Identifying Pathways to Computer Science: The Long-Term Impact of Short-Term Game Programming Outreach Interventions

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Abstract

Short-term outreach interventions are conducted to raise young students' awareness of the computer science (CS) field. Typically, these interventions are targeted at K–12 students, attempting to encourage to study CS in higher education. This study is based on a series of extra-curricular outreach events that introduced students to the discipline of computing, nurturing creative computational thinking through problem solving and game programming. To assess the long-term impact of this campaign, the participants were contacted and interviewed two to five years after they had attended an outreach event. We studied how participating in the outreach program affected the students' perceptions of CS as a field and, more importantly, how it affected their educational choices. We found that the outreach program generally had a positive effect on the students' educational choices. The most prominent finding was that students who already possessed a "maintained situational interest" in CS found that the event strengthened their confidence in studying CS. However, many students were not affected by attending the program, but their perceptions of CS did change. Our results emphasize the need to provide continuing possibilities for interested students to experiment with computing-related activities and hence maintain their emerging individual interests.

1 Introduction

Determining how to increase student interest in computer science (CS) has troubled the computing education community because the popularity of CS among incoming university students has radically declined in the first decade of the twenty-first century. This decline has given rise to numerous outreach programs that were established to increase the interest and engagement of young students—typically K–12—in CS. Although the number of CS majors is increasing, young students convey a lack of interest in computing as an academic or professional path (Decker and McGill, 2017). The reasons behind this lack of interest vary: some find CS boring, antisocial, or lacking creativity (Yardi and Bruckman, 2007). Many also overlook CS simply because they do not know much about it (Carter, 2006). Thus, it is important to continue the initiatives that focus on increasing interest in CS studies and CS careers.

To increase interest in CS, a five-day game programming summer workshop was established. Besides developing the participants' interest in CS, the workshop aimed at encouraging students to try out programming and increasing their understanding of computing. During the workshop, the participants learned CS concepts through exercises that were brought into the context of the students' everyday lives, which, in this case, was accomplished through games. The workshop included training on problem solving and hands-on tutorials familiarizing students with core programming topics, such as algorithms, data structures, and functions. Furthermore, the students designed and programmed their own game projects. The students worked in a collaborative manner, and team-forming and peer assistance was dynamic and student-based. That is, the teachers did not instruct the students on whether they should work in teams or individually. Each student presented his or her project on the last day of the workshop. To date, more than 900 middle and high school students have participated in these workshops.

Even though many of the studies investigating CS outreach interventions indicate increased motivation in learning CS concepts, the need to investigate the long-term impact of these interventions has also been shown (McGill et al., 2015). Given the number of programs that have been developed to address the need to increase participation in STEM (science, technology, engineering, and mathematics) fields, studies determining the long-term impact of these programs have remained surprisingly low. Thus, the current study offers insight into the following questions:

- How does student interest in CS develop during the years following the intervention?
- Do students independently re-engage with CS content? Do they persevere when confronted with difficulties when working with the content?
- Are their career aspirations affected?

We aim to answer these questions by identifying the pathways that contribute to the educational choices made by students. In particular, we aim to recognize how participating in outreach events affects these choices. To identify these paths, we interviewed participants who, at the time of the experiment, had already completed their secondary education; thus, they had already decided the next step of their educational journey. This research setting had a relatively small but dedicated group of students who participated in the interviews, similar to the study by McCartney et al. (2016), and the research is theoretically grounded in Hidi and Renninger's theory of interest development (Hidi and Renninger, 2006).

2 Related work

2.1 Student outreach in Computer Science

Besides the concern about securing a future workforce for the digital industries, learning CS can be beneficial for students in many ways. For example, a connection between computational thinking (CT) and general problem-solving skills have been argued by Wing (2006) and several other researchers. CS has been claimed to resonate with higher-order and algorithmic thinking skills and problem abstraction (Kafai et al., 2014; Sengupta et al., 2013), which are crucial skills for the future (Harel Caperton, 2010). At the very least, students who learn CS topics and computational thinking while at the middle and high school level have a predisposition to more quickly learn more advanced computing topics (Armoni et al., 2015). From these premises, CS is being increasingly included in compulsory education (Brown et al., 2014; Hubwieser et al., 2015), and this development is also occurring in Finland, where programming and other computational thinking skills are clearly denoted in the recent national core curriculum (Opetushallitus, 2014, In Finnish).

Successful outreach programs are documented in recent research literature (Decker and McGill, 2017; McGill et al., 2016, 2015). Typically, the goal of these programs is to acquaint young students with the discipline of computing and to develop their interest in computing-related studies and careers (Egan and Lederman, 2011; Maxim and Elenbogen, 2009; Lakanen et al., 2014). The activities included in these programs can be based, for example, on programming in general (Koorsse et al., 2015) or, more specifically, on game programming (as in the current study) (Al-Bow et al., 2009; Akcaoglu and Koehler, 2014; Kafai and Burke, 2015), electronics (Lau et al., 2009), or robotics (Doerschuk et al., 2011). Many of the programs promoting computing at the K–12 level are extra-curricular and occur during school vacations, meaning that the students (or sometimes the parents of these students) choose to participate in the events in their spare time. Moreover, some interventions are conducted by a university and are held in an academic environment, helping introduce students to research and teaching activities as well (Layer et al., 2012; Lakanen et al., 2014). Although some of these initiatives are one-off activities, many programs have been fortunate enough to receive funding that has enabled long-lasting work in encouraging students to pursue computing careers.

2.2 Earlier work on long-term impact

Choosing a degree program is a multifaceted decision that is often affected by multiple factors or a continuum of events. Although some of the factors of the decision-making process are obviously out of the reach of educators, for example, student background (household income, ethnicity) or views and preferences of family members, many other factors can be addressed through student outreach programs.

The impact of pre-college computing activities on the choice of a major have been reviewed by McGill et al. (2016), who searched for studies that discussed the findings of different outreach interventions. Out of the 73 studies they examined, only seven articles were characterized as longitudinal studies. The most prominent results came from the programs that had been running for several years. In the following paragraphs, we present findings related to the long-term impact of outreach programs that complement the aforementioned systematic literature review.

First, perceptions about the CS field and CS careers seem to have an even more critical role than one's (perceived) proficiency in CS and problem solving (Wang et al., 2015). For example, Carter (2006) argued that students with an apparent aptitude toward CS may choose not to study CS because of an incorrect or incomplete perception of the field rather than because of the lack of ability. This is supported by Rosson et al. (2011), who found that the existence of (both positive and negative) stereotypes related to the CS field were the main attributes for explaining career orientation.

Second, encouragement from both family members and non-family members has been one of the most critical factors that contribute to a student choosing to study CS (Wang et al., 2015; Paloheimo et al., 2011). Here, parents and relatives act as important role models (Paloheimo et al., 2011) because self-efficacy beliefs and academic achievement are linked to parental goal setting (Zimmerman et al., 1992). However, teachers or researchers are also in a position where they can contribute to the self-efficacy beliefs of a student and foster academic achievement, thus encouraging the development of interest to a more developed phase (Hidi and Renninger, 2006; Wang et al., 2015).

Third, sufficient and timely academic exposure has been found to be one of the most important explainable factors that influence whether students want to pursue a CS-related degree (Wang et al., 2015). In the early phases of interest development, the level of effort and self-efficacy can be low (Hidi and Renninger, 2006, p. 114). Consequently, it is important to design instructional conditions of the outreach so that they can contribute to the maintenance (and possibly the evolvement) of interest, such as by utilizing project-based learning and one-on-one tutoring.

In the outreach program presented in the current paper, these three aspects were particularly acknowledged and considered.

Although the efforts to promote the CS and technology fields are numerous, their long-term impacts are rarely investigated (McGill et al., 2015, p. 78). The need for this type of investigation is evident because the educational choices made by the students participating in an outreach event occur after the event is over. Guzdial et al. (2014) evaluated a broad and multifaceted set of interventions that included summer camps and after-school/weekend programs for 4th–12th grade students. Regarding long-term impact, an argument has been made that some of the reason behind the increase in CS advanced placement exam test takers in the state of Georgia—an almost 200% increase from 2006–2013—is attributable to the outreach program. In addition to the programs covered by McGill et al. (2015), Moskal et al. (2007) examined four outreach projects that included teachers, middle school students, and university faculty. Besides the increased content assessment scores in the pre/post-test, the researchers found increased attitude scores—though not statistically significant—regarding entering the university after high school. Moreover, Lakanen et al. (2012) investigated the computing-related activities of students two years after participating in a week-long summer camp; they discovered that 66% of the students continued making programs or games and that nearly 90% participated in some other computing-related activities, such as modifying source code, reading the workshop's learning material, and contributing to computing-related discussion forums.

2.3 Gender imbalance in CS

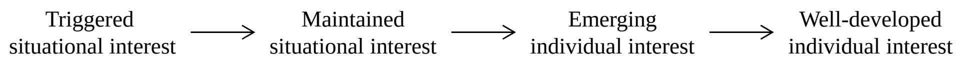
The most common theme in CS outreach, particularly in North America, has been the goal of broadening participation through gender diversity (Decker and McGill, 2017). The reasons for the gender imbalance have been widely examined to decipher the different factors alienating girls from involving CS in their academic and professional plans. Papastergiou (2008) argued that girls view CS as self-referencing and machine and programming oriented more often than boys. In a study where the majority of respondents were female, Almstrum (2003) stated that one of the most important attraction factors of CS is the sense of accomplishment that comes from solving problems with computers and the promotion or enhancement of well-being through problem solving was the strongest motivation. Women persisting in CS see computers as useful for expression and reject the stereotype of the computer geek (Margolis and Fisher, 2003). Being able to change the perception from just "tinkering" to a more versatile problem-solving perspective can play a major role in evening out the gender imbalance.

There may also be disparity in how much participation in prior activities affect the decision to study computing. McGill et al. (2016, p. 15) argued that boys may receive outreach more favorably than girls, stating that "female participants who do not ultimately major in computing have a much stronger negative perception of the computing activities than male participants who choose a major outside computing perhaps due to the type of activities influencing these views.” Consequently, outreach programs that target girls have been proposed and conducted, but even more importantly, the importance of a supportive environment from family, friends, and instructors has been emphasized (Hamilton et al., 2016).

Even if there may not be differences in the views of students who major in computing, senior high school girls generally tend to perceive advanced computing subjects as boring and express a strong aversion to computers (Anderson et al., 2008). A possible—yet speculative—consequence of boys encountering more outreach activities and receiving them more favorably is that their social environment may be prone to encouraging engagement in computing activities. Moreover, middle and high school girls have very limited knowledge about CS (Hur et al., 2017), and it can be difficult to think about becoming a computer scientist if one does not know what CS is or what computer scientists do.

Regarding broadening the participation, the purpose of our workshop was to generally start involving schoolchildren with CS topics. This was done in a context where the field, which is male dominated and in the context of the Finnish educational system that is characterized by the principal values of equity and equality (Saarela and Kärkkäinen, 2017). For example, higher education is free for everyone in Finland. Further, one of basic education’s top priorities is to prepare all schoolchildren to act with equal rights and equal duties in society, as well as in their work and family lives. With the educational possibilities being equally open to everyone, one could expect that factors such as gender would not play a role in Finnish students’ participation in CS or form a barrier when selecting their university major. However, this is not the case; the globally reported gender gap has been a problem also in the local, Finnish environment. Even though our results ultimately provide only some contribution to better understanding the role of gender in interest development, as presented later in Section 6, we feel that it is necessary for CS practicioners to actively take this into account in their teaching and projects.

3 Theoretical background



In the current study, the lens for interpreting the processes underlying interest and engagement in CS is adopted from the *four-phase model of interest development* (abbreviated as 4PM) by Hidi and Renninger (2006), which is depicted in Figure 3. In this model, interest is described as a driver that makes people do things; simply put, people are more inclined to commit themselves to things that they are interested in. Interest as a motivational variable “refers to the psychological state of engaging or the predisposition to re-engage with particular [content] over time” (Hidi and Renninger, 2006, p. 112). The content here can refer to classes of objects, events, or ideas. Evidently, a person’s *own efforts* greatly support the development of his or her interests (Hidi and Renninger, 2006; Sansone and Smith, 2000).

Interest in content develops through situational phases—which may arise in a short period of time, but are more vulnerable to interference—toward individual phases, which are more personal and persistent in nature. The first two phases, *triggered* and *maintained situational interest*, refer to psychological states of interest that emerge from short-term changes in affective and cognitive processing (triggered) and involve focused—possibly repetitive—attention and persistence over time (maintained) (Hidi and Renninger, 2006, p. 114). For instance, situational interest can be triggered by a surprising piece of information or a learning environment that includes group work or computers. Then, as the learner finds tasks meaningful or becomes involved personally in the activity, his or her situational interest can be maintained. The latter two phases, *emerging* and *well-developed individual interest*, refer to the psychological states of interest and to the beginning phases (emerging) or later phases (well-developed) of a relatively enduring predisposition to re-engage with particular classes of content over time (Hidi and Renninger, 2006, p. 114). Positive feelings, stored knowledge, and stored value characterize emerging individual interest. When moving to the stage of a well-developed individual interest, a learner can sustain long-term constructive and creative endeavors, generate curiosity questions, and generate more types and deeper levels of strategies to work with the given tasks. A student, for example, begins to asks questions out of curiosity, sets challenges for him- or herself, and exerts effort that feels effortless.

In an educational context, interest has been studied in connection to predicting which academic major a college student will choose (Harackiewicz et al., 2002). However, interest is the outcome of an "*interaction* between a person and a particular content" (emphasis added) (Hidi and Renninger, 2006, p. 112). This means that interest in a particular object or content is not embedded in a person; rather "the content and the environment define the direction of interest and contribute to its development," while "the potential for interest is in the person" (Hidi and Renninger, 2006, p. 112). Educators sometimes hold the misconception that the interests of students are polarized and that they either have or do not have interest in certain content, such as CS. Instead, Renninger and Hidi (2011, p. 178) suggested that educators are in a position to significantly contribute toward the academic interests of student through, for instance, instructional technology, organization of materials and making content personally meaningful and relevant.

There are also other conceptualizations that highlight the mechanisms behind the development of (academic) interests and that discuss career-related activity involvement and skill acquisition. For instance, interest is related to the concept of *engagement* or can be seen as a meta-construct of engagement (Fredricks et al., 2004). There also exist various definitions and some divergence concerning the concept of engagement (Henrie et al., 2015). One thing researchers agree on is that enabling a learning environment that engages learners in an activity or a task is important because engagement has been linked to important educational outcomes, such as student persistence in learning, satisfaction, and academic achievement. In particular, interest has been linked to *emotional engagement*, which describes the social, emotional, and psychological attachments one has to school (Lawson and Lawson, 2013). This emotional dimension to engagement was defined by Fredricks et al. (2004) and is operationalized by students' affective reactions, such as interest, enthusiasm, and excitement, among other emotional indicators (Henrie et al., 2015; Fredricks et al., 2004; Lawson and Lawson, 2013). Qualitative measures have often been used in measuring student engagement (Henrie et al., 2015), and these measures, such as interviews, are particularly useful for exploratory studies, where the definition of engagement and the methods for measuring engagement are not tightly fixed (Henrie et al., 2015, p. 46). In their review, Henrie et al. (2015, p. 44) found that the indicators of emotional engagement are most frequently studied, similarly to the current work, in the K–12 context. In the present study, we make an informed choice of choosing the theory of interest as our theoretical framework; however, the current research on student engagement (here, emotional engagement) supports our choice of qualitative measures that can be used to explore student engagement in the form of the development of student interest toward CS studies.

4 Context of study

The follow-up study reported in the current paper is part of a larger project that began in 2009 when the project team developed a week-long game programming workshop. This workshop formed the central activity of the outreach project and the context of the present study. The workshop was offered as an extra-curricular course during the summer holidays, and it consisted of 25 hours of work over five consecutive days. The workshop was held at the facilities of the organizing faculty and was open to all 12–18 year olds. Several thousand leaflets were distributed to local schools to invite students to join the workshops. We deliberately marketed the events as suitable for anybody who was interested in programming or in computer games, not just for students who were already personally involved in computing, informatics, or mathematics. Also, special attention was paid to the wording and layout of the leaflets, stating that prior experience in programming was not needed and that the CS subject matter was the key issue, with games only being a method to deliver the content.

The objective of the summer workshops was to introduce middle and high school students to the discipline of computing and to nurture creative computational thinking. As mentioned, the different aspects of computing were taught utilizing computer games as an application domain. We chose to use games as the context for the workshop assignments because games have appeared to be a promising approach for engaging and interesting students in CS (Baytak, 2009; Al-Bow et al., 2009; Repenning et al., 2010; Hadad, 2013). Although the contents were delivered using computer games as the medium, the main focus was, however, on teaching and learning programming fundamentals. For this reason, the detailed design of game assets (graphics, music, animations) or, for instance, the use of advanced tools for creating game content and game mechanics, was not included. The games were technically created using an open-source 2D game programming library, Jypeli, which was developed in-house. Visual Studio was used as the integrated development environment, and C# was used as the programming language.

To summarize, the main objectives of the workshop were to do the following:

- Give middle and high school students an overview of programming with a real-world context (games);
- motivate students to study more CS, engineering, and mathematics;
- give students relevant information about CS on which they could base their choice between different alternatives for further studies and careers; and
- let young students have fun with computing and give a positive experience of successfully making a working computer game.

During the workshop, the students were also introduced to CS studying opportunities at the local university.

The timetable of the workshop is presented in Figure 1, and it consisted of lectures, tutorials and exercises, the design and implementation of a game, and a final showcasing of the game. In Figure 1, lectures or other teacher-led portions are indicated by dark areas, while the time spent in computer labs with problem-solving activities and programming assignments is indicated by the white areas. The lectures were interactive, promoted active learning, and lasted 30–45 minutes each.

The purpose of these sessions was to orient students to think more like programmers and acquaint them with basic programming concepts and language syntax by showing illustrative examples. There was a maximum of two separate lectures per day, totaling seven hours during the week. The rest of the time, around 18 hours, was lab-based, student-centered work reserved for completing assignments and developing novel games. Each student was instructed to make a story or plot (verbal design) and to draw a sketch (visual design) for the game. Students also designed visual elements for their game by drawing game characters and the sprite graphics for the game elements. The stories and sketches were shared with other students in the course wiki environment. The time reserved for students to create their own games was around 12 hours, and four to six instructors guided the students in each workshop. On the final day, the class did a short campus tour (about one hour), where the lead instructor shortly presented CS-majoring possibilities and also shared his personal testimony about on how he ended up studying CS and how he felt about it. After that, the students were given the necessary material and links to the software that was needed to continue developing games on their own. Lastly, students presented their game projects to the whole class.

	Mon	Tue	Wed	Thu	Fri
9 am	Starting info	Functions	Loops, random numbers, gravity	Classes and methods of Jypeli library	How to continue at home
10 am	Get to know the tools	Carrying on with the Pong game	Designing and implementing own game	Implementing own games	Finalizing own game
11 am	Making the first game (Pong-tutorial)	Finalizing the Pong game	Implementing own game		
12 pm	What are algorithms	Handling collisions	How to make a level out of a tilemap (grid)		Showcase and best game voting
13 pm—15 pm	Carrying on with the Pong game	Designing own game	Implementing own game		

Figure 1: Timetable of the summer workshop

As reviewed in Section 2.3, a lot of effort has been devoted to bringing more diverse voices to the technology field. Although the current workshop was not designed specifically from the perspective of improving diversity in computing, the activities were designed and carried out in such a way that they underlined a welcoming and respecting atmosphere for all the participants, regardless of their backgrounds. Pedagogic and didactic details were designed in a manner that the workshop syllabus would be appealing but, at the same time, equally suitable for all students. This design was implemented at many points in time during the week. For instance, the very first example can be seen on the first workshop day when the teacher was building a snowman from three physical objects—thus, instead of focusing on a specific game genre or game culture, we chose playful examples that all participants could identify with. The need to use variables, functions, loops, and other programming fundamentals was founded on the need to solve "the problem of building a snowman" (or many snowmen). Circles representing the body of a snowman were then filled in with random colors and moved around with the help of a physics engine. The students were allowed to participate in the creation process with their own suggestions on what to do next with the snowman, such as constructing the snowman from four or five circles instead of three. By starting with this project, we wanted to illustrate some basics of turning plans and visions into a working prototype while avoiding an overly technical depiction of the program-creation process. In the first lab session, the students made a Pong clone by following a detailed tutorial and were encouraged to make their own textures on the padlets. Furthermore, during the lab sessions, we answered questions from the students regarding the relevance of the discipline, as well as the suitability of CS for both men and women, and we discussed the solutions that CS can provide to the challenges of the society. These talks were, however, a result of informal probings of individual students rather than structured conversations with the whole class.

External funding made it possible to offer the events for free, which was probably a factor that particularly drew students because such academic or hobby workshops typically have tuition fees. Despite being free of charge, we did not encounter a lack of commitment. For instance, dropout was below 5% on average.

4.1 Overall experience

In this section, we briefly present the results from our previous studies, which characterize the students' overall experience of the workshop and their post-workshop activities related to programming. These results give reader the necessary background on the method (Section 5), as well as on the analysis and results (Section 6) of the current paper.

Altogether, 741 students[1] participated in the workshops during the years 2009–2017. The student's self-reported interest in applying for science/computing studies rose from an average of 3.4 (pre-survey) to 3.6 (post-survey, scale 1: fully disagree. . . 5: fully agree) (Lakanen et al., 2014). A stronger effect appeared for those students who initially reported having a lower interest in computing. In another study (longitudinal, survey-based), we found that most of the students (91.3%) continued with programming or doing programming-related activities, and their interest kept increasing after the workshop (from 3.41 to 3.83, scale 1: fully disagree. . . 5: fully agree) (Lakanen et al., 2012). We also observed some indicative trends in the students' backgrounds, most notably that the pre-workshop programming experience correlates with a positive interest development (Pearson correlation 0.385, significance level 0.01). Having some prior experience and learning more programming in the workshop produced positive results because of the positive feelings and stored value expressed by the students, making it likely that the students would independently re-engage with programming content after the workshop. However, 57% of the students who had no or little previous exposure to programming had continued programming or participated in programming-related activities one to two years after the course. These results suggest that re-engaging with the content after the workshop does not solely depend on previous programming experience. Concerning the students with prior experience with programming, we cannot be certain

[1]The actual number of participant students is bigger, since many students have came to the workshop two or more times.

whether their interest was in a situational or individual phase when they took the pre-survey. However, their self-reported interest in computing or engineering studies did increase.

5 Method

The project under study was investigated as a whole using a mixed methods research approach (Creswell and Plano Clark, 2011) mainly comprising of multiple in-depth qualitative surveys taken by the outreach event participants. Prior to the present study, the existing quantitative and qualitative findings studied student preconceptions of programming (Lakanen and Isomöttönen, 2015), experiences of the participants during the event (Lakanen et al., 2014), and programming-related activities that the students did after they participated in an outreach event (Lakanen et al., 2012). Our focus in the current study is on the findings of a qualitative investigation, one in which students were interviewed about their educational choices and the impact that participating in an outreach event may have had on their choices. Furthermore, detailed background information and data on after-course experiences related to CS were gathered to reveal the underlying reasons for the educational choices of the students.

5.1 Participants

Volunteer participants for interviews were sought from the outreach project database. We focused on the students who took the workshop during their middle or high school years and had completed (or were just about to complete) their high school degrees. Thus, they had decided about their future studies. The average amount of time between when students had taken the workshop(s) and when they were interviewed was three years and six months, varying between two and five years. The students were then contacted using the information obtained during the events, mostly by email or phone. Search engines and social media (in this case, Facebook) were used to determine contact details because the contact information of some students had changed since they had taken the workshop. Most did not answer at all, and a handful of students said they were too busy with their current studies and thus refused to be interviewed. The interviewees were offered a movie ticket for their efforts.

Finally, out of the 94 contacted students, we were able to interview 20. In Table 1, we summarize the students by listing gender, age at the time of participation, their prior programming experience, and the category (result of the analysis; further explained in Section 6) of each student. The interviews involved 17 males and three females. The students' prior programming experiences varied mostly between none and low (see column *Earlier exposure to programming* in Table 1). The explanations of none, low, medium and high programming exposure are given below.

- None: No programming exposure whatsoever.
- Low: Some attempts to make a program without a particular aim, such as cut-and-pasting code listings from a magazine; some experiments with a tutor but no spontaneous programming experiences.
- Medium: self-directed programming within a limited environment, such as writing scripts to modify game logic; Self-directed programming of small applications; took voluntary or extra-curricular course(s).

Table 1: Interviewed students

ID	Gender	Earlier exposure to programming	Age	Category
Student 01	Male	Low	16	*4 - Confirmed not interested*
Student 02	Male	Low	15	*1 - Confirmed career option*
Student 03	Female	None	16	*4 - Confirmed not interested*
Student 04	Male	None	15	*2 - Novel career option*
Student 05	Male	Low	15	*1 - Confirmed career option*
Student 06	Male	Low	16	*2- Novel career option*
Student 07	Male	Medium	16	*3 - Stick to the other plan*
Student 08	Male	None	17	*1 - Confirmed career option*
Student 09	Male	Low	16	*2 - Novel career option*
Student 10	Male	Medium	16	*2 - Novel career option*
Student 11	Male	Medium	15	*3 - Stick to the other plan*
Student 12	Male	Medium	17	*3 - Stick to the other plan*
Student 13	Male	Low	15	*4 - Confirmed not interested*
Student 14	Male	Low	15	*1 - Confirmed career option*
Student 15	Female	None	15	*3 - Stick to the other plan*
Student 16	Male	High	15	*1 - Confirmed career option*
Student 17	Male	Medium	15	*1 - Confirmed career option*
Student 18	Male	Low	14	*2 - Novel career option*
Student 19	Female	None	16	*3 - Stick to the other plan*
Student 20	Male	None	16	*3 - Stick to the other plan*

- High: Enthusiastic self-directed or determined programming experiments, possibly with voluntary or extra-curricular courses.

Note that the elaborations of prior experience only concern programming particularly and do not relate to general computer using skills.

The interviewees participated in the programming events typically once, except *Students 4*, *10*, and *19*, who attended twice, and *Student 17*, who attended three times. In the analysis phase, we interpreted taking the workshop more than one time as if the later workshop(s) was a form of participation in any similar volunteer, hands-on CS project or activity.

The gender distribution of the interviewees—about 15% female, 85% male—well reflects the typical distribution of students majoring CS (Gavriushenko et al., 2017), but the distribution is different from the outreach participants, which was only 7%. In addition, the mean age of the interviewees (15.5 years) was slightly higher than the mean age of all the outreach event participants (14.5 years). The overall low number of female participants can be a limitation of the current study and is discussed in Section 8. Other than gender, our general understanding is that the workshop captured students from a wide range of socioeconomic and cultural backgrounds. Similarly, we believe that the studied sample represents the diversity in the Finnish middle school student cohort. However, we did not address students' socioeconomic (e.g., household yearly income), cultural, or ethnical status in the current study.

5.2 Procedure

All the interviews were semi-structured. The conversations were guided by the interview plan given in Appendix A. The students were interviewed one-on-one using audio-recording, and the recordings were then transferred to a computer and transcribed verbatim. The interviews lasted from 15 minutes to one and a half hours and mostly took place in the university building—the same building where the outreach events had been held. Students living in another town were interviewed via Skype. To ensure active discussion with the high-school-aged participants, we prepared a large set of questions and topics, but we also gave the students space to elaborate on the topics they found meaningful. More precisely, in many cases, the interviewer asked the interviewee to expand upon some points even though that particular topic was not part of the interview plan. In general, the students seemed relaxed, chatty, and unreserved, and the meetings were confidential. This trusting environment enabled the students to present critical thinking and think aloud about their feelings regarding the outreach events and the impact of the events on their personal lives. However, the *triple role* of the first author (teacher during the outreach events, interviewer, and researcher for the study, as discussed in Section 8) could have distracted some students, possibly causing them to leave out some critical thinking.

The transcribed interviews were then manually segmented through multiple iterations, after which the segmented data were coded, and the first versions of the individual pathways were generated (Basit, 2003). At this stage, we decided to depict the pathways as flow diagrams that would illustrate a continuum of events or experiences from the early ideas about CS until the participant's final judgment (Paloheimo et al., 2011). The direction of the arrow represents the chronological order of events. The pathway diagrams can also be described as *networks of motives* that indicate the factors that contributed to the development of the interest path (Olufadi, 2015; Blackwell et al., 2014; van den Beemt and Diepstraten, 2016). The factors could include notable events in one's life, such as purchasing a computer, the student familiarizing him- or herself with computer programming for the first time, or a close friend recommending an event. On the other hand, more long-standing contributing factors also arose at this stage: the work history of a close relative, a long-standing hobby, or more general interest in creativity, for instance.

Next, based on the low-level codes and the initial pathways, again through multiple re-reads, the data were subjected to pattern coding, where regularities in the data were further identified, and the low-level themes were transformed into a higher-level categorical scheme using the directed approach toward content analysis (Hsieh and Shannon, 2005, p. 1281) using the existing theory of interest development. During the early phase, we worked with an emergent mode where as few as possible *a priori* hypotheses about the data were allowed to influence the coding. This made the analysis largely data driven and inductive (Patton, 2002, pp. 453–456) and constantly comparative, which is similar to a *grounded theory* approach (Glaser and Strauss, 1999). In contrast, after the lower-lever coding, the observations were reflected through the four-phase model, making this part of the analysis theory driven and deductive (Hsieh and Shannon, 2005; Patton, 2002). Altogether, the qualitative analysis process integrated both inductive and theory-driven elements.

Below, the depiction of the main findings is organized according to the two fold nature of the analysis process. In Section 6, the high-level categories are first described, and then each category is augmented with its interpretation. To illustrate the motives and connections between them, as well as the links they have to the theory, the final pathway diagrams are presented with the interpretation of each category. The diagrams also display the cumulative and concurrent nature of the driving forces behind the motives of the students. As a whole, the analysis was an iterative and incremental process, and several adjustments were made to the coding scheme until the final categorical scheme saturated the data. Agreement about the themes and categories was reached by intensive discussions with other researchers and re-reviews of the data, which continued until the conclusions had been identified.

Choosing what to study is a complex, ongoing, and social process (Holmegaard et al., 2012, p. 36). For a teacher, it is important to understand that each student is unique. Here, we were not trying to force students and nuances that were emerged in the discussions inside some predefined general box. Instead, we aimed to understand the *phenomenon* behind these different cases while acknowledging the complexity of the decision processes. Again, our derivation of multiple pathways, reflecting the same theoretical model of interest development, was used to avoid these simplifications.

6 Results

This section is arranged based on the impacts found during the interviews on the educational choices of the students, and each subsection presents a distinct outcome—an *impact category*. Overall, we found four impact categories: (1) the course confirms CS as a probable career option, (2) the student sees CS as a career option and would have not considered it before, (3) the course has no significant impact on the student's career plans, and the student will not study CS as a major subject, and (4) the course confirms that CS is not an interesting career option for the student.

Under each of these impact categories, based on the interview data, we describe and explain why and how the students' backgrounds, earlier experiences in CS, and some other underlying factors affect final educational choices and interest in CS. After describing each impact category, 4PM (see Section 3) is used as a lens to interpret the category's underlying causes.

6.1 Category I: Confirmed career option

In this category, the students expressed that the outreach events had an important *confirming* or *strengthening* significance on how they determined to study CS in a university. We placed six students in this category: *Students 02*, *05*, *08*, *14*, *16*, and *17*. Three of these, *Students 02*, *14*, and *17*, had applied to study CS at the outreach organizer university. The other three students had applied to some other universities in Finland, and their majors were either CS or game design.

The students identified the outreach course as an occasion that played an important part in their decision-making processes by confirming their views of CS as a possible career option. They were already partly inclined towards the field of CS but had not made their final decision prior to the outreach course. Regardless of their earlier inclinations, the students stressed the importance of the new information and added enthusiasm for the field that were obtained during the course. For example, one student stated the following:

> The effect [of the course] was that I got to know that this university had this possibility [to study CS], with all these game-related courses. After that, I felt I was really on the ball so to speak (*Student 17*).

The students identified a variety of reasons why the course had confirmed their views. First, the course resulted in a feeling that they were *creating something* *new* when they wrote a computer game from scratch. Succeeding in creating working computer games was important because it was a concrete example of what an individual can do with programming. For example, *Student 08* had not tried programming before the course and said that in the beginning, it was hard to produce anything decent and that the game programming course proved that he could create a concrete and working product, even though "it wasn't a great game." Furthermore, he said that he debated a long time between mathematics and computer science but decided to go for CS because he wanted to study something where he could be creative. He discusses these points in the following:

> In my further studies, I want to do something where you can use creativity, such as programming. Particularly you can do that [use creativity] ... with [programming] games. I could get something done and ready, which can be hard when beginning programming. (*Student 08*).

The second item that enhanced the confirming effect was that the students in this category were passionate about games, in some cases even to the degree that it "defined who they are," as expressed by *Student 17*. This *game identity* consisted of not only playing, but also other elements that contributed to the community and culture around computer games. It included, for example, creating so-called *mods* (modifying rules of an existing game to change the underlying game logic or the storyline) and the social connections between the creators of different types of mods:

> Creating these mods can be described as programming with a graphical user interface. At that point [in my life, when the workshop occurred], I was very much into the creating mods... and I was active in that community. Computer games were such a big part of my life that I wanted to be making something myself that would give that same degree of satisfaction to someone else (*Student 17*).

Hence, participating in the outreach course was motivated by the game context, though *Student 14* stated that he *might* have come even if it was not about programming games specifically. The course also strengthened the students' game identity because they would now be able to contribute to the gaming community by sharing their game with the friends.

All students (apart from *Student 08*) had a background with at least some experience in programming prior to the outreach course. In all of these experiments, a friend or a family member acted as a mentor or at least encouraged the student to experiment. Regarding the activities after the outreach workshop, all the students showed interest in CS by taking voluntary courses during their high school studies, such as participating in open online courses or being active in some self-directed experiments related to programming. Those three students who ended up choosing to study at the organizer's university felt that the outreach workshop had a great impact on them and said they would probably have gone some other place to study if they had not come to the outreach event. For instance, *Student 14* expressed that the workshop significantly helped him decide between different study options:

> I think it supported the decision [to go for CS studies, and without the workshop] I would have had the image that "this might be fun, I probably could do this", but afterwards I was like "this *is* fun, I *can* do this." So, in a sense, the course made the question mark at the end go away (*Student 14*).

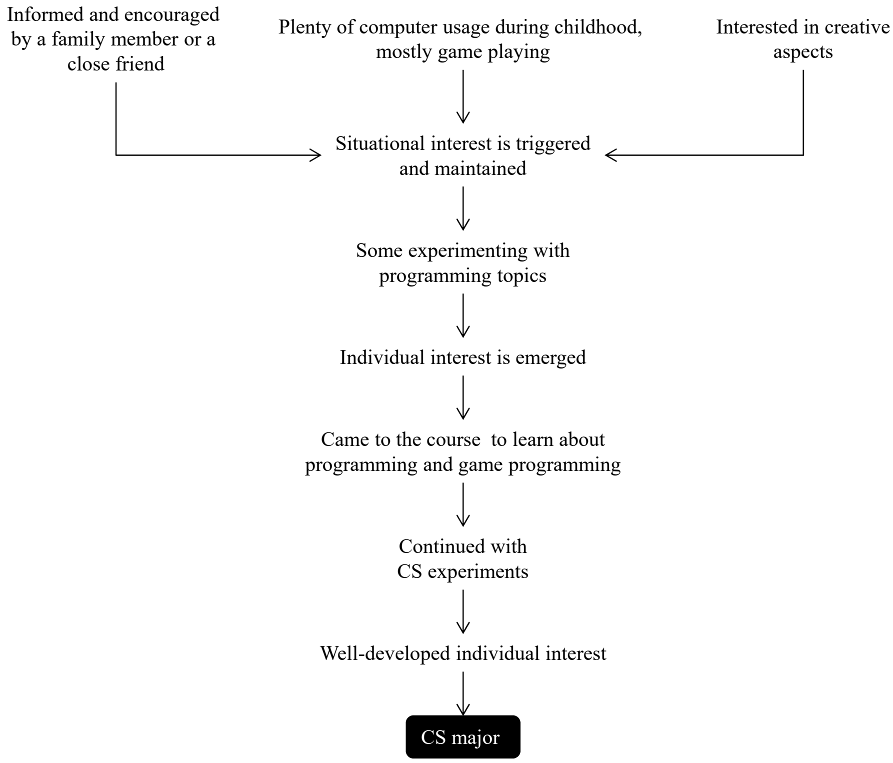


Figure 2: Typical pathway for Category I.

6.1.1 Interpretation of Category I: Strengthened a well-developed individual interest in CS

A typical pathway for Category I is presented in Figure 2. We found a common factor among the students who had experienced deepened, individual interest in CS because of the outreach was that computer games *worked as a catalyst to arouse and unleash creative activity*. For these students, the outreach worked as a path toward CS, boosting their willingness to choose CS as an educational career. Their image of CS studies was readily positive, but during the outreach event, they became even more engaged, especially because it enabled the students to use their imagination and creativity while developing the games. We interpret that although the students possessed an emerging individual interest before attending the workshop, the workshop encouraged students to seek out opportunities to re-engage with ideas about programming and CS. Because of these efforts, student interest in CS evolved into a phase of well-developed individual interest (fourth phase in four-phase model of interest development, see Figure 3).

Most of the interviewees were passionate about playing computer games, even contributing to the world of games in the form of gaming culture or taking part in social nexuses. The dream of being a professional in a games-related field could have been simmering since they were children. The world of games and the role of social networks in this world could be experienced as a part of the identity of a person, and for some students, the thought of becoming a creator instead of being just a consumer had grown over the years, and this possibility of creating something of their own to contribute to the world of games was an important reason for the positive impact of the event. During the events, students often wanted to stay in the class while in a state of *flow* (Csikszentmihalyi, 1991) and continue working in a creative mode with their games after the official working hours had finished.

The creative aspects of computing were supported by technology-savvy parents or close friends, and although not all students had actually tried programming before, a general pattern was that some self-directed experimenting with programming topics did occur prior to the outreach program. During the event, the participants obtained information about CS as a field, learned about the possibilities to study CS, and saw people working in the CS field, which confirmed the choices they had been thinking of.

Would these students have chosen to study CS if they did not participate in the outreach event(s)? It is possible, but based on the results of the current study, the outreach was an irreplaceable component of their path toward CS studies. From an organizational perspective, the outreach program increased awareness of CS studies, and based on the analysis, without the outreach events, the students—the three who came to study at our university—would probably have gone to some other place to study CS.

6.2 Category II: Novel career option

Students in this category originally had some other plans regarding their future studies. After participating in the outreach event, their plans changed to the point where they were now going to major in CS or information systems (IS; another possible major) or at least were beginning to see these subjects as likely options for upcoming studies. Five students were identified in this category: *Students 04*, *06*, *09*, *10*, and *18*.

These students indicated that the outreach was very important to their decision-making processes. More precisely, without taking the workshop, the students would have gone on to study some other subjects. Prior to the workshop, *Student 06* was going to major in mathematics or natural sciences, but after participating in the workshop, he decided to choose CS. *Student 09* was considering some other major at a technical university, and *Student 10* was interested in information technology in general but undecided about his exact major, while *Student 04* and *Student 18* were open to a range of options different than CS. Eventually, *Student 09* and *Student 04* did choose to study CS. *Students 18* and *10* have still not determined their major at the time of writing this paper, but they expressed seeing CS as a highly probable option for their future studies.

All students in this category expressed that they would not have been aware of the possibility to study CS, and thus chosen differently, if they had not participated in the outreach event. Therefore, the outreach had an even more radical impact on these students than on the students in the previous category. In the discussions, the students emphasized the importance of the *new information* they obtained not only about programming itself, but also CS studies, career possibilities, and people working in the CS field. This is illustrated in the following quotes:

> It had an impact on me [...] If I would have not participated there, I could have studied some other subject or chosen some other major. A technical field was close to my heart earlier, too [...] but my major could have been something else [without attending the workshop] (*Student 09*).

> It gave me a lot of new info about this place, and all these possibilities [to study CS], so I think it had a major impact on me. If I would not have come to the workshop, I would not know about these possibilities (*Student 04*; participated twice).

> First off, it stirred interest in me, because I learned a lot of new things. It helped me decide to go on with this topic. It felt like... my *thing.* If I did not participate the outreach, I probably wouldn't be so interested in programming. Maybe it would be a hobby or a side project, but not so important for me (*Student 06*).

Even the physical presence of being in a university building felt important to *Student 04*, who had never visited such a building before. He recalled that a concrete visit to the facility was important for him because he could then observe "what this place was about" (*Student 04*). Moreover, the students reported that they had no family members in the CS field, but their childhood homes had been very open to new technologies, both for utilization and entertainment purposes. Without mentors, the students either lacked earlier programming experience, their experiments had not been successful, or they felt that these experiments were not worth much discussion:

> I did try to write some JavaScript some time ago, but it didn't go very well. Maybe I just didn't feel up to putting too much time in it, or maybe I didn't have good instructions. It was just copying and pasting (*Student 18*).

Regarding the motives for participation, *Student 06* did not mention games or earlier programming experience, but he felt that his closest friend, who also attended the outreach event, was the most important factor leading him to participate. On the other hand, *Student 04* had taken some voluntary computing-related courses in middle school and identified the game theme as the main factor that sparked his interest: "I had played games a lot, so I thought it would be interesting to learn about making one of my own" (*Student 04*).

Overall, the motivation for participation varied, and the possible earlier experiences with programming and willingness to learn new things about programming did have some part in the motivation for some of these students. The change in their plans for educational choices also enabled the students to re-engage with CS, inducing some self-directed experimenting with CS topics or programming. All the students, however, needed some external support and were not able or willing to self-generate tasks to complete or problems to solve. For example, *Student 04* attended the outreach events multiple times during consecutive summers and continued the same game from where he had previously left it. In contrast, *Student 06* and *Student 18* took some voluntary computing-related classes during high school, which contributed to their increased understanding.

6.2.1 Interpretation of Category II: Emerged well-developed individual interest in CS

A typical pathway for Category II is presented in Figure 3. The outreach event had a strong impact on these students because of the *new information* they received about the CS field, CS studies, and the academic possibilities. Along with increased interest toward CS studies because of the outreach event (where two out of five participated twice), the students now considered CS to be their educational career. Without the new information, they probably would have studied some other subject. Also, unlike the pathway in Category I, the students did not have any family members or friends who would have tutored them, which would have made it easier for the students to conduct some self-study and self-directed programming. Therefore, they only had little information about CS topics beforehand, and the outreach ignited their interest in CS. In this sense, the outreach worked as a source of new information that helped

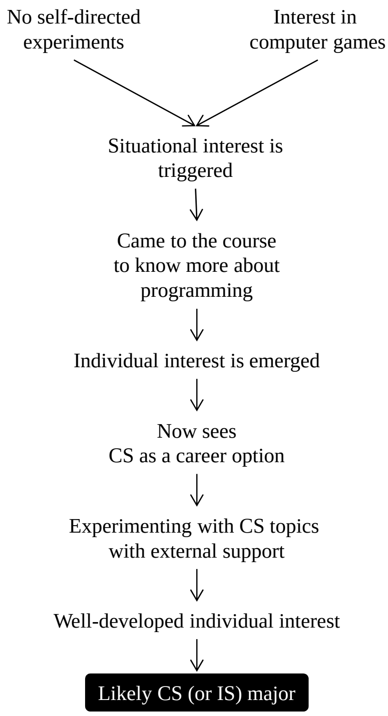


Figure 3: Typical pathway for Category II.

the students decide and choose between the different educational career options but it also gave them positive feelings about CS careers and increased the value of CS in their decision making. The findings from this category accord with the emerging individual interest phase (Hidi and Renninger, 2006, p. 114):

> Emerging individual interest refers to a psychological state of interest as well as to the beginning phases of a relatively enduring predisposition to seek repeated re-engagement with particular classes of content over time.

A commonality in this category is the students earlier lack of self-directed experiments with CS topics; here, their situational interest had indeed been triggered in their childhood or youth. All the students had been involved in some activity that had triggered and maintained their interest in CS and programming topics. For example, *Student 04* expressed that he was confident when working with computers, and even though he recalled his earlier experiences during childhood to be mostly playing computer games, our interpretation is that this confidence helped him develop and maintain situational interest toward computing in general. The same pattern can be recognized throughout the category; individuals who had used computer applications in their childhood and youth, even for leisure, felt that they were good at working with computers, which further fed (maintained) their interest. Thus, they were *engaged* in the content, (computer applications, computer games), and this engagement sustained and deepened their interest in the content. This situational interest motivated students to focus their attention and find out more about the topic. During and after the outreach event, their situational interest developed into an emerging individual interest, enabling the students to anticipate the subsequent steps in processing work with content, even though it required external support; students participated in voluntary CS activities but lacked purely self-directed experimenting.

From the organizational perspective, the outreach had a major impact on the two particular students who chose to major in CS at the organizer's school. Regarding the three other students, one chose CS studies at another university, while the last two are still making a final decision concerning their studies.

6.3 Category III: Stick to the other plan

This category consists of the students who had plans to study some subject other than CS before the intervention, so taking the outreach did not alter their plans. However, even though the outreach event did not trigger individual interest in CS and a CS career, the intervention did affect their *image* of CS as a field, university major, or career option. The category comprises the data from six students: *Students 07*, *11*, *12*, *15*, *19*, and *20*.

The motivation for participating in the outreach event varied between experimenting, practical reasons, and seeing whether the course had a utility value. First, students who were *experimenting* wanted to try something that they had never done before, and they were eager to explore, even though they knew (or presumed) that it would not be their future career. *Student 20* commented that his visit to the workshop was just a "sudden idea that came from [his] brother." *Student 19* described that her participation could be compared with "a parachute jump": she did not necessarily need a particular reason related to educational choices or an interest in computer programming to participate, but she rather wanted to experiment with something totally new to her. Second, some students had *practical reasons* for attending, as described by *Student 15*:

> Me and my brother always had to figure out something sensible to do during the school's summer breaks, when our parents were working. Also, they encouraged us to actually do and try out different things—we have been to a tennis camp, for instance. I wasn't interested in programming as such but on the other hand I didn't think anything negative about it either (*Student 15*).

Third, some students brought up that they looked for the *utility value* of the workshop—they could take advantage of their new skills in some other situations. For instance, *Student 07* mentioned that he had been designing websites for individuals and small businesses since he was 10 years old and expected that he might benefit from the workshop because he thought he would need deeper programming knowledge in his future projects. *Student 07* also added that "playing online games was something that was looked at dimly" in his home, but "utilizing computers for something beneficial was encouraged." *Student 12* had tried some programming beforehand and now wanted to learn game programming.

Two of the three female respondents were in this category, and both emphasized their strong skeptical preconceptions of CS and about the people working in this field. They also stated that even though this preconception had not totally disappeared by the time of the interview, the outreach event did slightly change it. The following quote illustrates this preconception that *Student 19* had, especially toward programming:

> I had this image, which is probably incorrect, that in these [studies requiring programming competence] they [the students] just have their noses buried in their computers, and everyone knows how to program. So I thought that I am not sure if I want to go there if they are all just making programs. (*Student 19*)

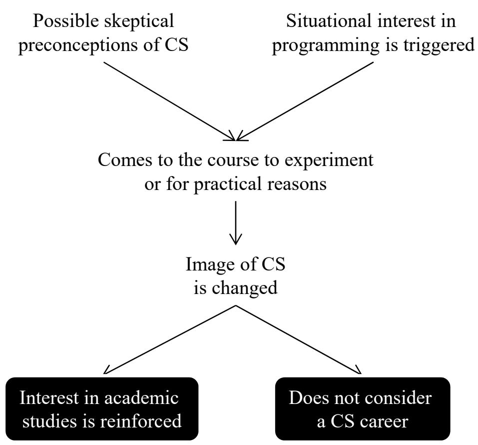


Figure 4: Typical pathway for Category III.

Later though, *Student 19* noted that she was happy to notice that her classmates in the game programming class were not "the kind of geeks that you see in the movies." However, a certain nerdy and masculine image still clearly remained in her mind. This was also the case with *Student 15*, who chose to major in education, representing herself during the interview in the following manner:

> I like to think that I am really far from a nerd who is sitting in front of his computer day in day out, and so I just think that if you don't do that [practice programming] all the time, you are not able to understand anything about it. I think that is the driving force and image about myself. I hope that I can get rid of these prejudices now that I need to face the new technology and think how I can use it in my teaching (*Student 15*).

In addition to the above-mentioned memories of skeptical preconceptions, other changes in the image of CS were recognized. *Student 07* identified that he now better understood "how a computer handles things and computer logic" while *Student 12* recognized games as "a whole new inspiring theme" that complemented his earlier programming trials, thus giving him a new perspective on CS. The students spoke of the workshop as a generally positive experience, and for many students, learning by making games in a university environment was new and fascinating because they had never visited a university before.

In general, the students reported that they had not continued programming-related activities after the workshop. There were some students, such as *Student 15*, who had chosen voluntary courses in middle school or high school, but none of the students had done programming in a *self-directed* manner. Generally, the lack of time during their high school studies seemed to be the greatest issue, with the "syllabus being so stuffed with physics, chemistry, mathematics, and languages," as *Student 07* explained about his tight schedule. Taken together, despite the various reasons for participating in the outreach event, the students considered that the workshop itself did not have an impact on their educational choices. All the interviewees did apply to universities, majoring in law (*Student 07*), mathematics (*Student 11*, *Student 12*), education (*Student 15*), or physics (*Student 19*).

6.3.1 Interpretation of Category III: Image of CS is changed

Figure 4 presents a typical pathway for Category III, which consists of students who were situationally interested in programming but eventually followed their original aspirations. Their interest in CS did not increase, but their perception of CS and the people working in the computing field changed. Furthermore, the students' reliability on their own CS skills changed, and for some, their interest in academic studies was reinforced.

An interesting feature that characterizes this category is the students had either confirmed their future career choice or were inclined to continue their studies in a subject that was familiar to them from the school context (e.g., mathematics, physics). Thus, their choices can be attributed to the current selection of mandatory or elective school subjects. The choices of these students can be seen as logical extensions of doing well in particular classes in high school (Seymour and Hewitt, 1997, p. 69). Furthermore, it appears that their choice trajectories were defined by early and specific career commitments (Cleaves, 2005, p. 473), and although the workshop generated positive feelings, it did not affect their career aspirations. These aspirations agree with why the students chose to participate in the workshop (experimenting, practicality, utility; see Section 6.3).

Another characteristic of this category is the juxtaposition of the students' pre-workshop preconceptions and their understanding of the future possibilities of CS careers. Although their earlier opinions were based more on prejudices than actual learning experiences or hands-on activities, the students described that the workshop made them more conscious of the possibilities of CS as a future profession. Regarding the preconceptions about CS, there were broad variations among the students, which were in part affected by earlier programming experiences. For instance, *Student 07* and *Student 12* had already made small, but nontrivial, programs by themselves, while *Student 19* and *Student 15* described that they had not tried any programming beforehand, so participating in a workshop was an "uninformed choice" for them in that they did not know what to expect.

This is illustrated in the following quote by *Student 19*. She was planning on majoring in physics in a distinguished university, but she was hesitant because of her programming skills. Then, she described her increased autonomy and self-determination because of her participation in the workshop as follows:

> In the workshop, I learned to do programming a little bit. So, I had the courage to apply to [a particular] university. I read somewhere that they do 3D modeling and programming [...] and I thought that maybe I can apply, and [if I get in] then maybe I will not "die" in there. After all, I did learn how to program my own computer game (*Student 19*; participated twice).

Even though the workshop intervention did not contribute to interest development, the previous analysis suggests that the workshop did contribute to student interest in pursuing an academic career. The perceptions of students toward their own competence or ability to succeed in a field that utilizes CS or computational methods was developed. Their career trajectories became more informed, and their personal academic interests were developed. For example, the phrase "I had the courage to apply [...]" signals some characteristics of the learner that are typical manifestations of an emerging individual interest. These characteristics include the learner having positive feelings about the content, being reflective about the content, and having stored knowledge and value. We do not interpret this "courage" to be just an appearance of fortitude or a heartened mindset. *Student 19* continued, saying the following:

> Interviewer: That sounds like the workshop did actually have quite a bit of an impact on you. Can you hypothesize, what would have occurred if you had not done the game?
>
> *Student 19*: In that case, I probably would have never applied to that university.

We conjecture that this might be an expression of *cognitive dissonance*: a striving for internal consistency in a situation where a person holds two conflicting cognitions, for example, attitudes, ideas, or conceptions (Festinger, 1962). To reduce this dissonance and to reach consistency between the expectations and reality of a person, a person is motivated to change either her actions or cognitions so that the uncomfortable psychological state becomes more comfortable. In Category III, the students would change some of their dissonant cognitions to help them reduce their cognitive dissonance. For example, *Student 19* justified her behavior (applying to a particular major, not CS) by adding a new cognition (i.e., "Even though CS and programming might be a bit nerdy stuff, I will need it to achieve my ultimate goal").

We mentioned that the students in this category spoke of a positive overall experience. However, these references to positive experiences must be interpreted with caution because the students mainly described how they perceived the overall atmosphere during the outreach event. This does *not* refer to increased interest because assessing interest based on "liking" alone cannot necessarily be interpreted as a change in interest (Renninger and Hidi, 2011; Krapp and Prenzel, 2011).

6.4 Category IV: Confirmed not interested

In this category, the students felt that whatever they had in their minds regarding their educational choices, the outreach confirmed that they would not major in CS. There were three students belonging to this category: *Students 01*, *03*, and *13*. These students concluded that the workshop event did not arouse engagement in experimenting with CS in their free time or in CS studies, but it rather confirmed that they would look at some other interesting fields.

Two students, *Student 01* and *Student 13*, had some exposure to programming beforehand, while *Student 03* had no earlier exposure. *Student 13* had experimented with what he called "elementary things," more precisely, making a personal homepage with some functionality that required some scripting that he counted as learning some "very basic programming tricks." The father of *Student 01* was "in the IT business doing some software development related code." This participant's father had shown him some examples of program code and even helped to write a *Hello world* code. However, as was the case with the other students in this category, *Student 01* lacked self-directed experiments.

Instead, all the respondents in this category highlighted the great amount of time that they spent just playing computer games in their childhood. This great fascination in the "world of games," as described by *Student 03*, and the desire to obtain information about the game industry and careers related to this world of games led to interest in taking part in the outreach event:

> I wanted to learn more about what is this world of making games, because I was so interested in games at that time. I had just completed the [nine years of] basic education, and I wanted to check out if this would be the thing in my future studies (*Student 03*).

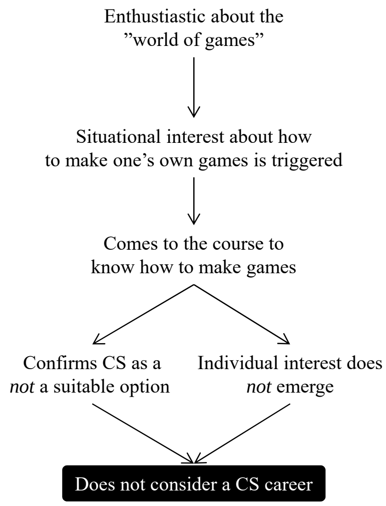


Figure 5: Typical pathway for Category IV.

In addition to an interest in game-playing, *Student 01* noted that he was generally interested in games and wanted to learn “how making games would be in its most simple form”; his method of creating games was that there were both simple and complex ways to do this, and the method that was adopted in the workshop was the simplest.

Unlike other respondents in the current study, the students in this category were rather brief in explaining how the outreach was as an experience, as well as their memories of the experience. For example, *Student 01* felt that “it was a fun experience... it was a nice pastime”. Thus, he placed an emphasis on having fun and spending time in an environment filled with discussions about games. One interviewee suggested that the workshop timetable was a bit too tight to make a game, as follows:

> Briefly, we designed a game, and made it very slowly and with difficulties. It was a little hard to remember how everything had to be done. I mean, even though we had some [learning] material, I couldn’t figure out in my mind how everything had to be put together (*Student 03*).

None of the students in this category continued programming after the workshop, downloaded their game from the university server, installed game development software, nor remained active in some other way. Two students brought up that they could now better understand the logic behind computer games, which they said was a positive result.

To summarize, even though the outreach event did help students better understand the underlying idea of programming and changed some of their misconceptions about CS, it also helped them decide to choose some other field than CS for their future studies. For example, *Student 13*, as well as *Student 03*, expressed that the workshop made it clear that “programming is not my thing.” Furthermore, *Student 13* considered the reason for this to be that he preferred something more technical, “like electrical engineering.” Similarly, *Student 03* emphasized that “it became clearer [during the workshop] ... that the programming part is not my thing,” while *Student 01* also meandered around the topic, but then he said, “I would say that I have now seen what programming is, and I think I’m done with it.”

6.4.1 Interpretation of Category IV: Nonemerging individual interest

A typical pathway for Category IV is depicted in Figure 5. This category consists of participants who came to the conclusion that CS, and programming in particular, was not their "cup of tea." The students' situational interest had been triggered because of an interest in computer games: all the students in this category were enthusiastic computer game players. However, as they progressed through the tasks and were more involved personally in the content, they were unwilling to re-engage with the ideas about game development through programming. Rather, some negative feelings about the topic emerged, hindering the students' ability to be interested in and value programming. Thus, they made no effort to find more information about programming (and CS in general); individual interest did not emerge.

We call these students *disengaged*, a term discussed by Shernoff et al. (2003), who inspected student engagement in the classroom setting and found three characteristics of instruction crucial to overall engagement: *challenge*, *skill*, and *relevance of instruction*.

Regarding our outreach event, the students' perceptions of the challenge was twofold among the students in Category IV. On one hand, *Student 01* brought up that he expected to see how to make games at the simplest level, so the challenge he had set for himself was low. Although he anticipated little or no challenge, the experience turned into only recreation or amusement for him. Although his prior programming experience was minimal, he was a skilled computer user and presumably unafraid to try out new things related to working with computers. However, these minimal earlier coding efforts created overconfidence in his perceived skills. Interestingly, this confidence in his computer-using skills and perceived programming skills did not translate into challenging himself to do programming tasks. This experience correlates to what Shernoff et al. (2003) calls relaxation (low challenge, high skills).

On the other hand, *Student 03* experienced severe difficulties during the game development phases, giving her the impression that her skills were insufficient to meet the challenges. This significantly hindered her experience, and eventually, it became evident to her that she would not continue to seek new challenges, as she pointed out:

> It became clearer that the programming part in making games is not my thing. I liked the design part the most. I have always been more of a designer and not a maker (*Student 03*).

Regarding instructional relevance, students are "more likely to become engaged with authentic academic work that intellectually involves them in a process of meaningful inquiry to solve real life problems that extend beyond the classroom" (Shernoff et al., 2003; Lamborn et al., 1992). The students in this category spoke of the high level of perceived relevance of instruction, and the participants related themselves strongly to the gaming context and felt that games were a relevant part of their lives. Furthermore, the students identified the instruction that was related to games to be an important motive for their participation.

Unlike the students in Category I, who also spoke about having a passionate interest in the world of games (Section 6.1), the students in this category did not bring up the idea of becoming a creator instead of a consumer. This indicates that even though the disengaged students found the game theme itself to have instructional relevance, they did not professionally relate themselves to game development because the challenge provided by the tasks did not meet the skill set of students in a manner that would enable the experience of flow (see, (Csikszentmihalyi, 1991)). For some students, the challenge was too low, while for some students, it was clearly too high. Would the flow experience yield to the emergence of the students' individual interest? This is a matter for further study.

7 Discussion

We found four general categories that can describe the long-term effect of an after-school computing outreach event. The findings support the claim that participation in a computing outreach event has a long-term impact on the development of interest in computing. The impact worked in both ways, meaning that after participating in the event, the students found it easier to express their level of interest in CS, regardless of whether they selected CS for further studies. In the following paragraphs, we discuss the main implications of the results for curriculum educators and scholars who are aiming to develop student interest.

Introducing students to interesting and apposite content is important and helps students engage in a creative process. The ability to engage in a creative process to solve problems or design artifacts, for instance, computer programs, is essential to engineering (Daly et al., 2014). This engagement with the content is seen in Category I. The students here had an idea of studying and working in the computing field, and this aspiration later focused on CS and was inspired by the creative endeavors inspired by the outreach event. An important factor in the growth in student interest was the possibility to create something new, to create programs according to their wishes, and to see the results of their work. Learning programming by creating computer games can be seen as learning CS through developing creative skills, which enhances the students' ownership of their work and attaches the learners to the content. The process of producing meaningful artifacts, for instance, by modifying the logic of existing games or otherwise contributing in the gaming culture, was something that was already somewhat familiar to them and something they could identify with. Because games are large part of the everyday lives of these students, it is possible that they found learning in a game context to be meaningful and as providing them with increased motivation (DeClue, 2009). Meaningful interactions make beginner programmers create a connection with the content and consequently sustain their engagement with it (Scaico et al., 2017). In the present study, whether it was conscious or unconscious, the students found a "self-transcendent purpose for learning" (see (Yeager et al., 2014)) and were able to persist with the task (during the workshop) and generate self-set challenges that further cultivated their interest. It has been proposed that finding a purpose for learning and working hard in an academic context might effectively lead to better self-regulation (Yeager et al., 2014). The results of the present study indicate that finding a purpose for learning and generating interest are interconnected. However, not all tasks in a classroom can be made fun or interesting at all times. Thus, it is highly important that students can develop skills that enable them to persist in working on tasks that might feel uninteresting or tedious and still be able to find these tasks personally meaningful.

For the students who fell into Category II, the outreach was a game changer, a factor that turned a situational interest into an emerging individual interest, which was then maintained through self-regulated and externally supported re-engagement with CS-related content. This perseverance to work with and effort to learn about CS content increased their valuation of CS concepts and turned their interest into the phase of well-developed individual interest. Hence, better perceptions of the CS field and CS career prototypes played a critical role in their educational decisions, which agrees with several earlier studies (Carter, 2006; Rosson et al., 2011).

Although 11 interviewees out of 20 chose to major in CS or in a CS-related field, the decisions of the five students in Category II (25 %) were clearly affected by the outreach event. This is in line with McGill et al. (2015), who found that 22.3% of the respondents indicated that participating in the outreach program affected their decision to choose a CS or related major. A higher impact was found in a study by Harriger et al. (2012), where as many as 37% of the respondents stated that attending the outreach event changed their career goals to a technology-related career.

In contrast, Category IV students were situationally interested about computing before attending the outreach event. However, because of their attendance, they discovered that the computing field was not of interest, ending up being disengaged. This group agrees with the findings by Cleaves (2005, p. 480) regarding the funneling identifier, where students eliminated CS from their choices through negative selection.

Regarding the students in Category III, the outreach changed the students' views of CS but, interestingly, also increased their general academic awareness and interest in university studies generally by resolving a cognitive dissonance. Here, the students gained insight into professional CS, and reinforcing their beliefs about their capabilities regarding their academic careers, even if they actually lost interest in studying CS. However, Cleaves (2005, p. 481) claimed that in science, in general, a discourse of increasing antipathy toward science in secondary school is because of the lack of practical work in science classes (Kelly, 1986; Woolnough, 1996; George, 2000). These claims are in line with the existing literature about the experiences of students with science, which speaks of *personal irrelevance* or *perceived difficulty* (Osborne and Collins, 2001; Lyons, 2006). Furthermore, Lyons (2006, p. 603) noted that science subjects are perceived as relatively difficult among students and that this perceived difficulty can have a variety of contexts and interpretations. For instance, he posited that "the key studies demonstrated that [. . .] more often, however, difficulty of school science came from frustration associated with passive learning, memorization, or the *irrelevance of the content, rather than from any intellectual challenge*" (emphasis added).

We note that high school students' preconceptions regarding CS can often be described by views on meticulous tasks requiring a large amount of memorization (Lakanen and Isomöttönen, 2015). For example, in the current study, Category III students showed the presupposition of the irrelevance of CS and skeptical attitudes toward programming, giving impressions about an over-theoretical field or impractical tasks. Based on the outreach event, these images were changed, at least to some degree, even though the students from this particular category did not choose to enter CS careers.

The workshop clearly failed in drawing more female participants, even though there is a growing public attraction in learning to program and solve problems with computing (Saarela and Kärkkäinen, 2017). The current study included only three female participants, which is simply too few to draw definite conclusions when it comes to gender. Although the present study hints at null development of interest for females (none of the female participants' interest was developed positively), it is unknown whether that has anything to do with gender—this aspect needs further research. It is clear, however, that future workshops need to address the gender gap in the workshops' designs. Regardless of gender, it is vital that the computational concepts are linked to the real world and real lives of the learners so that they can feel confident in their programming abilities (Rubio et al., 2015).

8 Limitations

To start with, the first author had a "triple role" throughout the research process: he was a teacher in the summer outreach event, conducted the interviews, and performed the primary analysis. This combination of roles can be seen as both enriching and restricting. During the events, the relationships between the students and teacher became somewhat close because of daily interactions; as a result, a possible communication barrier was lowered. However, because the familiar interviewer also belonged to the faculty, there is a possibility of a social desirability bias that may have caused over-reporting the positive impact or understating the negative impact. Several different interview questions were asked from the interviewee and then analyzed to make the actual long-term impact analysis as objective as possible. Particularly, the interpretation of the impact was not solely based on the impact reported by the students, which would be the most vulnerable to this type of bias.

Second, the research relied on volunteer participation, which may have caused self-selection bias. The response rate was somewhat low, with 21% of the possible population of students being interviewed. It is possible that the students who selected a CS major were more willing to come to the interview to talk about it than a student who decided to choose a different career option. We argue, however, that this kind of a bias did not occur because almost half of the interviewed students (nine students out of 20) did not apply for CS studies. Furthermore, this was a small and unique sample. To be able to make broad generalizations in the quantitative sense, the study would have required a larger sample population and a randomized controlled trial. We suggest this as a future study. However, the findings of the current study provide educators with a baseline understanding of the outreach event's impact phenomenon. Particularly, the application of interest development as a theoretical framework can be an important tool for researchers who are further investigating student interest.

Third, with only 7% of the research participants being girls and with earlier research suggesting that girls might have different outreach experiences than boys (Wang et al., 2015; Rubio et al., 2015), the gender imbalance poses a limitation for the present study.

Fourth, the current study relied on self-reported data. Although researchers often feel confident that self-reported data—whether interviews or surveys—can appropriately assess interest (Renninger and Hidi, 2011, p. 175), there may be potential complications when using self-reports. In this study, we analyzed a homogeneous age group of young adults and performed qualitative analysis based on the transcribed semi-structured interviews over many iterations and a multiple repetitions to produce the final, stable set of pathways.

9 Conclusions

The present study has extended our understanding of how and why outreach impacts the educational choices of students. The goal of these programs was to acquaint young students with computers and computing and to support their educational choices in computing-related studies and careers. We argue that the presented findings about the impact of outreach events have clear implications for educational practice and for future methods of conducting extra-curricular student outreach programs.

First, because a multitude of different outreach programs exist and are starting to attract students into computing, universities and other organizers running these programs should pay attention to how to maintain the student interest. Offering sources for external support helps students experiment with computing-related activities and maintain individual interest in CS. These sources for external support could include, for instance, follow-up courses, computing clubs, or interest groups in social networks. Furthermore, the findings in the present study suggest that if a student lacks self-directed experimentation *before* attending the outreach event, there is a greater need for external support *after* the event to maintain the interest of that student. However, the non-representative gender sample of the present study calls for further research to understand the role that gender plays in interest development.

Second, including the components of *fun* and *creativity* in the outreach activities enables students to become acquainted with personally relevant content. Determining how to accomplish this without sacrificing learning objectives requires careful consideration. In our program, we included game programming as the theme, by which we intended to lower the barriers to programming. Though the current study indicates that the game theme contributes to interest development, it is debatable whether that particular contextualization is a good "one-size-fits-all" solution. If the CS content was delivered using some other medium, would there have been more girls? Would it have affected boys' interest development? Although the game theme clearly unleashes creativity for many novice programmers, it has been suggested by Robertson (2013) that game-making projects might act as a double-edged sword that can be appealing to boys but less appealing to girls.

Third, these results highlight the importance of diverse research methods. Although the present study exploited qualitative methods, there is a need for multimethod or mixed methods studies to enhance the reliability of the results. For instance, a research design combining quantitative methods (such as activity tracking or online surveys) and qualitative methods (such as interviews or observations) would contribute more to investigating the gradual development of student interest. An even longer follow-up study with an in-depth qualitative inquiry would give information about the paths of the participants throughout their university studies.

A Interview plan

1. Background
   (a) Your birthday?
   (b) How much and for what purposes have you used a computer in your childhood / youth?
   (c) Any programming or other CS-related experiences?
   (d) Any family background related to CS/programming?
2. Experiences during the event
   (a) Describe what you did during the workshop (exercises, final project, etc.).
   (b) What was the experience like? What kind of memories does it bring back?
   (c) Why did you participate in the course? Try to analyze the different factors affecting your participation.
3. Computer science or programming-related activities after the course
   (a) What CS/programming-related activities have you done since the course?
   (b) Have you gone to other CS/programming-related courses or taken classes in your school?

4. Further studies
   (a) What are your study options for your major? To what (majors, universities) have you applied, if any?
   (b) What were the main reasons for selecting those majors/universities?
5. Impact of the outreach
   (a) What is your opinion of the impact of the outreach workshop on your study options? Try to analyze different scenarios, for example, if you applied to CS, would you have applied if you did *not* participate in the outreach?
   (b) What other impact did the workshop have on your educational choices?

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