career. The role of higher education and curriculum is clearly significant for the second group. Most engineering and computer science degree programmes introduce programming subjects early, and focus on programming skills in the early parts of the curriculum. This addresses the computer perspective more than the systems perspective. Consequently, our theoretical framework will be helpful to study how students re-negotiate meaning, thereby improve our understanding of their evolving conceptions of knowledge and learning.

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