What Do I Need To Learn? Computing Competence Described by Novice Students

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***Abstract*—This is a full research paper. Computer science is a young, dynamic and rapidly evolving discipline. Content knowledge has been the focus for higher education in the subject but none-technical skills have gained increasing attention. To develop competence in the discipline, dispositions are also needed, this aspect is however new to computer science education. This study explores novice computer science students' perceptions of essential competencies for success in the field. Reflective texts from 133 students at two Swedish universities collected during their first week have been qualitatively analysed using the Competency learning framework (CoLeaF) and tested for statistically significant differences within the student group using a Chi-Square analysis. CoLeaF describes a competence in terms of its dispositional, skill and knowledge elements. Students were primarily focusing on disposition and skill elements. Motivation, perseverance and creativity were the most common dispositions and skills related to problem solving and logic were most prominent, followed by collaboration and communication. Math was the predominant knowledge element reflected on, particularly by students with more prior programming experience. Differences emerged between legal genders, with females emphasizing curiosity, being structured, having a goal, and being challenged more than males. The study highlights a need for CS education to cultivate both technical expertise and non-technical qualities alongside a deeper understanding of ethical and societal responsibilities within the field.**

***Index Terms*—Competence development; Computer science; Student perceptions**

I. Introduction

Computing is a dynamic and multifaceted academic field that continues to evolve, with ongoing discussions about its definition [1]–[3]. It has its origins in various traditional disciplines, such as the logical-mathematical, the science, and the engineering tradition, and has rapidly expanded, fueled by advancements in digital technology. Today, the field is undergoing a new paradigm shift driven by the rapid development of Artificial Intelligence and its profound impact on society and individuals. The expansive nature of the discipline is evident in its diverse branches, including cybersecurity, human-computer interaction, artificial intelligence, health informatics, and computational theory, which are interconnected in various ways. The field's size and complexity make it challenging to grasp its totality, and its definition has always been fluid, shaped by diversity and interdisciplinary collaboration. This evolutionary and interdisciplinary nature characterises computer science as a living discipline but also makes it challenging for novice students to understand what they sign up for when pursuing a career in computing.

What has become evident in recent years' development of the field is that non-technical and non-mathematical abilities are becoming increasingly important [4]–[6]. These abilities include, for example, communication skills, collaboration skills, problem solving abilities and creativity, as well as ethical, sustainability, and integrity considerations. They complement technical skills and play a central role in the rapidly changing landscape of computer science. The ability of professionals in the discipline to work in dynamic, interdisciplinary, and interactive environments, in addition to their technical expertise, is crucial for the complex landscape computer science has become. Non-technical skills also encompass values and attitudes. These are reflected in the technology being developed and thus affect society as a whole [7].

The Association for Computer Machinery (ACM) and IEEE Computer Society (IEEE-CS) addressed the importance of soft skills complementing technical and mathematical skills and knowledge in their Computing Curricula 2020 report (CC2020) [8]. CC2020 is an evolution of the influential Computer Science Curricula 2013 document [9] and provides international recommendations for bachelor programs in computing as well as a vision for the future of the discipline. The new recommendations shift from a knowledge-based to a competence-based view of learning and educational outcomes, reflecting a change in how education in the discipline needs to be be structured. A competence is described as associating elements of knowledge and skills, that were the focus of previous curricula, with dispositional elements in the context of a task. Knowledge is "what" you know, the factual understanding that forms the foundation of competence. Skills refers to "how" you apply the knowledge, the ability to put knowledge into action. Disposition refers to the "why" behind your actions, values and motivations and influences how you use your knowledge and skills. Knowledge alone is not enough to be a competent graduate within computing, the skills to apply the knowledge and the dispositions to use knowledge and skills for the best outcome are all indispensable.

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This study investigates Swedish novice computer science and information technology students' perception of what competence they need to have or develop to become professionals within the field of computing. The study is guided by the research questions:

- What elements of competence do novice students in computer science describe as useful in the context of computer science and to learn how to program?
- Are there differences between categories of students regarding their perceptions of competence elements useful in the context of computer science and to learn how to program?

Understanding students' preconceptions of the field and their expectations on their education will help us support students at the beginning of their studies, which may affect retention. It will also help us in the development of future computer curricula and to better understand how the field is generally perceived. This study lays a foundation for future studies exploring how computer science students' perception of what competencies are important within computing develops over the duration of their studies.

II. Related Work

Disciplines such as medicine, law and education have a tradition of incorporating professionalism in education. Professional aspects of computer science are now gaining increased attention which promotes transformation of computer science education towards a stronger competence focus. A main driver of the transformation is a shift of focus in the recommendations for computing education in the CC2020 report [8] by ACM and IEEE. CC2020 follows recommendations given in the IT2017 report [10] and subsequent CC reports [11], [12] embracing the notion of competence as a basis for computer science education. The main change in focus lies in the recognition of dispositions as an essential aspect alongside, and combined with, knowledge and skills to build competence in the discipline. It embraces not only what the student knows and can do, it also embraces what the student does with what they know and do [13]. This change of focus in curricula recommendations reflects a shift in the perception of the discipline.

In industries' expectations of computer science professionals [14]–[16], dispositions frequently take priority over skills and knowledge. Traditional computer science curricula, however, cover only technical knowledge and skill aspects. This fosters students to become mostly technically focused learners [17] and creates a gap between competence acquired in education and competence needed by the computing industry [18], [19]. Computer science graduates need to understand computer science professional's role as "agents of change", i.e, that competence and virtue are connected in the profession. To this end, it is needed to step beyond the technical focus and to integrate dispositional aspects into the learning outcomes.

Although skills are not new to computer science higher education, they need some further attention. McDermott and Daniels [20] argue that a skill is more than just a derivative form of knowledge, that it is grounded in practice, demonstration and performance. Computer science professionals need both technical and non-technical skills [4]–[6]. Skills such as problem solving, communication and teamwork are frequently mentioned as important within the profession, organisational skills are also highlighted in some computing professions. In computing program curricula at European universities communication and teamwork are consistently present while for example creativity is severely underrepresented [21]. Similarly to dispositions, soft skills going beyond being just a derivative form of knowledge, is also not straight forward when it comes to methods for assessment [22], [23].

Clear et al. [18] explores transitioning from knowledge-based to competency-based curricula using the CoLeaF-model [13], [24], [25] to re-express knowledge areas as competencies. The transformation was proven to be challenging, mainly due to the fact that learning outcomes do not explicitly address the relevance of dispositions. Knowledge and skills are familiar concepts to most computer science educators, but the notion of disposition is a new dimension. The CC2020 report lists dispositions that are expected of competent computing graduates in addition to technical knowledge and disciplinary skills. These are (without any hierarchy): Adaptable, Collaborative, Inventive, Meticulous, Passionate, Proactive, Professional, Purpose-driven, Responsible, Responsive and Self-directed. In job ads, collaboration (including aspects such as communication) and responsibility are predominant while professionalism is less frequent [14]. A possible explanation is that professionalism is addressed as a sum of other dispositions. Life-long learning orientation is also mentioned frequently in the professional context of computer science [15], [19], [26]. Tagare et al. [15] found that some dispositions promote or aid other dispositions, for example life-long learning orientation is promoted by curiosity and adaptability.

In software engineering, a field within computing, Malhotra et al. [27] provides a literature review investigating the transition towards competence-based software engineering training. Their findings indicate that competence-based education is beneficial in engineering education, e.g. it supports life-long learning and fosters an empowered and inclusive learning culture. It also alters the focus of the teacher. Ethical and sustainability awareness and considerations are under spotlight in today's digital society. Both of these have strong dispositional requirements. Incorporating ethical considerations in computing education is an ongoing process [28]–[30] and CC2020 [8] recommend making this incorporation explicit. Sustainability is a later addition to computing education [31]. Although there is a weak connection between learning outcomes and sustainability competence, students rate sustainability-related competence as important for future professional practice [32].

Broadening the scope of learning outcomes has potential for expanding students' learning. While some learning outcomes are easily translated to become competence-based, many are not. Making the transition to competence-based education will transform the expectations on both teaching and learning activities and assessment. A natural question is then how to assess such human characteristics [33]–[35]? Using reflective exercises [36] or more long term approaches such as portfolios [37] instead of assessing outcomes from specific activities are investigated. Reflection on learning [38] is an example where reflection is used for assessment as well as to increase students' awareness of their own professional competence. Educators' own beliefs about their ability to foster students' dispositions vary [39], [40]. Hence, transforming to a competence-based computer science education means both transforming curricula and ensuring that educators can support and assess students' competence development. To develop students competence not only regarding technical content is a way to help build their professional identity [41], in this process it is also important to include the aspect of teachers as role models [42] in the context of the profession. A competence-based computer science education may also support legitimisation of participating in the discipline in new and different ways [43].

Although some work aims at understanding how a transformation to competence-based curricula in computing education can be made, in particular regarding learning outcomes and assessments, little efforts have yet been made to understand students' perceptions of what competencies they believe are important to have. Kiesler et al. [44] investigated how students see themselves applying the dispositions of being adaptable, collaborative, persistent, responsible and self-directed in their course assignments. They found that students were aware of these dispositions and how they translate into behavior. Persistence was most frequently associated with investing time and effort despite frustration. The use of external sources was frequently expressed as being self-directed. Responsibility students mainly addressed as meeting deadlines. Quality of work was given less attention and responsibility towards for example teammates was not addressed at all. A case study on Swedish fourth-year computer engineering students' perception of competency development in their education showed that some students were knowledge-focused while some were dispositions-focused [25]. The majority of students encompassed competencies containing at least one skill component. Most of the expressed competencies lacked dispositional elements which demonstrates that even students near their graduation are unaware of the role that dispositions play in their future career. Frezza et al. compared the fourth-year students' answers to first-year students' perceptions of what competencies they expected to develop. The main differences were that first-year students stated more dispositional-related competencies but fewer non-technical skills and that competencies expressed by fourth-year students were more saturated.

A. Theoretical Framework

The Competency Learning Framework (CoLeaF) is a tool designed to describe competencies within a discipline, originally developed for the subject of computer science [13], [24], [25]. A competency in this framework is defined as "The personal qualities causally related to effective performance in an area of work" [25, p. 171].

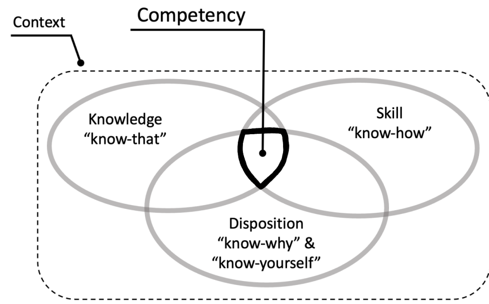

Fig. 1. Illustration of Competency

A competency is built from three sets of component elements, one set of knowledge elements, one set of skill elements and one set of dispositional elements, and it is always situated in a context, as demonstrated in Figure 1. Knowledge ("know-that") is concerned with cognitive qualities such as knowledge of the theoretical foundation on which programming is based or computer architecture. It builds the core concepts and content knowledge of a subject. Skills ("know-how") are instead the more practical qualities needed to perform a task, often developed over time and in interaction with others. Examples of skills are oral communication, teamwork and coding. The behavior demonstrated when applying one's knowledge and skills are the dispositions ("know-why" and "know-yourself"). These can also be referred to as attitudes. Never giving up on solving a problem and ethical awareness are examples of important dispositions for computer science. The different components in a competency are often not equally weighted. Some competencies are for example more knowledge-focused while others are more oriented towards dispositions or skills. However, all three components are always present. Since learners develop and construct new competencies by building on their existing ones, it is natural to see these relationships in between competencies, some might even share component elements.

In this study, the CoLeaF way of describing competencies provides a framework for how to look at and understand the statements made by students with regards to what qualities, or competence elements, they express as important.

III. Research Method

Qualitative data in the form of reflective texts have been gathered from novice students in computer science and information technology study programs at university level. A total of 133 students from two Swedish universities, Uppsala University and Mälardalen University, gave consent for their answers to be used in this study. The reflective texts are written as course assignments during the first week of the education. The assignment asked students to reflect on motivations for enrolling in the study program, their perception of the subject and what qualities and experiences they believe to be important. The data used in this study is derived from answers to reflective questions regarding

TABLE I
PARTICIPATING STUDENTS

	CS		IT		
	Male	*Female*	*Male*	*Female*	
UU	28	7	38	13	86
MDU	37	10	-	-	47
	65	17	38	13	
	82		51		

- What prior experiences they believe will be important for them in computer science and to learn how to program.
- What qualities/competencies they believe are important to succeed in their studies within computer science and programming.
- What they believe will be most challenging in their studies.

The distribution of participating students based on university, study program and legal gender can be seen in Table I. Students were also asked to describe their prior programming experience, which were then divided into two groups, 'Low' (70%) and 'High' (30%). 'Low' corresponds to no experience or experimenting with programming at home or taking a few lessons at school whilst 'High' corresponds to more experience, such as taking high school courses or describing multiple projects in different languages or environments. The distribution is roughly equal between universities. Looking at legal gender, females have a slight overrepresentation in the 'Low' group (80% of female students).

The student population as well as the selection of universities are described in more detail in Uppsäll et al. [45].

A. Data Analysis Process

Content analysis [46] was performed on the data in two steps. The first step consisted of an iterative inductive analysis where initial categories were identified in the data. In the second step, the categories were deductively organised as competence elements of the CoLeaF components of knowledge, skills and dispositions. In each iteration of the first step, coding of a subset was conducted individually by two researchers after which categories were discussed with a third researcher. Following the discussion, categories were revised and definitions altered. This approach was applied until there was a high consensus between the three researchers. In the second step, organisation of categories according to CoLeaF was mainly done by the first author with frequent discussions with two other researchers.

Following the qualitative analysis, a Chi-Square test of Independence [47] was conducted to find statistically significant differences between student categories in the data. In the analysis students were categorised according to legal gender (male and female), university (Uppsala University (UU) and Mälardalen University (MDU)) and programming experience ('Low' and 'High'). All tests were conducted with one level of freedom and assume a null-hypothesis where the expected distribution follows the percentage distribution amongst the participants. The results are compared to a p-value of 0.05.

TABLE II
DISPOSITION ELEMENTS

DISPOSITIONS (no of students, no of references)
Motivation (80, 146)
Interest (57, 73)
Will/engagement (28, 28)
Curiosity (21, 23)
Have a goal (5, 5)
Being challenged (5, 5)
Grit (42, 48)
Creativity (32, 40)
Structured (11, 11)
Detail oriented (8,8)
Keep learning new things (7, 7)
Open minded (5, 5)

IV. RESULTS

The most frequently mentioned elements are in the disposition and skill components, much less attention is given to the knowledge component. 82% of the reflections contain some reference to a disposition and 78% contain some skill-element. Only 24% directly reflected on knowledge-related elements. The distribution of elements and their frequency in the data can be seen in Table II (for dispositional elements), Table III (for knowledge elements) and Table IV (for skill elements). While some reflections are more on a surface level, some go deeper in describing what specific aspects are referred to and why.

A. Dispositions

Elements concerned with motivation (60%) are the most frequently occurring dispositional elements, where having an interest in the subject or something related to the subject such as computers or technology at large, takes predominance (43%). Having engagement (21%) with and in the subject, containing the desire to learn and understand aspects of computer science as well as to have an internal motivation, passion and desire to excel in the field, is together with being curious (16%) also important elements under the umbrella term of motivation. The element of being curious contains aspects such as exploring the subject and seeking knowledge to gain a deeper understanding, being open to new development, anticipating seeing what can be accomplished and curious to find new solutions. Being challenged, by oneself and others (4%), and to have a goal (4%), both with studies as well as the future profession, is also reflected upon as important motivational elements. One of the students reflect upon the importance of being curious and ambitious together with challenging oneself to seek new solutions in the dynamic nature of programming in the following way:

> I can imagine that when learning to program, curiosity alone can take you a long way. There is a lot

> to be learned by pausing when you have finished a programming task, reflecting on the code, and experimenting with different parts of it. Computer code feels very "tactile" in this way; either it works or it doesn't, and it can be an interesting challenge to find the "best" way to solve a given problem. However, that solution may not be the best if you add new aspects to other parts of the program. [translated]

Having perseverance, or grit, is also reflected on by many of the students (32%). This is described in terms of working through setbacks and failures, without taking the easy way out. To be stubborn and not give up, have patience and spend countless hours on finding a solution are also aspects in which students describe perseverance. Another aspect of having grit is to handle constantly being faced with new problems. Students also clearly connect the element of grit with the element of interest and being curious, the following quote demonstrates this connection:

> I believe that perseverance and curiosity are valuable qualities to possess when learning something new, especially in Information Technology/Computer Science, as it often requires a lot of trial and error to find a solution to a problem. [translated]

Creativity is a dispositional element mentioned almost as frequently as grit (24%). Students reflect on creativity in terms of finding new solutions and the best possible solution. It is also referred to as having a flexible mind and thinking outside the box. That knowledge and experience in computer science allows for creativity and creating something new is also reflected upon, as well as utilizing the different computing tools in different manners and for different purposes. Approaching a problem from different angels and being innovative is also discussed in student answers. Creativity is in many reflections linked to other elements of disposition as well as to different skill elements, such as problem solving. The following quote is an example of how a student think of creativity in interplay with problem solving skills and motivational dispositions:

> For me, Information Technology/Computer Science is a way to be both creative and technical, which I have always been drawn to. It's a way to use two seemingly very different ways of thinking for the same project. [...] I also believe that you need to have a creative mindset to be most successful when learning to program. When you encounter problems, you need to be able to be flexible and creative in your thinking, as a problem doesn't always have a specific solution. A problem can be solved in many different ways, and the more you are used to thinking outside the box, the easier it will be to find one of the solutions. [translated]

The dispositional elements of being structured (8%), being detail-oriented (6%), life-long learning (5%) and having an open mindset (4%) appear less frequently in the students' reflections. Being structured is partly about the person being structured about their work, which correlates to some extent to being detail-oriented, and it is partly about applying structure to one's solutions. Being meticulous and having a good eye for details, together with being able to create a detailed path from problem to goal are all detail-oriented related descriptions. Students state in different ways that the subject is ever-changing and a few of the reflections very clearly demonstrate that being humble to the vast and never-ending pool of new things to learn in the discipline is important and that one never becomes fully learned. Being able to adapt to the ever-changing landscape of the discipline and using their knowledge and competence in new and constructive ways is also part of their reflections.

TABLE III
KNOWLEDGE ELEMENTS

KNOWLEDGE (no of students, no of references)
Math (32, 35)
Knowledge about computers (2, 2)

B. Knowledge

The knowledge component is the least mentioned in the data. Students reflect on math having a strong connection to computer science and programming (24%) and the knowledge of how a computer is built and works (2%). The connection of math to computer science and programming is mainly demonstrated in terms of problem solving and logical thinking and reasoning. Using mathematical functions in programming solutions and using mathematical patterns is also mentioned. When asked what experiences students think will be helpful to them, students with prior programming experience answered that the experience of knowing some programming would be helpful. Some students stating no prior programming experience similarly answered that having programming experience would be beneficial. Roughly half of the students stated that previous experience with computers would be helpful. These statements are however not counted and addressed in this study since they are not expressed in terms of what qualities are needed in the field.

C. Skills

Skills are, like dispositions, a well represented component in students' reflections. The main elements are concerned with a specific way of thinking (57%) which, due to its wide nature, have been divided into more fine-grained elements. Problem solving (42%) and logic (25%) are the most frequent elements associated with this special way of thinking. Less common elements mentioned are algorithmic thinking (5%), analytical skills (3%) and pattern recognition (2%). Some students reflect that a specific way of thinking is needed but without further explanation or insights into what this might entail. Logic skills are often addressed in terms of problem solving but are also addressed as cause-consequence relationships, logic needed to understand computers and being able to "run" computer code in one's head. Problem solving is, when further

TABLE IV
SKILL ELEMENTS

SKILLS (no of students, no of references)
Way of thinking (76, 131)
Problem solving (56, 71)
Logical (33, 39)
Algorithmic thinking (6, 6)
Analytical (4, 5)
Pattern recognition (3, 3)
Communication and collaboration (53, 73)
Collaboration (teamwork) (41, 52)
Communication (e.g. oral presentation) (16, 17)
Writing (5, 5)
Study techniques specific to computer science (35, 40)
Finding information (7, 8)

broken down, concerned with finding solutions, methods for problem solving, visualizing problems, not seeing problems as a hindrance and thinking about different perspectives and from different angles. Problem solving is also described to be the center of computer science and programming and that a computer scientist is a problem solver. It can also be used as a tool in the acquisition of knowledge. This quote demonstrate how the students describe problem solving in terms of other skill elements who together solve a problem with specific goals:

> I believe that having strong problem solving skills, recognising similarities to previous programs, identifying patterns, and breaking down large tasks into smaller parts is crucial for success. [translated]

Skill elements concerning collaboration and different kinds of communication are also frequently described by the students (40%), where collaboration in terms of teamwork is predominant (31%). Here the students reflect on working towards a common goal, being efficient in the collaborative setting and solving problems together. They also reflect upon the importance of having an open communication within the team, meaning responding well to criticism, admitting when they are wrong and daring to share ideas. When reflecting on teamwork they also talk about collaborating remotely and having leadership skills, meaning taking responsibility, progressing the work and making sure all team members are on board. Communication in the forms of asking for help and oral presentations (12%) and academic writing (4%) are also addressed as important skill elements.

Many students addressed the aspect of study techniques, many in general terms but some in terms more specific to the subject (26%). Many of the subject-specific study techniques addressed relate to skills and dispositions needed beyond the more general educational context, such as having confidence within the subject, combining theory and practice, working in a systematic manner, spending time and effort on tasks, asking questions and daring to try things out. Some students reflected on the skill of finding relevant information (5%), mainly using the internet as a resource.

TABLE V
DIFFERENCES BETWEEN STUDENT GROUPS. * MARKS P-VALUES CLOSE TO BUT HIGHER THAN 0.05

Legal gender:	**Male**	**Female**	**p-Value**
Disposition: Being challenged	2	3	0.045
Disposition: Curiosity	11	9	0.026
Disposition: Have a goal	2	3	0.045
Disposition: Being structured	5	6	0.011
University:	**UU**	**MDU**	**p-Value**
Disposition: Creativity	27	4	0.007
Skill: Writing	0	5	0.002
Skill: Problem solving	44	12	0.029
Knowledge: Math	26	6	0.050
Programming exp:	**Low**	**High**	**p-Value**
Knowledge: Math	17	14	0.053*
Skill: Algorithmic thinking	2	4	0.045
Skill: Analytical	1	3	0.045
Skill: Problem solving	46	10	0.059*

Elements of skills and dispositions are often combined in the reflection, the following quote is an example of the sometimes tight entanglement of the two components:

> The most challenging aspects of my studies will probably be the creative, problem solving part of the education. I have always been creative since I was little, but I have sometimes had difficulty coming up with solutions to problems that I have never encountered before. And if I do, I have difficulty sharing them. Either it is because I have difficulty explaining what I mean or I do not feel completely confident in my idea and therefore choose not to share it. [translated]

D. Distribution Between Student Groups

In the Chi-Square analysis, looking for statistically significant differences amongst student population groups, some elements for some groups were found to have interesting differences. All elements calculated to a p-value lower, or very close to 0.05 can be found in Table V. It is worth noting that some of the tested elements have a very small occurrence amongst the students. However, the difference is still interesting to account for in the results. There are also differences that are not statistically significant in this data but may be worth further investigation. In the following text, p-values will be used for statistically significant differences while percentages will be reported for other differences.

Looking at the components themselves, a higher percentage of the female students have reflected in terms of dispositions (53% of the female students compared to 43% of the male students). The male students are a bit more concerned with knowledge and skills. However, the differences between gender for these components are marginal. As can be seen in Table V, Female students have more frequently than male students reflected on being curious (p-value: 0.026), being structured (p-value: 0.011), having a goal (p-value: 0.045) and being challenged (p-value: 0.045). Being creative is also more frequently mentioned by the female students (37% of the female students compared to 19% of the male students). Being detail oriented (13% of female students compared to 4% of male students) and being structured (20% of female students and 5% of male students) are also more frequently reflected on by the female students. Overall, motivational dispositions are more frequent amongst the female students than the male students (73% of female students compared to 55% of male students).

Dispositions are more frequently reflected on by students with low prior programming experience (48% of the students in group 'Low' compared to 39% of students in group 'High'). Students with higher prior programming experience reflect more on knowledge than the students with less experience (12% of the students in group 'High' compared to 6% of students in group 'Low'). Students with low prior programming experience are more thrown to grit and perseverance being important than the students with more programming experience (34% of the students in group 'Low' compared to 23% of students in group 'High'). Having engagement in the subject is also more frequently mentioned by students with low experience (19% of the students in group 'Low' compared to 10% of students in group 'High'). On the other hand, students with more experience are more aware of the importance of being structured (15% of the students in group 'High' compared to 5% of students in group 'Low'). Comparing universities, the disposition of being creative is mentioned more in the answers from students enrolled at UU than by students enrolled at MDU (p-value: 0.007).

The knowledge element of math is, as can bee seen in Table V, more frequent amongst the students with more programming experience (p-value: 0.053*). There is also a higher percentage of the students enrolled at UU than MDU that reflects on computer science and programming's strong connection to math (p-value: 0.050).

For the reflections regarding skill elements, the distribution between legal genders is quite equal. There are however differences when it comes to university and level of prior programming experience. As seen in Table V, the skill of writing is only mentioned by students enrolled at MDU (p-value: 0.002) and problem solving skills are more reflected on by UU students (p-value: 0.029). Problem solving skills are also more frequently mentioned in reflections by students with none or very little prior programming experience (p-value: 0.059*). On the other hand, the elements of algorithmic thinking (p-value: 0.045) and analytical thinking (p-value: 0.045) are more frequent amongst students with more experience. Looking at the overarching skill element way of thinking there is no difference between students with no or little programming experience compared to students with more experience.

V. Discussion

It is encouraging to see that novice students' perception of what competencies are needed in the discipline have large elements of both dispositions and skills. Knowledge is not as pronounced in their reflective texts which demonstrates that when entering the computer science or information technology education, students are not as knowledge-focused as they are shown to be later in their studies [17], [25]. This however, might have a natural explanation in that they have a difficult time knowing what knowledge elements are important before gaining a greater understanding of the discipline. This explanation is strengthened by how the same students have a quite vague perception of what the discipline entails [45]. This notion aligns with the finding by Frezza el al. [25] that students in their later years describe more saturated competencies. The questions on which their reflective texts are based, ask about what qualities and competencies they need in computer science and programming which eliminates the content knowledge of programming from their reflections, which can be assumed to otherwise be the most focal content knowledge amongst these students. The presence of students with very little, or no, prior programming experience can also be a reason for the low demonstration of knowledge elements in the texts.

Putting the dispositional elements in students' reflections in alignment with the 11 dispositions listed in CC2020 [8], roughly half are to some extent touched upon by the students. Dispositions not reflected on are Proactive, Professional, Responsible, Responsive and the dispositional elements of Collaboration. Being a team player and willing to work with others are however underlining some reflections regarding collaborative skills. Some dispositional elements present in students' reflections, such as grit and life-long learning, promoted by curiosity and having an open mind, can be sorted into multiple CC2020 dispositions. In line with findings by Kiesler et al. [44], students in the present study also highlight dispositional elements concerning investing both time and effort. Life-long learning [15] as well as having collaborative and communication skills [14] are noted by the students as important competency elements to have in the work-life. However, the disposition of being responsible is not mentioned, neither towards deadlines and team mates, nor towards society. Although the same students describe the discipline to have societal implications [45] they don't seem to connect this to them needing dispositions related to responsibility. The lack of realisation of the importance of ethical and sustainability awareness in computer science strongly indicates the importance of motivating these dispositions within the educational context.

Students reflect on that there is a specific way of thinking that needs to be adapted in computer science and programming. Many explain this way of thinking as problem solving and together with communication and collaboration skills the students' perception of skills needed in the profession are inline with skills frequently mentioned in industry [4]–[6]. The focus on communication and teamwork is also inline with the case study by Frezza et al. [25] and aspects addressed in computer science curricula [21]. When it comes to students' description of problem solving as a specific way of thinking, we need to ask the question of what the students mean when they talk about problem solving? Differences in the distribution of answers regarding a specific way of thinking between their level of prior programming experience, indicate that more experience equips students with a wider understanding of what problem solving can entail, such as algorithmic and analytical skills.

Interestingly, dispositional aspects are more frequent among the female students responses, especially motivational elements such as for example curiosity. Creativity is also more frequently mentioned among female students in the results and a disposition often missing from computer science curricula [21], providing insights that may be useful both in recruitment and retention towards a more balanced gender distribution within computer science. Even though the reflective texts were gathered during the very first week of the programs, some of the results still indicate the effect of the educational context. There is for example an over-representation of answers regarding creativity at Uppsala University. Of course, we cannot know for sure but it can be assumed that the high focus on creativity during the first week in the Uppsala study programs have affected students' answers. The high representation of problem solving among the Uppsala students is, on the other hand, more surprising since this is a topic frequently addressed at both universities during the first week.

Investigating what elements of competence novice computer science and information technology students describe as useful in the context of computer science and to learn how to program and framing it within a competency learning framework provides insights into how our novice students perceive what qualifications they will need to develop as well as what expectations they have of the educational program. It also sheds light on what aspects of competence they are not aware of yet, providing insights into elements that must be motivated by the educational setting. It can also demonstrate differences in student population that may be used in the important work of recruitment and retention towards a more inclusive computer science discipline. This study provides understanding of students' perception of competence within computer science and is an important baseline for future studies investigating how students' understanding of important competencies are affected and developed over time.

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