Exploring Gender Differences in Primary School Programming

Linda Mannila
Dept. of Computer and Information Science
Linköping University
Linköping, Sweden
linda.mannila@liu.se

Anna Åkerfeldt
Dept. of Teaching and Learning
Stockholm University
Stockholm, Sweden
anna.akerfeldt@su.se

Susanne Kjällander
Dept. of Child and Youth Studies
Stockholm University
Stockholm, Sweden
susanne.kjallander@buv.su.se

Fredrik Heintz
Dept. of Computer and Information Science
Linköping University
Linköping, Sweden
fredrik.heintz@liu.se

***Abstract*—As a result of the increased digitalisation, many countries have introduced programming in their primary education curricula. One main objective is to give all children equal opportunities to develop the skills needed to be an active participant and producer in a digitalized society. This also addresses another important objective, that of increased diversity and broadened participation. Despite technology being a natural part in our everyday lives, stereotypical views of programming as a primarily male activity still exist. In this paper, we explore girls' and boys' experiences of programming at school and in their spare time. The study is situated in primary school classrooms in Sweden, where programming was introduced in a cross-curricular manner as part of digital competence in 2018. While most students reported having some programming experience, it was quite limited. The results show that, compared to the girls, boys in grades 4-9 are somewhat more positive towards programming and get more programming experience both at school and in their spare time. Similarly, boys rated their self-perceived programming skills higher than the girls. In grades 1-3, no gender disparity was found in students' attitudes, experiences or skills. However, the gender differences in grades 4-9 were not reflected to an equally high extent in the students' programming skills, as girls and boys did equally well on many skills related tasks. The analysis highlights the importance of well planned, motivating and relevant tasks in order to provide positive experiences of programming in the classroom.**

***Index Terms*—K-12 education, primary school, programming, gender differences**

I. Introduction

The increased digitalization has highlighted the importance of understanding the technology and its underlying principles. As a result, many countries have introduced computer science (CS) topics, such as programming, in their K-12 curricula. This has given rise to a boom in research on programming at this level of education from different perspectives, such as tools, curriculum, pedagogical models, learning results and assessment.

The reasons for introducing programming at lower levels of education are manifold. One main objective is to give all children equal opportunities to develop the skills needed to be an active participant and producer in a digitalized society. This also addresses another important objective, that of increased diversity and broadened participation. Despite technology being a natural part in our everyday lives, stereotypical views of programming as a primarily male activity still exist. Researchers have suggested several potential reasons. Cheryan et al. [1] describe three factors explaining the gender gap in computer science: a masculine culture, lacking early experience and low self-efficacy. Girls and women are also often negatively stereotyped as having lower abilities and interest in technology (e.g., [2]). Sentance [3] argues that introducing programming early on "[...] challenge stereotypes around who can study computing." (p.1).

One of the hypotheses when introducing programming at lower levels of education is that it will decrease the gender gap as 1) many teachers at primary level are female [4] and 2) students will experience programming in a diverse environment. The question is whether this holds true in practice.

As programming is still a new topic at school, students' experiences vary. Some students' views and experiences of programming may also be influenced by family members or friends who program. The so-called science capital [5] includes all science-related knowledge, experiences, attitudes and resources that affect children's experience of science and their wish to learn more. This also includes the impact of family and friends. Research has found that the science capital concept can be applied to programming [6], and as a higher science capital is commonly related to a higher interest [7], it is important to consider the outside of school context when discussing children's experiences of learning to program.

In this paper, we explore girls' and boys' programming skills and attitudes towards programming in primary school in Sweden. The study is situated in a longitudinal project of programming didactics, in which we have developed an assess-

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ment framework focusing on three aspects – experience, skills and self-efficacy – giving us broad insight into the students' interest levels, know-how and programming background. The main research question addressed in this study is:

RQ: How, and to what extent, do girls and boys experience programming at school and in their spare time?

We start by briefly discussing programming in the Swedish curriculum, after which we review previous work on gender differences in computing in general, and programming in particular. Next we present the study settings and our results, followed by a discussion and some concluding remarks.

II. Background

A. Programming in the Swedish Curriculum

In 2015, the Swedish government gave the National Agency for Education (Skolverket) the task to revise the curriculum for primary (K-9) and secondary education (grades 10-12). The government explicitly stated that the curriculum should a) strengthen students' digital competence and b) introduce programming. In 2017, a new curriculum was introduced, coming into force one year later. The curricula texts have later been slightly modified, with the latest version coming into force in fall 2022.

The curriculum for grades 1-9 introduces programming both implicitly, as part of the cross-curricular theme digital competence, and explicitly, in the subjects mathematics and technology. While the learning objectives in mathematics focus on algorithms and the basics of programming, the aim in technology is for students to develop a) an understanding for the role programmed systems play in our environment and everyday life, and b) skills to create technological solutions on their own. The progression for programming as a practical skill for the three grade levels (1-3, 4-6, 7-9) is given separately for the two subjects [8]:

Mathematics:

- 1-3: Constructing, describing and following unambiguous step-by-step instruction as the basis for programming. The use of symbols as instructions.
- 4-6: Programming in visual programming environments. Constructing and using algorithms when programming.
- 7-9: Programming in visual and textual programming environments. Creating, testing and improving algorithms when programming.

Technology:

- 1-3: Controlling artifacts using programming.
- 4-6: Controlling own constructions or other artifacts using programming.
- 7-9: Controlling own constructions using programming.

B. Gender Differences in Programming

Computing in general, and programming in particular, have traditionally been considered male-dominated disciplines, and already in 1999, Carter and Jenkins [9] wrote an article asking "Gender and programming – what's going on?". Starting in the early 2000s many initiatives and efforts were carried out in order to increase the proportion of females pursuing a career in CS, but men have continued to outnumber women in CS over the years (e.g., [10]) and do so still today (e.g., [11]).

The traditional view of programming as a primarily male activity still exist, and girls and women are often negatively stereotyped as having lower abilities and interest in technology (e.g., [2]). Cheryan et al. [1] describe three factors explaining the gender gap in CS and other technical fields: a masculine culture, lacking early experience and low self-efficacy. While early interventions were aimed at students at high school, research has shown that the gender disparity appears already in elementary school with the differences growing as students reach middle and high school ([4], [12], [13]). This has resulted in efforts being introduced at lower levels of education.

The research on girls' and women's ability is not clear. For instance, some studies have indicated that women and girls need more time to reach the same CT skill level as men (e.g., [14], [15]), while other studies showed that elementary school girls did equally well ([16]) or even better ([17]) than boys on CT related tasks. Despite higher CT skills, girls tend to have more negative attitudes towards programming (e.g., [18]). This may lead to a situation where girls' skills are at a high level, but their attitudes hinder them from continuing to develop their skills [17]. It thus appears crucial to work on changing stereotypes and improving girls' attitudes towards programming.

Sentance [3, p. 1] argues that introducing programming early on can "[...] challenge stereotypes around who can study computing" while Stout et al. [19] suggest that positive experiences can serve as a buffer against potential negative impact of gender stereotypes. Likewise, Cheryan et al. [1] argue that early experiences can help show both girls and boys that they "belong and can succeed" (p. 1) in these areas, which was shown by Master et al. [20] as they found that girls with programming experience report interest and self-efficacy at the same level as their male counterparts. This, the authors concluded, is encouraging as it suggests that girls' interest – or lack thereof – is not set in stone. Sun and colleagues [17] argue that positive experiences can result in students more actively pursuing programming-related activities, and Won Hur et al. [21] highlight the importance of programming experiences in the classroom as a means to increase girls' interest and confidence in the field.

III. Method

A. Study Settings

This study was conducted as part of a longitudinal research project on programming didactics in Sweden. Classes in two schools were selected to be followed during three years throughout each grade level (1-3, 4-6, 7-9). The schools are located in the suburbs of a large city, organised by the municipality and are so-called unit schools, meaning that students attend the same school from preschool up to ninth grade (age 6-15). Programming and digital competence have been considered important in these schools and all students have their own device.

B. Data Collection

The data for this study were collected using the PESS framework, which is described in greater detail in [22]. The framework consists of online questionnaires focusing on three areas related to programming: previous experience, self-reported attitudes and skills. We have developed three versions of the framework, one for each education level (grades 1-3, 4-6, 7-9), taking into account the age of the students and the curriculum requirements. The framework is longer for grades 4-6 and 7-9, compared to the one designed for grades 1-3. While we have more or less the same data for grades 4-9, having fewer questions in grades 1-3 naturally also resulted in less data.

The assessment instrument was distributed to students in the two schools in 2020, i.e. two years after programming became a compulsory part of mathematics and technology. All in all, 984 students took part in the study (Table I). The category *GN/NA* corresponds to students identifying themselves as gender-neutral (GN) or not wishing to answer (NA). In this paper we will focus on girls and boys in particular.

TABLE I
STUDENTS TAKING PART IN THE STUDY.

	Girls		Boys		GN/NA		Total
	n	%	n	%	n	%	n
Grades 1-3	91	36%	124	49%	40	16%	255
Grades 4-6	164	47%	165	47%	22	6%	351
Grades 7-9	184	49%	165	43%	29	8%	378

Based on our research question and the discussion in section II-B above, we base our analysis on questions related to students' skills, attitudes and experiences.

According to the national curriculum, the focus of programming instruction in grades 1-3 should be on step-by-step instructions, for instance, through analog programming. The three skills tasks (1-3) included in the assessment instrument at this grade level are presented in Fig. 1.

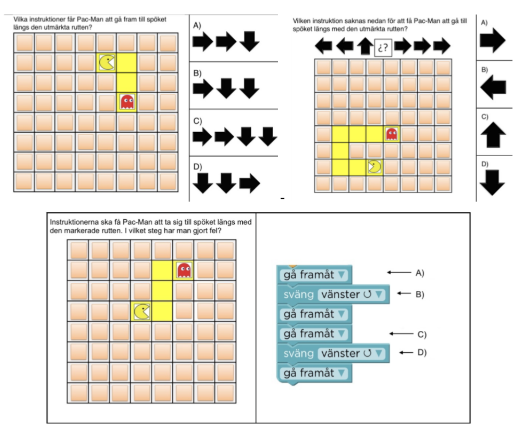

Fig. 1. Tasks (1-3) included in the assessment instrument for grades 1-3.

The goal is for Pacman to reach the ghost following the yellow path, and the students' task in the respective task is to 1) select the correct sequence of instructions (arrows), 2) select the missing instruction and 3) identify the incorrect instruction.

In grades 4-6, algorithms and block based programming are introduced. The three skill tasks (1-3) in the corresponding instrument are presented in Fig. 2.

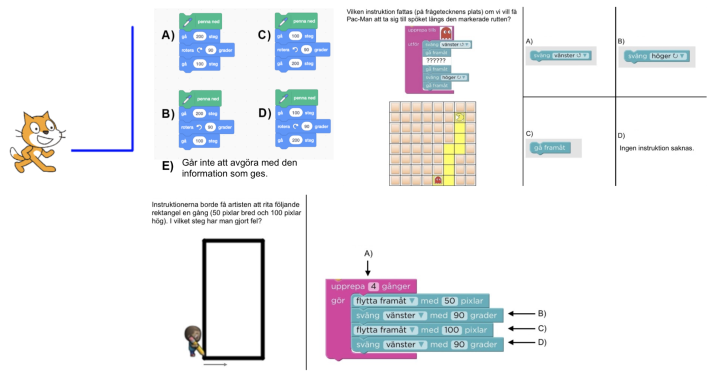

Fig. 2. Tasks (1-3) included in the assessment instrument for grades 4-6.

The tasks require the students to 1) select the sequence of blocks that will draw the given figure, 2) select the missing instruction and 3) identify the incorrect one.

Finally, the two tasks (1-2) included in the instrument for grades 7-9 (Fig. 3) are, in line with the curriculum requirements, more complex. These tasks also include nested instructions. Students are to 1) select the correct block-based sequence and 2) identify the incorrect block.

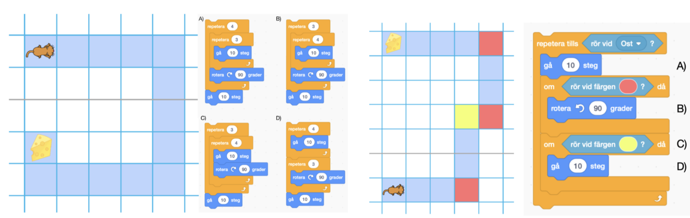

Fig. 3. Tasks (1-2) included in the assessment instrument for grades 7-9.

Student attitudes and experiences were analysed based on both Likert-scale type (scale 1-5) and open-ended questions. The Likert-questions focused on students' attitudes towards and experiences of programming at school and in their spare time. In the open-ended questions the students were asked to explain why they think programming is part of the curriculum as well as what they find most positive and negative about it.

C. Analysis

The data collected using the PESS framework contain both quantitative and qualitative data. Descriptive methods were used to present the quantitative results, and two sample t-tests were performed to compare the responses between girls and boys. Correlations were calculated in order to reveal potential relationships in the data. The open-ended answers

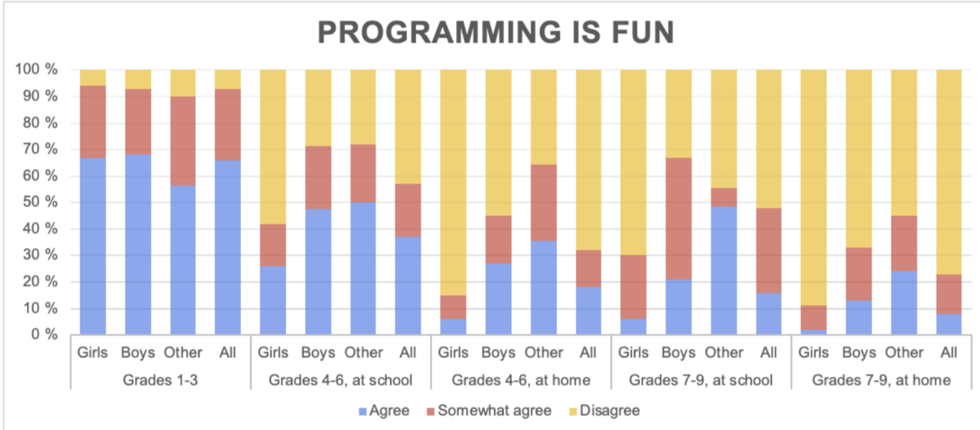

Fig. 4. Experienced level of fun when programming at school and in the spare time.

were analysed using content analysis, identifying main themes arising from the data.

D. Ethical Considerations

The research project was approved by the Swedish Ethical Review Authority. We collected informed consent from both teachers and from the students as well as from the students' guardians. All participants that participated in the study were informed and asked about participation through written informed consent. The student could decline to participate in the study even if the guardian had consent to the child's participation. Before the project started we attended guardian meetings to inform them about the research project and gave them the opportunity to ask questions.

IV. Results

In this section, we present results based on the data collected using the PESS framework.

A. Quantitative Data

The younger the students, the more fun they appear to find programming (Fig. 4). No significant differences were overall found between boys and girls in grades 1-3. We will therefore focus our discussion on grades 4-9.

As the diagram in Fig. 4 shows, there is a notable disparity between boys and girls starting in grade 4. The difference is significant both in grades 4-6 ($t(314) = 4.61$, $p < 0.001$) and 7-9 ($t(309) = 6.24$, $p < 0.001$). Similar trends can be found when looking at other belief related questions. The younger the students, the higher they rate their self-perceived programming skills (Fig. 5), as over 90% in grades 1-3 somewhat agree with being good at programming compared to only 60% in grades 7-9. While there is no difference between girls and boys in grades 1-3, the difference is significant at middle school level ($t(327) = 5.32$, $p < 0.001$). There is a notable, but not significant, difference also in grades 7-9.

The level of self-perceived programming skills, that is, the experienced proficiency, correlates with positive attitudes towards programming among most students in grades 4-9. The correlation is the strongest among boys in grades 4-6, where the experienced proficiency correlates with the view of programming as part of their future profession ($r = 0.54$), programming being something for them ($r = 0.48$), wanting more programming at school ($r = 0.65$), finding programming fun both at school ($r = 0.52$) and in their spare time ($r = 0.60$). The correlation was somewhat lower for girls in grades 4-6 and boys in 7-9, but a clear relationship was nevertheless found. No correlation was, on the other hand, found among girls in 7-9 between the attitudes towards programming and the experienced proficiency or the amount of programming experience.

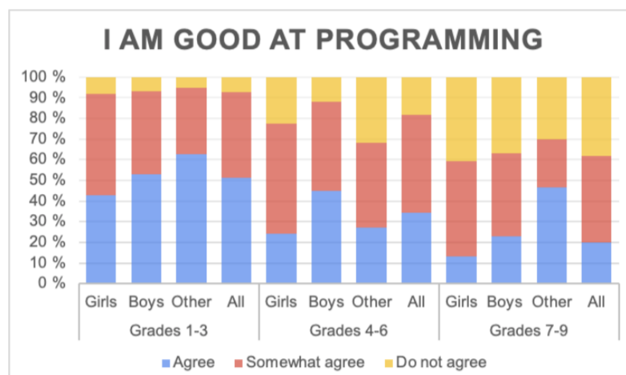

Fig. 5. Grade 1-9 students' views on how good they are at programming.

Students in grades 1-3 would like to have more programming at school to a larger extent than those in grades 4-9. While the proportion of students in general wanting more programming at school decreases, the difference between girls and boys (Table II) is significant in both grades 4-6 ($t(307) = 6.88$, $p < 0.001$) and 7-9 ($t(322) = 4.76$, $p < 0.001$). The boys' interest seems to decrease rather slowly, from over 70% wanting more programming in grades 1-3, to around 65% in grades 4-6 and finally 55% in grades 7-9. Among girls the drop is more drastic, from over 60% in grades 1-3 to only

TABLE II
STUDENTS' VIEWS ON PROGRAMMING (GRADE 4-9), * = P < 0.05, ** = P < 0.001.

		Grades 4-6			Grades 7-9		
	Gender	**M**	**df**	**t**	**M**	**df**	**t**
Programming is ***not*** for me.	Girl	3.46	305	-5.76**	3.78	326	-6.75**
	Boy	2.60			2.85		
Programming tasks at school are difficult.	Girl	2.97	301	-6.57**	2.67	275	-3,63**
	Boy	2.20			2.23		
Programming tasks at school are boring.	Girl	3.33	310	-3.26*	3.43	279	-2.51*
	Boy	2.87			3.10		
Programming at school is fun.	Girl	2.51	314	4.61**	1.99	309	6.24**
	Boy	3.21			2.73		
I would like to have more programming at school.	Girl	2.29	307	6.89**	2.16	322	4.76**
	Boy	3.43			2.85		
Programming in my spare time is fun.	Girl	1.58	295	6.77**	1.36	347	6.36**
	Boy	2.58			2.04		
I would like to program more in my spare time.	Girl	1.61	295	5.68**	1.34	347	6.80**
	Boy	2.47			2.08		
I believe I will have a profession that includes programming.	Girl	1.84	244	4.42**	1.56	257	4.78**
	Boy	2.58			2.15		

around 30% in grades 4-6 with a slight increase to 35% in grades 7-9.

Table II shows the means of student responses to Likert-type questions on the scale 1-5 (1 = totally disagree, 5 = totally agree, "do not know"-answers were ignored). The attitudes towards programming seems to become less positive as students grow older, and students find the programming tasks they meet at school more boring than difficult. As the table shows, the gender differences are significant for each question, both in grades 4-6 and 7-9. Girls find the tasks more boring and difficult and do not want more programming at school to the same extent as the boys do. Although boys do not seem very certain of programming being part of their future career, even fewer girls believe so.

How the students experience the tasks they work on at school seems to be related to other factors. For instance, finding the tasks difficult correlates with an increased feeling of programming not being for them among boys in both grades 4-6 (r = 0.37) and 7-9 (r = 0.52). In addition, difficult tasks at school seem to be related to less interest in programming outside of school for boys in grades 4-6. For the older boys (grades 7-9), difficult tasks correlate with a decreased interest in programming at school (r = -0.37) and less certainty of programming being part of the future profession (r = -0.36). Among the girls, the experienced difficulty level of the tasks did not correlate with any other factors.

Experiencing the tasks as boring was, not-surprisingly, found to be negatively correlated with finding programming at school in all student groups. In addition, boring tasks correlated with less belief in programming being for them among all students in grades 4-9. For girls boring tasks were also related to a smaller interest in having more programming at school, both in grades 4-6 (r = 0.37) and 7-9 (r =0.50). Similarly, tasks experienced as fun correlated with students believing that programming is for them and wanting more programming at school (boys and girls in grades 4-9). The importance of the tasks was further highlighted as a high correlation was found between fun tasks and programming being fun at school (r between 0.71 and 0.89). Furthermore, programming being considered fun correlated with seeing programming as part of a future profession in all groups (girls 4-6: r=0.42, boys 4-6: r=0.46, girls 7-9: r= 0.33 and boys 7-9: 0.55).

While most students reported having some programming experience, for most the experience was quite limited with students in grades 4-6 having somewhat more experience than those in grades 7-9. Boys in grades 4-6 reported on the largest programming experience. There was also a significant difference between the genders in grades 4-9 ($p < 0.05$). Of those who do program, boys tend to be more active. In grades 4-6, 22% of the boys program at least once a month compared to 7% of the girls. The corresponding percentages in grades 7-9 were 12% (boys) and 3% (girls). The majority of students in grades 4-9 reported programming more seldom than once a month at school (60% in grades 4-6, 65% in grades 7-9). A few students in grades 4-6 never program (4%), while almost every fourth student in grades 7-9 (23%) reported never to program at school.

The analysis also showed that the majority of students do not program in their spare time (55% in grades 1-3, 57% in grades 4-6 and 80% in grades 7-9) and only a few reported having taken part in extracurricular programming activities (14% in grades 4-6 and 12% in grades 7-9). Boys had more experience of extracurricular activities compared to girls (17% vs. 9% in grades 4-6; 17% vs. 7% in grades 7-9). These differences were also found to be significant ($p < 0.001$). While no relationship was found between the amount of programming experience at school and students' views on programming, the programming experience outside of school, for instance, correlated positively with boys' view of programming as part of a future profession (r = 0.55 in grades 4-6, r = 0.61 in grades 7-9) and negatively with girls' views on programming not being for them (r = -0.38 in grades 4-6, r = -0.34 in grades 7-9). The amount of programming in their spare time also correlated positively with finding programming in their spare time fun and wanting to program more outside of school (grades 4-9, boys and girls). Having a family member who works with or has programming as a hobby seems to have a positive relationship with students' view of themselves as working with programming in all other categories than girls 7-9. No similar correlation was found with friends working with or having programming as a hobby.

B. Open-ended questions

The analysis of the open-ended questions indicated that most students in grades 4-9 (approx. 50% of the girls and 40% of the boys) commonly believed that programming has been introduced in the curriculum due to job opportunities and as a means to address future needs.

> *I think it is because most jobs in our generation deal with or are related to some kind of programming, which makes it important just like any other subject in order to prepare us for the future and future jobs.* (Girl, 7-9)

> *In the future it is very good to know how to program, because it can become a job.* (Boy, 4-6)

Other main reasons found were that technology is everywhere, programming being important, useful and good to know, as well as, quite simply, to learn to program and understand the technology.

> *It is important to know programming as technology becomes more and more central to our society.* (Boy, 7-9)

Some students also mentioned reasons such as programming being new and modern, and having it in the curriculum makes it easier to see whether it is something one could be interested in.

> *So that we can try it out and see if it is something we like.* (Girl, 7-9)

Around 20% of the students stated that they did not know why programming has been introduced.

In the open-ended question asking students to describe what they find most positive about programming, the gender disparity was once again notable. Around 20% of girls in grades 4-9 found nothing positive about programming, with an additional large proportion stating that they did not know (15% in grades 4-6 and 28% in grades 7-9). The corresponding proportions among boys were smaller. The most positive aspect overall was the creativity aspect: creating and designing something new (23% of girls and 30% of boys in grades 4-6, 17% of girls and 21% of boys in grades 7-9).

> *You can be creative and come up with new solutions that can change the entire society.* (Girl, 4-6)

> *I think it is fun to be creative and create, both on my own and with others.* (Girl, 7-9)

This also included comments on the possibility to do almost anything with programming, without specific right and wrong solutions.

> *You can do anything, the freedom...* (Boy, 7-9)

> *Coming up with everything yourself while there is nothing telling you what is right or wrong.* (Girl, 7-9)

> *You can both create easy and fun small games to share with friends, but also very large and advanced games that capture millions of players all over the world, like League of Legends.* (Boy, 7-9)

Similar to the quantitative data, the open-ended answers also showed that boys find programming more fun than girls. Other positive aspects mentioned by both girls and boys were the possibility to try different solutions, finishing a project and succeeding.

> *When you finish and can feel proud of what you have done.* (Boy, 4-6)

> *Managing to do something difficult that you have struggled with for a long time.* (Girl, 4-6)

The third open-ended question dealt with the negative aspects of programming. Not surprisingly, the quantitative results were echoed in the students' answers. Girls in grades 4-9 found programming more difficult than did the boys. Students also found it frustrating not to understand, and not getting the help or instructions needed.

> *It can be tricky and it is not easy to get help.* (Girl, 4-6)

Students also found programming boring, in particular due to having to work on uninspiring tasks.

> *That all tasks are almost identical, which is really boring.* (Girl, 4-6)

> *I have not really tried programming yet, because all we do is mimic the teachers and do not learn anything.* (Girl, 7-9)

Both boys and girls considered bugs a negative aspect, in particular when getting stuck on solving an issue in the program.

> *That a little thing can ruin everything.* (Boy, 4-6)

> *Not understanding what you have done wrong.* (Girl, 4-6)

Debugging was also related to time issues.

> *If you make a mistake it can take hours to find the error.* (Boy, 7-9)

In grades 7-9, some students had worked with text-based programming, which could be seen in quite a few students finding it frustrating to have to remember the syntax of a programming language and using it in an exact manner.

> *When a single character can result in the entire program not working.* (Boy, 7-9)

> *The exactness, that you have to be careful in order for everything to be right in the code.* (Girl, 7-9)

C. Skills Tasks

Boys and girls in grades 1-3 managed equally well on the first two skills tasks (Table III). The third task, which involves blocks instead of arrows (Fig. 1) and calls for debugging the given program, was somewhat more difficult as only 42% of the students answered it correctly (40% of the girls, 50% of the boys). Over a third (34%) stated that they did not know the answer. Here we saw a difference between girls and boys: while equal proportions answered the question incorrectly, more girls answered "do not know" (38% vs. 27%).

TABLE III
STUDENTS' RESULTS ON THE SKILLS TASKS IN GRADES 1-3.

	TASK 1		TASK 2		TASK 3	
	Girls	Boys	Girls	Boys	Girls	Boys
Correct	97%	94%	78%	76%	40%	50%
Incorrect	3%	6%	9%	16%	21%	23%
Do not know	0%	1%	12%	9%	38%	27%

Table IV show the results on the skill tasks for students in grades 4-6 (Fig. 2). While the majority (69%) of the students answered the first task correctly (66% of the girls, 72% of the boys), the second and third task were more difficult (33% and 44% correct). In the second task, students were asked to decide which block was missing in order to complete the program. Boys clearly outperformed the girls on this task, but the analysis of students' responses also indicated that many students may have misunderstood this task, trying to control the ghost instead of Pacman. In the third task, the difference between girls and boys was again smaller. More boys than girls answered the third task incorrectly, and we also see the same tendency as in the third task for grades 1-3; when uncertain, girls seem more likely to answer "do not know" instead of guessing.

TABLE IV
STUDENTS' RESULTS ON THE SKILLS TASKS IN GRADES 4-6.

	TASK 1		TASK 2		TASK 3	
	Girls	Boys	Girls	Boys	Girls	Boys
Correct	66%	72%	21%	44%	41%	50%
Incorrect	22%	16%	66%	44%	25%	30%
Do not know	12%	12%	13%	12%	34%	21%

The two tasks given to students in grades 7-9 (Fig. 3) were clearly more difficult (Table V). Only 21% and 30% of all students respectively answered the questions correctly. Again, boys outperformed the girls, who in turn answered "do not know" to a higher extent.

TABLE V
STUDENTS' RESULTS ON THE SKILLS TASKS IN GRADES 7-9.

	TASK 1		TASK 2		TASK 3	
	Girls	Boys	Girls	Boys	Girls	Boys
Correct	14%	27%	20%	42%	41%	50%
Incorrect	54%	56%	42%	34%	25%	30%
Do not know	32%	18%	38%	24%	34%	21%

V. DISCUSSION

The results presented above indicate that in general, students' interest drops after grade 3, which confirms results presented by, for instance, Kong et al. [18], who showed that younger students had a more positive attitude towards programming than the older ones. Kong and colleagues also found that boys in grades 4-6 were more interested in programming than their female peers, a result that is echoed in our study: our data highlight significant gender differences in students' attitudes towards and experiences of programming starting in grade 4. In grades 1-3, on the other hand, no disparity was found in students' attitudes, experiences or skills. This is in line with previous research, indicating that girls start losing interest in technology at middle school level [13].

Our findings indicate that boys in general have a higher science capital when it comes to programming starting in grades 4-6. Boys have more programming experience both at school and in their spare time, find it more fun, and want do have more programming in the classroom as well as outside of school. Girls tend to consider programming as something that is not for them and do not see programming as part of their future careers. Our results thus highlight the importance of school as a leveling factor, in order to, as Gerson and colleagues [6] put it, "ensure that the divide between those with and without science capital does not widen".

Boys in grades 4-9 also outperform the girls in the skill tasks, but not to the extent that could be expected considering the differences found in the attitude and experience data. The data also show, that girls choose the "do not know"-answer to a higher extent than boys. This indicates that some girls rather leave a question unanswered instead of guessing, which is in line with other studies that have identified reasons for different behaviours among boys and girls when deciding on how to answer a multiple choice question. For instance, Iriberri and Rey-Biel [23] found that boys tend to be more eager to guess on multiple choice questions, while girls rather play it safe. Differences in terms of self confidence and risk aversion can also result in girls leaving questions unanswered [24] — not picking an answer avoids the risk of picking an incorrect option. Another reason can be found in stereotype threat, that is, the idea that stereotypes result in worse individual performance by affecting self-confidence [24]. For instance, Riener and Wagner [25] found differences in how willing boys and girls were to guess the answer to more difficult problems and could contribute this result to stereotype threat.

Our findings thus confirm previous research showing that girls in general tend to be rather negative towards programming, but more research is needed to say something conclusive about the differences in skill level as, for instance, in [14]–[16]. This result also needs to be fed back to the next iteration of instrument design, as additional tasks may be needed in order to paint a more varied picture of students' programming skills. Also, as pointed out by Sun et al. [17], programming skills alone are no guarantee that girls will want to pursue these skills further. Rather, negative attitudes can block such aspirations.

Considering that early programming experiences can have a positive impact on girls' interest in CS in general, and programming in particular, our results may not appear especially promising. They do, however, reveal some insights that can be helpful in improving the situation.

First, many students find the programming tasks they work on in the classroom boring. This was found both in the quantitative data and in the open-ended questions: doing similar tasks over and over again, in the worst case, only mimicking what the teacher does, is far from the creative activity programming could be. Clearly, such a context does not offer the type of positive experiences that Stout et al. [19] suggest could serve as a buffer against negative stereotypes and Master et al. [20] argue could increase girls' interest and self-efficacy. Our results confirm the importance of positive experiences in the classroom, as the findings suggest that tasks that are considered fun correlate with an increase in students' positive attitudes towards programming at school, which in turn has a positive relationship with wanting more programming and seeing programming as part of their future career. This result was found for all students in grades 4-9. As most students in general, and girls in particular, appear to get most of their programming experience at school, it is important that the programming they encounter feels meaningful and interesting.

Our results thus highlight the importance of the programming tasks students are given, as boring tasks may be detrimental for students' interest. The open-ended questions give examples of how the classroom can serve as a context providing both boys and girls with positive programming experiences, as the students describe feelings of success, getting to see the results of their work, managing to debug and fix a program as well as creating something on their own or together with friends. Creating such opportunities requires planning, varied activities and a well-designed progression.

Second, the open-ended questions revealed that many girls finding programming difficult and frustrating, did so in particular because they could not get the help they needed. While teachers are commonly seen as the expert in the classroom, students are used to getting the answer when needed, rather than having to figure things out on their own. The situation is, however, different regarding programming. When programming was introduced in the curriculum, the teachers were supposed to both learn programming themselves and how to introduce it in the classroom. Many teachers still struggle with including programming in their teaching, and there is a need for continuous support structures such as professional development, time and resources [26]. This is a challenge not only to teachers in Sweden, but globally [27]. At the same time, there is a need to foster students' problem solving skills and give them strategies to find solutions on their own.

Third, many students appear to think that the main reason for having programming in the curriculum is related to the job market and skills that might be needed in the future. This may result in programming not feeling relevant in particular for girls, who commonly show interest in topics that they feel can make a difference and are in line with their values [28]. When introducing programming at school, it should be done in a way showing how it can be a useful tool for students to solve problems and be creative already today. This, of course, puts additional requirements on planning the programming tasks and activities to be used in the classroom.

VI. Concluding Remarks

In this paper, we have reported on a study among students in grades 1-3, 4-6 and 7-9 in Sweden, focusing on how they experience programming at school and in their spare time. Considering the objectives of introducing programming in the primary school curriculum, programming instruction needs to be designed so that it reaches all students. As positive experiences may be particularly beneficial for girls and children with lower science capital, the importance of providing such experiences at school is crucial if we want all students to have equal opportunities. While our results paint a picture of a situation where girls starting at middle school level, quite stereotypically, are more negative towards programming than their male peers, the findings also contribute to the knowledge base on aspects that need to be considered when introducing programming in grades 1-9. Maybe most importantly, our data highlight the need for well-planned, motivating and relevant activities with a clear progression as a means to provide students with positive experiences, which in turn can lead to more positive attitudes and an increased interest in wanting to learn more. Since interest in programming tends to decrease for each grade level, efforts should be made to provide positive experiences throughout grades 4-9.

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