Novice Students Explain: What is Computer Science?

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***Abstract*—This full research paper explores how novice computer science and information technology students at two Swedish universities describe the subjects of computer science and programming. Computer science is a young, dynamic and multifaceted discipline and is currently undergoing a paradigm shift, mainly due to the rapid development of Artificial Intelligence and its connection to society and individuals. Computer science is becoming integrated into elementary school curricula and these aspects combined make it important to investigate how students perceive the subject. Reflective texts from 133 computer science and information technology students have been analysed using inductive content analysis and statistically significant differences among students have been investigated using Chi-Square analysis. The results show varying perceptions of the field, from quite basic and narrow views to more nuanced understandings that encompass its multidisciplinary nature and societal implications. Interestingly, female students were more inclined to consider the societal implications of computer science, suggesting potential avenues for enhancing educational strategies and fostering gender diversity within the field. The results in this study highlight the importance of continuous investigation into students' perceptions to guide educational approaches, promote inclusivity, and cultivate diverse perspectives within the ever-evolving discipline of computer science.**

***Index Terms*—Student expectation; Student identity; Computer science**

I. Introduction

Computing is a young, dynamic and multifaceted discipline and discussions about its definition are still ongoing [1]–[3]. The discipline has been reshaped several times already and is currently undergoing a new paradigm shift due to the rapid development of Artificial Intelligence and its connection to society and individuals. It is probable that the perception of computing, or computer science, especially by new generations, is changing and it is important that we try to understand this change. Partly to better be able to support and guide students in the subject, as well as to better understand the challenges the field is facing and how the new generation of computer scientists will be able to contribute and influence the direction of the discipline.

The fast digitalisation of society has woven technology and society together and made digitalised solutions part of our everyday life to an extent never seen before. A big contribution to this is the rapid development of Artificial Intelligence, particularly the way generative AI has attracted interest and is now impacting a wide range of society [4]. Due to the rapid digitalisation of society, many countries have added computer science, or aspects of it, into their educational systems. In Sweden, programming was added to the elementary school curriculum [5] in 2017 with the vision of strengthening digital competence by supporting children and teens in computational thinking. Elements of programming were added to the subjects of mathematics and technology in lower secondary school (grades 7-9). This will, in turn, have an effect on computing in high school since the students enter with prior knowledge in programming. The first groups of students that have gone through elementary school with a curriculum containing elements of programming are now reaching an age where it is natural to continue on to university studies.

This study investigates how computer science and information technology students in Sweden perceive computer science as they begin their academic programs. This paper is guided by the following research question:

> How do students entering the field of computer science describe the discipline?

This work will help us better understand the expectations of novice students, which can be used to support and guide students during their studies. It also provides insights that can be used in the work with recruitment and retention in the subject. Novice students' perception of the subject also gives insights into how the changes in elementary school curriculum and societal digitalisation affects the understanding of the field.

Earlier studies have explored students' perceptions of the field of computer science, with Sweden being part of the context [6]. However, this was before computer science was introduced into the Swedish elementary school system. Now, the first individuals whose elementary school has been influenced by a curriculum including programming and digital competence are reaching university level. This, coupled with other indications that the field is undergoing a paradigm shift, makes it necessary to examine how the discipline is perceived in this new context.

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II. Related Work

Computing, a discipline with roots in several traditional fields, has grown and branched out rapidly. With today's highly digitalised society, it is reasonable to assume that the rapid development will continue. Tedre [1], Primiero [2] and Rapaport [3] provide historical accounts on how the field has evolved within academia and describe three main traditional disciplines that computing has roots in: the logical-mathematical tradition, the science tradition, and the engineering tradition. The breadth and complexity of the subject become apparent in the many branches that exist and that relate to each other in various ways, such as cybersecurity, human-computer interaction, artificial intelligence, health informatics, and computational theory. Tedre argues that the subject has grown so large that it is difficult to understand the size and shape of the discipline as a whole. He also argues that the discipline has never been narrowly definable but is a living discipline that has emerged through diversity and interdisciplinary collaboration, and that this is something that characterises the subject. Unfortunately, there are misconceptions about the discipline that risk harming its identity and that can lead to expectations not being met by education and profession within the field [7]. These misconceptions include for example that computing, or computer science, equals programming, that computer science is basically science and mathematics, and that old computer science is obsolete.

Research have investigated the motivational factors behind students' decisions to study computer science at university level [8]–[13], where interest has emerged as a strong driving force. Particularly, interest is clearly linked to programming, computer games, and problem-solving [8], [9], [14], but also to contributing to societal development [6]. Studies have also been conducted to examine how the reputation and development of the field, as well as the perception of possible career paths, influence the choice of study [10]–[12], [15]. Being faced with negative stereotypes affect individuals' self-representation, which in turn can affect interest in the field [16]. Rubegni et al. [17] suggests working with storytelling as a way of increasing diversity in computer science by showcasing different career pathways and in that way providing a more consistent picture of the field. Another factor behind deciding to study computer science is how one perceives their own ability, where previous programming experience plays a role [8]. Prior experiences in programming affect what the student expects from the subject area and from education in the field [18]. Having unclear expectations has been found to have a significant correlation to high drop-out rates [19] and misconceptions about the profession is found to affect students' self-efficacy negatively [20]. Understanding the motivation behind starting an educational program in computer science, as well as why one chooses to stay in it or leave the discipline, is crucial for promoting increased interest in the area and it also provides insights into how the subject is perceived.

Students' perception of computer science has been studied to some extent previously. However, these studies have mostly focused on a subset of computer science, namely programming, and only within the context of a specific course or year of study. Kinnunen et al. [6] examined first-year students' initial expectations of studies and careers in computer science. Students described the subject as broad and constantly evolving, but for many, computer science was equated with programming, and many students' identities within computer science were strongly linked to programming. This portrays a very narrow perception of the subject area. Peters [21] describes how students at the beginning of their computer science studies, in several cases, had a broad and interdisciplinary view of the subject and a future career, but how this was pushed aside during the course of their education in favour of a much narrower view of a computer scientist as a technical problem solver. Funke et al. [22] investigated how men and women in the US perceive the subject area and how they differ from each other. The results show that men tend to focus on technical aspects such as hardware, mathematics, and logical problems, while women tend to focus more on creativity, communication, or career opportunities. The results also showed that despite the research subjects indicating that they had been in contact with computers early in their lives, they do not seem to know what the field of computer science entails.

Studies aimed at understanding what potential computer science students consider computer science to be [23] and what view undergraduate computer science majors have of the discipline [24] found that a large body of the students did not have a useful orientation in the discipline. Although students portrayed views of computer science, these views are on a high level, lacking specifics. In a German study [25], novice computer science students' ideas of what the subject means to them were explored and different types of notions about computer science were found. These portray the view of computer science as a means to influence the real world, theoretical views of the discipline, and computer science as a translation activity between man and machine. They include students who show a differentiated view where computer science is described as a mixture of different disciplines as well as students portraying no clear picture of the field. These correlate to some extent to the findings of Hewner [24] who found students describing computer science as theory, programming and it being interdisciplinary but without understanding the role of theory in the subject or portraying views on more specific levels. The German study has been followed up with an exploration of how the students idea of what computer science is develops over the first semester [26] showing that a development of perception can be seen for almost all students taking part in the study but that there were no consolidated conceptions formed after this period of time. McGuffee [27] found that undergraduate students entered with a too broad view of the subject but after the first CS1 course students instead portrayed a too narrow view. This demonstrates the effect of the study environment on students' perception of the field which is also brought forward by Peters [21].

III. Research Method

Qualitative data has been collected via reflective texts from a total of 133 novice students at computer science (CS) and information technology (IT) study programs at two Swedish universities. The reflective texts are collected as a course assignment during the students' first week at the study program and consent has been given for texts used in the study. To gain understanding of the incoming students' perception of the field it is important to gather data as early as possible, before their perception is affected by the study environment. In the assignment, the students are asked to write a reflective text where they elaborate on questions regarding

- their experience of computer science and programming
- their reasons for starting a computer science or information technology study program
- how they would describe the subject
- what qualities they believe will be beneficial within the field
- what they believe will be most challenging and what will be most rewarding in their upcoming studies within computer science and information technology.

The reflective text format is chosen, over other types of qualitative data collection, based on that it provides a way of letting the students themselves formulate their thoughts at the same time as it facilitates gathering data from a large number of students during a short timeframe.

Since the questions guiding the reflective texts refer to both computer science and programming, student texts either refer specifically and clearly to one, or both, of the subject areas, or it cannot be clearly determined from the texts which the student is referring to. The data provides insights both into the students' perception of computer science and their perception of programming. This work however, focuses on how they describe computer science, in which programming is a subfield.

A. Student Population

The two Swedish universities participating in this study are Uppsala University (UU) and Mälardalen University (MDU). Uppsala University is the oldest university in Sweden, founded in 1477 [28]. It is a prestigious university, with a strong academic culture, recruiting students from all of Sweden. Mälardalen University is Sweden's most recent university, founded in 1977 [29]. The area in which it is situated has a strong industrial history and the recruitment is mainly local. The differences between the two universities are important in this study due to the potential difference in students they attract and the potential difference in their perception and experience of what computer science is. Collecting data from students at both universities provides an opportunity to obtain a richer dataset.

Students are enrolled in one of three different study programs; a three-year Bachelor program in Computer Science at Uppsala University or at Mälardalen University, or a five-year Masters program in Information Technology at Uppsala University. The distribution of university, study program and legal gender is shown in Table I.

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		

Students were asked to describe their prior experience with programming and computers. Their described experience with computers are mainly limited to using the device. When it comes to programming experience the descriptions are more specific. About 30% have no prior experience and just over 40% have very little experience, in line with a couple of lessons in school or some hobby trial and error at home. These two categories are combined into a 'Low' group concerning prior programming experience (a total of 94 students). Roughly 10% have large experience with programming, describing several programming projects in several languages and environments and/or having taken several courses in programming prior to starting their computer science or information technology program at university. The remaining 20% have programming experiences comparable with one high school course and/or some hobby projects but with very limited exposure to different languages and environments. These two categories are combined into a 'High' group (a total of 39 students). The distribution of prior programming experience is roughly equal at the two universities and across legal gender, with male students having slightly more experience than female students.

B. Data Analysis Approach

The qualitative data was analysed using an inductive content analysis [30] with the aim of investigating what categories emerged from the data. The analysis was conducted in an iterative and collaborative manner. Initial categories were defined and a subset of the data was individually analysed by two researchers based on the initial categories. The analysis was followed by joint discussions with a third researcher where categories and definitions were revised to better reflect what was described in the data. The previous subset together with a new subset of the data were then analysed according to the revised codebook and again followed by joint discussions leading to revision of categories and definitions. After this iteration only minor changes were made to the categories and roughly half the dataset had been analysed with high consensus between the researchers. The analysis process continued with analysis of the full dataset by the first author. The process was accompanied by frequent meetings with the third researcher as well as a fourth researcher, who did not take part in the initial creation of the codebook. Quotes not directly fitting into the inductively generated categories were set aside and discussed in more detail during the meetings.

Following the qualitative analysis, a Chi-Square Test of Independence [31] was made to find any statistically significant differences among student population groups. The groups tested were based on legal gender, university and their self-reported prior programming experience grouped into 'Low' and 'High'. All tests were conducted with one level of freedom and compared to a p-value of 0.05.

IV. Results

On an overarching level, the reflections show that a majority of the students make a distinction between how they perceive and explain computer science and how they perceive and explain programming, as two separate, but also related, subjects. The results also show students not describing a clear distinction between computer science and programming (42 out of 133 texts). Here one cannot be certain if this springs from them not separating the two, or if it is a result of how the question in the reflection assignment was formulated. Nevertheless, primarily the same subcategories can be found in the subset of students not describing a distinction between computer science and programming as in the subset of students describing a distinction, the groups were therefore aggregated in the analysis. No student explicitly describes computer science and programming to be entirely the same but for the descriptions that were not clearly connected to either of the fields, it is not possible to say if such a perception is present. The focus of this study is students' perception of computer science. Programming constitutes a branch within computer science, which is supported by 20% of the students who clearly stated exactly this, and the data is analysed with this relation between the subjects in mind.

In the texts, one can see descriptions related to the **content of computer science** and the **properties of computer science**. The most frequent description of how the students perceive computer science has to do with descriptions of the content of the subject. They describe this as (in order of most frequently described) (i) programming, (ii) the study of computers, (iii) working with information and data in different ways, (iv) today's digital society, (v) problem solving and (vi) that it is about improving solutions. The first two descriptions have a predominant frequency among the responses. A summary of how students describe the content of computer science can be found in Table II. Most students have made references belonging to multiple categories and some students have two or more quotes in the same category which underlies the decision to present the results with both number of students and number of references for each main category.

When students describe the properties of computer science, the predominant description is that it is multifaceted, followed by that it is a theoretical subject. Other properties are described to be that computer science is applied, creative and has a strong connection to maths. These are summarised in Table III.

TABLE II
Students' descriptions of computer science content

Content of Computer Science *(total no of students: 132, total no of references: 371)*
Programming *(108 students, 201 references)*
As a language
As a tool
A tool for problem solving
A tool for creativity
A tool for abstraction
As a practical skill
Study of computers *(77 students, 82 references)*
The computers' structure and functionality
Multiple aspects
Applying
Applying based on understanding of use
Deeper insights
Communication
Social benefits and/or ethical consideration
Information and data *(34 students, 34 references)*
Do something with information/data
Use information/data
Use information/data with a purpose
The study/theory behind information/data
Development of theoretical knowledge about information/data
Digital society: broad use for society *(25 students, 25 references)*
Impact on society
Develop society
Problem solving *(15 students, 15 references)*
An important part in computer science
A natural part in computer science
Improving solutions *(14 students, 14 references)*
Make systems more efficient
Make systems easier to use

A. Content of Computer Science

The majority of the descriptions of computer science is concerned with programming, explained in different ways and with different levels of understanding (see Table II). Programming is described as a tool, both in very general terms and with more specifics such as a tool for problem solving, a tool for creativity and a tool for abstraction. It is also described as a language and as a practical knowledge or a skill. The majority of the students (77 students, 96 references) depict programming in terms of giving instructions which can also be covered by it being described as a tool and a language. However, it is not possible from the students' texts to say that it is correlated.

The second most frequent description of computer science is the study of computers. However, multiple levels of descriptions and foci can be seen in this category. The most rudimentary description, that does not give much insight into how the students think about this, is the description that the subject of computer science is the study, or science, of computers.

Interestingly in this category some students perceive computer science to be just about the software, leaving the hardware to some other subject, undescribed which. Some students also add a dimension of history into their description of computer science being the study of computers, more precisely how computers have developed through time. While others instead add a dimension of future, talking about research into how computers will be used in the future. A progression of this elementary perception is adding the structure and functionality of computers. This has in turn evolved into three branches; one adding more specific aspects to what the study of computers means, one demonstrating a perception of applying the knowledge, and the third moving deeper into the structure and functionality. The first two branches end here, with a glimpse of a more nuanced understanding in the second branch. The third branch however, develops into two new branches. One focusing on the communication, both between systems/computers and between computer and programmer. The other branch focuses on the study of computers with the aim of learning how to help society and understanding the ethical implications of what can be done with computers and computer science. These two branches demonstrate the most specific and nuanced description within this category of computer science being the study, or science, of computers.

The description of computer science being about information and data also show different understandings and levels of conception. Here one can observe two parallel understandings, one concerned with processes and the other with structures. Talking about computer science as being about information and data as processes starts on the most fundamental level with merely a description of doing 'something' with the information or data, such as assembling, storing, calculating or just handling. Looking to more specific levels of description we find using the information or data in some way, for example automating. Going one level further, students describe computer science being about using information and data with a purpose. The other understanding demonstrated in this category is more structural and has to do with theory. Here we find students describing computer science as being about the study and theories of information and data. From this level, a growth can be seen towards development of theoretical knowledge.

Besides these predominant perceptions of the content of computer science, the students also describe it as problem solving, improving solutions and that computer science is about our digital society. The description of CS having to do with today's digital society can be situated on three hierarchical levels; from stating that the subject has a broad use for society, to that it has an impact on society and further on to that computer science develops society. The difference between these is that when talking about how computer science develops society there is a sense of 'doing' involved, as in for example creating things that facilitate society or to make computers more user-friendly for the broader public. This sense of 'doing' is not visible in the descriptions regarding impact, here the answers are more focused on the weight of technology in today's society and on how computer systems can help people. The following quote demonstrates the description of impact on society:

> How people interact with today's technology, and the importance it has in our modern society belongs to the subject of computer science. [translated]

How computer science develops society is described as:

> Create things that make everyday life easier. [translated]

Problem solving is described as being an important or natural part of computer science. This quote demonstrates how students describe how they look at problem solving in the field, other than just barely stating that it is important:

> A lot of mental thinking on how to deal with different problems. [translated]

When students describe computer science in terms of improving solutions, they mention making digital systems more efficient and easier to use and the knowledge of how information and systems can be used in the best possible way.

TABLE III
STUDENTS' DESCRIPTIONS OF COMPUTER SCIENCE PROPERTIES

Properties of Computer Science *(total no of students: 45, total no of references: 53)*
Multifaceted: wide subject *(24 students, 24 references)*
Computer science has a wide use
Computer science is internally wide
Wide knowledge is required for applying computer science
Theoretical knowledge *(14 students, 14 references)*
Theoretical basis, specific and narrow
Theoretical basis (wider)
Theoretical principles as a foundation for computer science
Theories to help apply computer science
Strong connection to math *(7 students, 8 references)*
Applied *(4 students, 4 references)*
Creating ideas for application
Creating applications
Creating applications with a specific purpose
Creative *(3 students, 3 references)*

B. Properties of Computer Science

In parallel to descriptions regarding the content of computer science, student responses also show what properties they perceive characterise the subject, see Table III. The two predominant properties of computer science described is that it is multifaceted and that it is theoretical knowledge. Other properties that can be found in the response has to do with computer science being applied, creative and having a strong connection to math.

Students describe the subject as wide and multifaceted, some only state that it is wide and that the boundary to other subjects is fuzzy. On a more nuanced level, the students describe that computer science has a wide use, both for society and industry. Or that the subject is internally wide, meaning

TABLE IV
DIFFERENCES BETWEEN LEGAL GENDERS

	Female	Male	p-value
Content of computer science	30 (100%)	102 (99%)	0.963
Programming	24 (80%)	84 (82%)	0.934
Tool	9 (30%)	29 (28%)	0.868
Language	5 (17%)	16 (16%)	0.891
Practical skill	3 (10%)	10 (10%)	0.964
Study of computers	14 (47%)	63 (61%)	0.358
Information and data	7 (23%)	27 (26%)	0.784
Societal implications	12 (40%)	13 (13%)	0.002*
Problem solving	3 (10%)	12 (12%)	0.813
Improve solutions	6 (20%)	8 (8%)	0.070**
Properties of computer science	10 (33%)	35 (34%)	0.957
Multifaceted	8 (27%)	16 (26%)	0.207
Theoretical knowledge	1 (3%)	13 (13%)	0.168
Math	0 (0%)	7 (7%)	0.1533

TABLE V
DIFFERENCES BETWEEN THE TWO UNIVERSITIES, MDU AND UU

	MDU	UU	p-value
Content of computer science	46 (98%)	86 (100%)	0.906
Programming	39 (83%)	69 (80%)	0.867
Tool	14 (30%)	24 (28%)	0.846
Language	10 (21%)	11 (13%)	0.239
Practical skill	5 (11%)	8 (9%)	0.814
Study of computers	32 (68%)	45 (52%)	0.254
Information and data	7 (15%)	27 (31%)	0.072**
Societal implications	9 (19%)	16 (19%)	0.945
Problem solving	4 (9%)	11 (13%)	0.482
Improve solutions	3 (6%)	11 (13%)	0.276
Properties of computer science	15 (32%)	30 (35%)	0.778
Multifaceted	11 (23%)	13 (15%)	0.822
Theoretical knowledge	4 (9%)	10 (12%)	0.596
Math	2 (4%)	5 (6%)	0.708

that it consists of many different things on many different levels of detail or abstraction. That the subject is internally wide is demonstrated by the following quote:

> Everything from how to build a computer to how the different parts of the computer actually work. [translated]

Another focus described, that also falls into the subject being multifaceted, is being able to apply one's knowledge about the many different aspects and details of computer science to solve problems.

The description of computer science being theoretical demonstrates different levels of perception, starting from a theoretical basis about specific aspects of computer science, to show understanding that there is a larger, wider, theoretical basis. It is also described using theoretical principles as a foundation and using the theories to apply knowledge within the field. Overall, the descriptions range from a quite narrow view of computer science to a deeper as well as broader understanding of the subject properties.

Some student responses describe computer science as applied. In these descriptions multiple layers can be found starting at coming up with ideas for different types of applications to how to create applications, actually creating applications and finally creating applications for a purpose, as solving and preventing problems. It is also mentioned that computer science is creative, that it opens up

> a world of possibilities [translated]

and that the subject has a strong connection to math, without providing deeper insights into what that means. The descriptions of applied and creative are mentioned by very few students in this dataset and are therefore not further accounted for in the results of the study.

C. Distribution Among Student Groups

In general, the descriptions exhibited considerable cohesion across legal gender (Table IV), university enrollment (Table V), students self-reported programming experience (Table VI) and the study program they are enrolled in (Table VII). The Chi-Square analysis found differences in two categories to be statistically significant compared to a p-value of 0.05. However, some categories not found to be statistically significant are also worth highlighting. All resulting p-values are presented in Tables IV to VII where statistically significant differences are marked with an asterisk (*) and differences with a p-value between 0.1 and 0.05 are marked with double asterisks (**).

Looking at differences between gender, the most striking is regarding societal implications where the frequency of discussing these aspects of computer science is far more common in female responses (p-value: 0.002). Improving solutions is another category more frequently mentioned by female students. The more technical and theoretical aspects, on the other hand, are more predominant among the male students. Although few students in total described computer science and programming to have a strong connection to mathematics, this perception was more frequent among students with prior programming experience (p-value: 0.014). Students with a higher level of programming experience were also more prone to discuss properties of computer science and programming than students with little or no prior programming experience. No differences between the two universities were statistically significant. However, the subject being about information and data as well as improving solutions are more common in the reflections from students enrolled at Uppsala University. From the students at Mälardalen University, descriptions of the study of computers and programming being a language are more frequent. Comparisons between the two study programs indicates that computer science students might be more prone towards thinking of the subject in terms of programming as a language and the more general study of computers.

TABLE VI
DIFFERENCES BETWEEN LEVELS OF PROGRAMMING EXPERIENCE

	High	Low	p-value
Content of computer science	39 (100%)	93 (99%)	0.955
Programming	33 (85%)	75 (80%)	0.779
Tool	9 (23%)	29 (31%)	0.445
Language	5 (13%)	16 (17%)	0.579
Practical skill	4 (10%)	9 (10%)	0.909
Study of computers	23 (59%)	54 (57%)	0.916
Information and data	8 (21%)	26 (28%)	0.458
Societal implications	9 (23%)	16 (17%)	0.463
Problem solving	4 (10%)	11 (12%)	0.821
Improve solutions	4 (10%)	10 (11%)	0.951
Properties of computer science	16 (41%)	29 (31%)	0.358
Multifaceted	8 (21%)	16 (17%)	0.666
Theoretical knowledge	3 (8%)	11 (12%)	0.516
Math	5 (13%)	2 (2%)	0.014*

TABLE VII
DIFFERENCES BETWEEN STUDY PROGRAMS

	IT	CS	p-value
Content of computer science	51 (100%)	81 (99%)	0.906
Programming	39 (76%)	69 (84%)	0.638
Tool	11 (22%)	27 (33%)	0.237
Language	4 (8%)	17 (21%)	0.067**
Practical skill	7 (14%)	6 (7%)	0.231
Study of computers	22 (43%)	55 (67%)	0.080**
Information and data	14 (27%)	20 (24%)	0.708
Societal implications	10 (20%)	15 (18%)	0.838
Problem solving	7 (14%)	8 (10%)	0.493
Improve solutions	7 (14%)	7 (9%)	0.358
Properties of computer science	13 (25%)	32 (39%)	0.195
Multifaceted	8 (16%)	16 (20%)	0.619
Theoretical knowledge	3 (6%)	11 (13%)	0.194
Math	1 (2%)	6 (7%)	0.190

V. DISCUSSION

It is not surprising that similar themes emerge in this data as in previous research [6], [23]–[25], there is a focus on programming and the study, or science, of computers. Overall the perceptions are quite unspecific and it is difficult to know what students perceive as 'science' in this context. However, they seem in this study to be more nuanced and not nearly as vague as in the findings by Greening [23] where many students did not provide a perception at all. In the study by Greening, some students who gave a definition of computer science provided one related to learning how to use the computers. That computer science is about using a computer is also present in the study by Hewner [24]. This is not however a description given in the present study.

It is particularly interesting to look at the results in the present study in the light of the results of Kinnunen et al. [6] due to the similarity of context and study approach but with almost ten years between data collections. The study by Kinnunen et al. was conducted in the context of Finnish, British and Swedish novice computer science students' expectations on the degree program, the Swedish data sample is comparable to the data sample in the present study. The data collection from the Swedish students was also conducted as reflective text during the students' first week at the computer science and information technology programs at Uppsala University. The present study however, adds a larger data set within the Swedish context since it also collects data from a second Swedish university, Mälardalen University. Although the focus of the data collection is slightly different in the two studies, one can see differences in the description of computer science having societal implications made by 18% of the students in the present study compared to 11% of the Swedish students in the study by Kinnunen et al. Kinnunen et al. also looks at these aspects in a broader sense, namely the goal of using computer science to contribute to development or 'making a difference' which includes perceptions related to societal aspects. This umbrella perspective was given by 18% of the Swedish subset of answers. When comparing this perspective to the results of the present study one needs to also take into consideration the perceptions of computer science being about improving solutions. The correlating umbrella perspective in the present study is described by 25% of the students. That computer science is society-centered is also addressed by the data in the study by Greening [23], where this description was given by 11.1% of the students intending to continue in computer science and by 3.57% of all students participating in the study. Contributing to societal endeavours is also present in Peter's longitudinal study of students' experiences of participating in the discipline [21], but emerging first among the third-year students. A comparison between these three studies, and particularly the present study and the Swedish subset in the study by Kinnunen et al. [6] demonstrate a slight increase in awareness of computer science having societal implications among the novice computer science and information technology students, which is encouraging to see. Based on the rapid development of Artificial Intelligence since the study by Kinnunen et al., societal aspects of computing have become recognized as central. This is a probable explanation to the increased awareness of computer sciences' societal implications among novice students.

What is particularly interesting in the present study is the difference in the description of computer science having societal implications between legal genders. Female students are more concerned with the societal implications of the discipline than male students, and they are more drawn to using their competence to improve solutions and the multifaceted nature of the field. Taking these results into consideration in computer science educational programs can have implications on female students' retention in education.

Improving solutions is, for us as professionals in the field, strongly connected to problem solving. This however, does not seem to be the case among these novice students indicating a view on problem solving concerned with finding 'a' solution to a given problem. The connection between improving solutions, problem solving and societal implications is also not clear in the students' reflections, which is further highlighted in [32] where students did not mention responsibility as an important trait for computing professionals.

Surprisingly few students connect computer science and programming to mathematics and those who do are all students with more programming experience. Since programming is now part of the mathematics curricula in elementary school in Sweden, one would expect a more frequent connection. However, not all students participating in this study have experienced these changes, thus the full effect might not yet be seen at university level.

Overall, the majority of the students bring a quite unspecific and vague understanding of what the subject entails. This means that we can assume that students, when they apply for and decide to start a computer science or information technology educational program, don't really know what they are signing up for. Supported by [19], [20], this can be one reason underlying the high dropout rates in the discipline. Understanding that this vague perception is what students bring with them helps teachers to support and guide novice students on their journey. With this said, it is important to keep in mind that some students demonstrate a deeper insight and a more nuanced perception of the field. This variation in students' perception of the subject provides a challenge for computer science educators.

A. Limitations

The reflective texts were collected as part of course work. It has been clearly stated in the information given to the students that there is no correlation between participating in the study and the assessment of the course assignment. However, there may be misconceptions about this among the students that we are not aware of.

The texts have been collected during the first week of the program with the aim of gathering incoming students' perceptions of the field. There are however possibilities that they have been affected by what has been discussed both in and outside of class during this week. There is also the possibility that students have not made a personal reflection but rather used the internet or books to answer some of the questions, for example the question of what they think computer science and programming is. Both of these potential limitations have been considered and multiple questions addressing the focus of the study from different directions were added to the assignment with the aim of limiting these risks. When analysing the texts, one major limitation emerged from how the descriptions on one of the given questions in the assignment was given by some of the students. The question was formulated as

> Describe and reflect on what you perceive the subject areas of computer science and programming to be. [translated]

which led to some students clearly stating if they were talking about computer science or programming, or both, but some students not doing so. These answers, starting with for example "It is" and "It has to do with" is hard to clearly categorise. However, the same main categories could be seen in this group of student reflections (42 out of 133 texts) as in the ones clearly stating if they talked about computer science or programming and the groups have therefore been merged in the analysis process.

VI. Conclusions and Future Work

This study aims at exploring the perceptions of computer science among novice university students at two Swedish universities. The discipline is undergoing a paradigm shift, computer science and programming are introduced into elementary school curricula and the rapid development of Artificial Intelligence and its connection to society and individuals are all affecting how the field is perceived. The data in this study, collected from reflective texts during the first week of the program, reveals a wide spread in how the field is perceived by the students, from a very basic and narrow view to more nuanced perceptions weaving in its multidisciplinary nature and societal implications.

With differences observed between students with varying levels of programming experience and across genders. Notably, female students are more inclined to consider the disciplines' societal implications, hinting at potential implications for educational strategies and gender diversity within the field.

This knowledge can help us support students entering the subject and better understand the challenges the field is facing. It also gives us insights into how the new generation of computer science professionals will be able to contribute and influence the direction of the discipline. In this study, small differences are visible in relation to previous studies, mostly around the perception of the societal implications of computer science, but we cannot say if they are lasting or how it will develop.

These findings underscore the need for continuous investigation into students' perceptions, guiding educational approaches, and promoting inclusivity and diverse perspectives within the discipline.

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