# Computer Science Attitude as a Descriptor to Understand Inclusion in Non-Conventional Learning Experiences

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Abstract: Non-conventional learning experiences (e.g., hackathons and coding camps) are increasingly popular to broaden participation in computing. It is relevant to analyze the profile of participants of non-conventional learning experiences to outline better whether they efficiently attract profiles that can enrich future professional profiles in Computer Science (CS) with an inclusive and diverse approach. Picking up from that need, this paper attempts to shed light and better understand the original attitudes toward CS that participants display upon joining an informal CS-relevant educational activity. To this end, we analyze, as a compelling case, the participants' attitudes of two coding camps carried out recently. This analysis permits us to discuss what type of students are attracted by these events, provide a more detailed analysis of the participants' profiles, and better understand whether informal educational events effectively thrive diversity in science. The compelling case presented in this paper promotes discussion and raises questions for future research.

## 1 INTRODUCTION

Attracting curiosity and prospective career development on STEM topics (in particular, Computer Science) has been a genuine concern that, in recent times, has gained major attention from education, governmental, and industrial sectors. The growing need for well-trained professionals to sustain the demands of the sector and the lack of diversity in computing (including gender, racial minorities, people with disabilities, and other dimensions of diversity (Rankin and Thomas, 2020)) motivate the wide variety of outreach activities that attempt to broaden participation in computing (DeWitt et al., 2017; Liebenberg et al., 2015) and increase its popularity (Decker et al., 2015; Champagne, J., 2016). In particular, non-conventional learning experiences (i.e., experiences that do not necessarily issue a diploma, degree, or record) provide curricular flexibility, appropriate staff capacity, infrastructure access, and access to effective programs. Examples are *camps*, *hackathons*, and, in general, "short-time collaborative innovation activity focusing on some use of computer skills" (Porras et al., 2019).

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Getting closer to younger generations and protecting minorities is a job that can trace its origin to the very roots of formal education. The K-12 time span is an ideal period to build excitement with computing (Solyst et al., 2022) since research shows that K-12 learners develop life aspirations that eventually are translated to career choices and selection of majors (Jackson et al., 2011). Thus, the design, implementation, supervision, and follow-up of formal or non-conventional learning experiences in this early phase of education should be taken very seriously, as they may lay foundations or create seed effects toward selecting a relevant major.

The real impact of non-conventional learning experiences on very young students can be understood only with time. Analyzing, in the long, run the career choices that participants eventually make is of great relevance to research and understand better the growing offer of non-conventional learning experiences, as well as their impact on the attitudes and perspectives that participants display. Moreover, it is of great relevance to analyze the profiles of participants taking part in these experiences to outline more precisely whether these learning experiences efficiently attract diverse profiles that can enrich future professional profiles in Computer Science (CS) with an inclusive approach.



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In this paper, we present the experience of a compelling case by discussing the insight gained running a coding camp targeted at high school students to indicate how it identifies and promotes questions for future research to answer. The coding camp has been offered for the last ten years (including two online editions), and through that experience, several aspects and traits of its execution can be discussed. In particular, we elaborate on the participants' attitudes towards CS before participating in the coding camp. In this way, we lay the basis for discussing what type of students are attracted by non-conventional learning experiences to understand better whether they are effective in thriving diversity in science, in particular, CS and software development.

The rest of the paper is organized as follows: Section 2 provides background and an overview of related work; Section 3 presents the experience of a compelling case; Section 4 reports the results of the analysis performed during the considered case; Section 5 discusses the presented case and Section 6 raises questions for future research to answer.

## 2 STATE OF THE ART

Inclusiveness is considered a crucial characteristic for experiences that, through an informal educational environment, make an intent to attract talent to scientific and technological subjects (Warner and Guo, 2017) because participants can improve their skills, feel part of a community, build their network (Chen and Kelly, 2013), and have an impact in communities (Mtsweni and Abdullah, 2015).

Non-conventional learning experiences (such as hackathons and coding camps) commonly attempt to be inclusive and serve as an instrument of science and technology outreach, including specializing in attracting minorities and fostering diversity. While diversity improves, in general, the learning environment (Paloheimo and Stenman, 2006), it is especially beneficial for underrepresented and non-traditional students (Hardin, 2021), who may find technology a tool to grow their capacities, extend a network, and grow personally and professionally toward a career of high impact and added value for themselves and their communities. Nevertheless, research shows that hackathons have had limited participation from underrepresented groups and non-traditional students (Kos, 2018).

Most existing studies focus on logistics guidelines for non-conventional learning experiences (Fronza et al., 2020; Gama, 2019; Nandi and Mandernach, 2016; Lara and Lockwood, 2016; Happonen et al., 2020; Schulte and Knobelsdorf, 2007). The studies focusing on inclusiveness mainly consider registration numbers (Hardin, 2021), while few studies collected data on the experiences the participants had and the barriers they faced. For example, participants consider extra-curricular learning experiences more open and inclusive (Thayer and Ko, 2017). However, stereotypes of *nerdiness* and *intelligence* exist (Thayer and Ko, 2017) as in other computing education contexts (Lewis et al., 2016); moreover, participants need considerable perseverance and confidence (Thayer and Ko, 2017) and educational benefits are unequal between genders (Hardin, 2021).

Regarding gender-related issues, Kovaleva et al. focused on the lack of gender diversity in hackathons: the authors summarized the literature-based solutions and suggested female-inclusive measures to improve gender diversity (Kovaleva et al., 2022). Several factors affect participation and success in computing programs, including background experience (Biggers et al., 2008; Wilson and Shrock, 2001) and sense of belonging and stereotypes (Hardin, 2021; Cheryan et al., 2013; Lewis et al., 2016).

COVID-19 resulted in using technologies and innovative pedagogies to facilitate the transition to an online environment (Siegel et al., 2021). As a result, some research works have explored *remote* non-conventional learning from different angles. For example, researchers analyzed how these events involve less-confident students (so often female, especially in CS) (Davies, Madeleine, 2021) and foster professional skills and collaboration (Steglich et al., 2021; Gama et al., 2021; Affia et al., 2022) while keeping an element of fun (Fronza et al., 2022) and being culturally responsive (Solyst et al., 2022). Other works focus on the effect of hackathons and coding camps on the perception of CS (Lusa Krug et al., 2021; Ma et al., 2022) and self-efficacy in communication (Begel et al., 2021).

However, research reported several issues that need to be solved when running non-conventional events online, including communication issues (Herbsleb and Moitra, 2001), lack of a sense of belonging (Mooney and Becker, 2021), lack of engagement (Powell et al., 2021), fatigue due to prolonged computer use (Yousof et al., 2021), and reproducing the face-to-face dynamics (Fronza et al., 2022). A recent systematic review collected the best practices for organizing online/remote hackathons and code camps (Happonen et al., 2021).

Finally, we noticed that research works fall short of characterizing the type of participants according to their preferences and original approach to science, particularly in a *longitudinal* manner, i.e., by comparing different editions of the same learning experience. This work picks up from that need, attempting to shed light and better understand the original attitudes and approaches that participants have upfront upon joining a non-conventional learning experience that will get them closer to Computer Science. Identifying this open avenue, we frame the goal of this work to analyze the attitude of participants of two recent coding camps. This analysis will permit us to discuss what type of students are attracted by these events and provide a more detailed analysis of the participants' profiles to understand better whether informal educational events effectively thrive diversity in science.

# 3 COMPELLING CASE

Understanding better the attitudes that participants show during learning experiences may help explain the approach learners construct upon career choices in science and technology majors. To elaborate on this crucial open item in literature, we focus the goal of this work on analyzing the participants' attitude toward Computer Science at the beginning of two editions of an online coding camp directed to high school students. In this coding camp, participants learn Software Engineering practices and use didactic tools for software development that expose them for the first time to a software development project, taking particular care in developing high-quality software (Fronza et al., 2022). In particular, participants learn how to build mobile applications with Thunkable (https://thunkable.com), i.e., using a drag-and-drop feature to build user interfaces and a puzzle metaphor to code the functionality.

The coding camp (https://mobiledev.inf.unibz.it) is free of charge and takes place yearly at the Free University of Bozen/Bolzano, Italy. There are no selection criteria or restrictions on the attended high school to create a truly interdisciplinary environment. Registrations are accepted on a first-come, first-served basis.

This paper reports two subsequent editions of the coding camp, hereafter referred to as *CodingCamp1* and *CodingCamp2*, respectively. Both were online editions due to the pandemic emergency (Fronza et al., 2022). In the two editions, we surveyed the participants about their attitudes toward Computer Science, which permitted us to describe a general profile of the participants and use such profile to adjust communication, messages, complexity, and teaching style to the specific needs voiced by the class.

## 3.1 Instructional Strategy

The coding camp consists of twenty hours of activity over five days, divided into five sessions:

- Session 1 (4 hours): foundations of logical thinking, structured sequencing, and data abstraction;
- Sessions 2-4 (12 hours in total): iterative development of mobile apps;
- Session 5 (4 hours): completion and presentation.

Each element of the strategy (Table 1) fosters eXtreme Programming (XP) practices (Fronza et al., 2022). Games allow participants to release energy before focusing again on the online session to help reduce fatigue due to prolonged computer use (Yousof et al., 2021). After each game, 15 minutes are reserved for reflections on the takeaway message. Thus, each game requires around 20-30 minutes.

## 3.2 Participants

The coding camp targets high school students (aged 15-19) with diversified disciplinary backgrounds. As a common characteristic, participants have little or no previous software development knowledge.

The communication strategy to reach potential participants was the same for both editions. All schools in the area received communication via email; the coding camp was also promoted through pre-event press coverage, which included newspapers (including online versions) and major social media. *CodingCamp1* and *CodingCamp2* were the ninth and tenth editions of the coding camp; thus, the event has achieved a certain relevance and can rely on word of mouth among students, families, and teachers.

## 3.3 Computer Science Attitude

The literature review presented by (Washington et al., 2016) identified several computing and engineering-related surveys that measure students' attitudes toward and interest in CS and engineering. Among the surveys that measure attitudes toward Computer Science, the one introduced by Hoegh and Moskal (Hoegh and Moskal, 2009) was proven both reliable and valid; moreover, the tool targets first-year majors and non-majors, which can be considered close enough to our target audience (i.e., students in the second part of high school). Finally, it has been successfully used as a basis for creating other tools, such as the one measuring Computer Science Attitude and Identity (Washington et al., 2016). Based on these considerations, we derived the survey we used in this paper from (Hoegh and Moskal, 2009) by identifying

Table 1: Elements of the instructional strategy (adapted from (Fronza et al., 2022)).

| Element | Session | Length (min.) | XP Practice | Description |
|---|---|---|---|---|
| Manipulatable examples | 1-5 | – | User stories | Manipulatable examples (Burnett and Myers, 2014) allow participants to explore ideas from the perspective of learning by doing, i.e., by creating new configurations and designs by tailoring software components in their software environments. |
| Focus on problem-solving | 1-5 | – | Small releases, testing | The coding camp supports an opportunistic and incremental (Burnett and Myers, 2014) working style by focusing on problem-solving rather than on SE lifecycle. |
| Alert without imposing | 1-5 | – | Refactoring, testing | We alert participants to dependability problems and assist them with their explorations into those problems to whatever extent they choose to pursue such explorations. |
| We are here to help | 1-5 | – | Small releases, teamwork, on-site customer (i.e., one of the facilitators) | Participants ask for support (using the dedicated button in Zoom) by first describing the attempted solutions. Student tutors visit the assigned breakout rooms regularly (Fronza et al., 2021). |
| Block-Based Programming | 2-5 | – | Continuous integration, refactoring, testing | Thunkable (https://thunkable.com) fosters problem-driven learning and XP practices (Corral et al., 2021; Fronza et al., 2022); it builds apps both for iOS and Android and an emulator on PC is available. |
| Teamwork | 1-5 | – | Collective ownership, pair programming, metaphor and coding standard | Facilitators form teams (Oakley et al., 2004) of three students from different schools; mixed teams include two females (Gammie and Matson, 2007). Teams choose the logo/name. They can collaborate on the same code or develop software parts individually. When not in plenary, teams work in Zoom breakout rooms. |
| Game: Paper tower | 2 | 18 | Prototyping and iterating, quick collaboration, simple design, teamwork | Building the tallest freestanding tower using 20 A4 paper sheets. Takeaway messages: prototyping/iterating, collaborating, the value of cross-functional teams. |
| Game: Color wheel | 3 | 15 | Simple design, teamwork, user stories | Creating a color wheel using the highest number of colors and objects. The takeaway message is to work together toward a solution by identifying small steps. |
| Game: Thirty items | 4 | 15 | Prototyping/iterating, quick collaboration, teamwork | Finding 30 items with given characteristics. Takeaway message: the importance of understanding ambiguous requirements (e.g., is an object valid for more than one category?) and team self-organization. |
| Game: Boosting attention | 3-4 | 10 | Teamwork, simple design | *Who likes what?* Participants mark their preferred hobby/activity on a shared bingo-like screen. *Gimme five*. Participants high-five the persons right next to them on the screen. |

the following three constructs as a focus for our survey:

- *Confidence Construct (C)*: students' confidence in their ability to learn Computer Science skills;
- *Interest Construct (I)*: students' interests in Computer Science;
- *Professional Construct (P)*: students' beliefs about professionals in Computer Science.

Table 2 shows the questions from the original tool (Hoegh and Moskal, 2009) we used in this work. A total of 22 randomly-ordered questions were included in the survey, which was anonymous and did not collect demographic information. A four-point Likert scale was used to ensure participants chose a positive or negative response to each question.

Table 2: Constructs and survey questions (derived from (Hoegh and Moskal, 2009)).

| | |
|---|---|
| Confidence construct | |
| C1 | I am comfortable with learning computing concepts. |
| C2 | I have little self-confidence when it comes to computing courses. |
| C3 | I do not think that I can learn to understand computing concepts. |
| C4 | I can learn to understand computing concepts. |
| C5 | I can achieve good grades (C or better) in computing courses. |
| C6 | I am confident that I can solve problems by using computer applications. |
| C7 | I am not comfortable with learning computing concepts. |
| C8 | I doubt that I can solve problems by using computer applications. |
| Interest construct | |
| I1 | I would not take additional computer science courses if I were given the opportunity. |
| I2 | I think computer science is boring. |
| I3 | I hope that my future career will require the use of computer science concepts. |
| I4 | The challenge of solving problems using computer science does not appeal to me. |
| I5 | I like to use computer science to solve problems. |
| I6 | I do not like using computer science to solve problems. |
| I7 | The challenge of solving problems using computer science appeals to me. |
| I8 | I hope that I can find a career that does not require the use of computer science concepts. |
| I9 | I think computer science is interesting. |
| I10 | I would voluntarily take additional computer science courses if I were given the opportunity. |
| Professional construct | |
| P1 | A student who performs well in computer science will probably not have a life outside of computers. |
| P2 | A student who performs well in computer science is likely to have a life outside of computers. |
| P3 | Students who are skilled at computer science are less popular than other students. |
| P4 | Students who are skilled at computer science are just as popular as other students. |

## 4 RESULTS

Table 3 shows the number of participants and survey respondents with respect to the total number of participants in the two editions. In *CodingCamp2*, we improved the communication strategy related to the survey, i.e., we explained how the survey would be helpful for us to shape the proposed activities. This may explain the higher response rate in *CodingCamp2*.

Table 3 also shows the representation of gender within the two editions. Marketing and communication strategies have stayed the same, so the authors could not find any explanation for the increase in female participants at *CodingCamp2*.

To analyze survey responses, we assigned each item a numerical score (from 1 to 4), with reverse scoring of negatively worded questions (such as C2 and I1); then, we calculated the CS attitude score for each respondent by summing the values of each question. Thus, the CS attitude score ranges from a minimum of 22 (i.e., the respondent answered "1" to each of the 22 questions) to a maximum of 88 (i.e., the respondent answered "4" to each of the 22 questions). Figure 1 compares the CS attitude of the participants in the two editions of the coding camp under investigation: *CodingCamp1* and *CodingCamp2* have nearly identical medians (i.e., 66 and 67, respectively) and comparable variability.

## 5 DISCUSSION

Table 3 and Figure 1 permit us to build up an insight into the attitude of participants and hence permit us to draw a high-level line about the diversity of profiles attracted by this coding camp:

Table 3: Number of participants and survey respondents with respect to total number of participants.

| | *CodingCamp1* | *CodingCamp2* |
|---|---|---|
| Participants | 80 | 100 |
| Male | 66 (82.5%) | 69 (69.0%) |
| Female | 14 (17.5%) | 31 (31.0%) |
| Respondents | 62 (77.5%) | 95 (95%) |

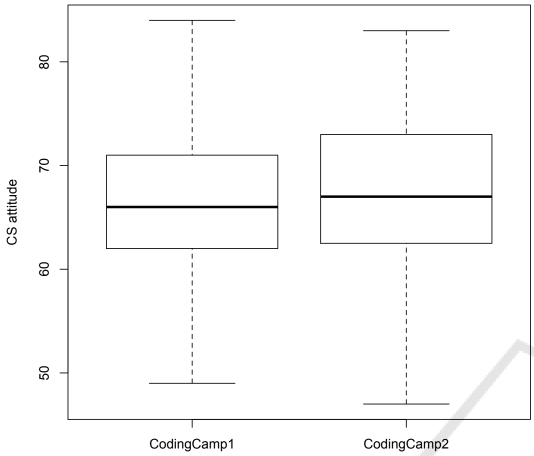


Figure 1: Attitude toward Computer Science of the participants in the two editions of the online coding camp under consideration.

- The gender diversity of attracted participants denotes consistency with the trend in STEM roles in the European Union, which ranges from 22 to 46 percent in 2022[1]. Indeed, the proportion of women participating in the coding camp spans 17 to 31 percent.
- The learning experience of the coding camp attracts students with a Computer Science attitude rather medium. This is an indicator of success in the aspect that being a technical learning experience that attempts to broaden participation in CS, the target audience that effectively gets attracted is not only a population that already has a disposition to programming or science (which would have been observed as a higher CS attitude).
- The fact that the learning experience does not have any pre-requisite effectively attracts a diversity of profiles; however, Figure 1 shows that few students have a low CS attitude. A larger population with a low CS attitude would be a good descriptor of higher success in attracting skeptical or less science-prone profiles.
- It is pertinent to note that the effort to publicize the coding camp is minimal, and the lack of publicity also cuts out a possible bias given by the fact that advertising targets an audience, which in this case is a more science or engineering-prone population, that may skew the data towards higher CS attitudes.
- The two editions of the coding camp yield similar results in terms of CS attitude. Observing this trend through time (acknowledging that the analysis is limited to two editions) sheds light on the aspect that the behavior of the data is not limited to what happened once.
- As the trend of coding camps, hackathons, and similar experiences is relatively recent, the need for longitudinal studies that permit the analysis of trends through time is evident.

## 6 CONCLUSION AND QUESTIONS FOR FUTURE RESEARCH TO ANSWER

In this paper, we show the insight collected by surveying the Computer Science attitude of participants of two editions of a coding camp. This analysis attempts to motivate a discussion about what type of students are attracted by these events and better understand whether non-conventional learning experiences effectively foster diversity in talent attracted to science and technology. Although the study presented in this paper represents an early analysis, we can identify the following questions that motivate future work and deeper discussion on the subject:

- What are the best strategies to attract volume and diversity into STEM subjects? Is a high-ranked attitude a good descriptor of targeted selection, or is a medium-ranked attitude an indicator of diversity, influencing and convincing towards Science?
- What is the difference posed by conducting these learning experiences online or face to face? Is there any influence or impact on gender diversity, attitudes, and other participants' characteristics?
- What are characteristics, beyond gender, that effectively represent diversity in science (for instance, attitude, localization, citizenship, and ethnic background) that should be part of a validated measurement tool?
- The importance of conducting longitudinal studies on the subject. An analysis like the underlying work of this paper represents a picture of a situation observed in a particular context at a specific

[1]https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20220211-2

moment in time. A long-term analysis enables the study of other factors that can impact the attitude and the profile of participants and the evolution of these factors through time.

Non-conventional learning experiences in early education can be a precious resource to broaden participation in CS. The insight collected by this work shows promising views that the audience attracted is not only a population that already has a disposition to CS but also different kinds of profiles, which eventually contributes to fostering diversity in science and technology.

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