Nurturing Hybrid Work Literacy in Upper Secondary Schools: Selecting the Best Hybrid Work Configuration for Coding Camps

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ABSTRACT

This research full paper presents findings on whether different hybrid work configurations during coding camps result in equal quality products.— **Background:** Hybrid work has become the new normal way of working for many professionals, including software developers — some work from home, others from their office, and others from a combination of both. Thus, educating people on hybrid work is crucial. However, there is a lack of evidence and guidance to support educators in organizing hybrid non-conventional learning experiences, such as coding camps and hackathons. **Research question:** *How do different hybrid work configurations impact the final product teams develop during coding camps for upper secondary school students?* **Methodology:** We organized a hybrid coding camp at our university to teach upper secondary school students (aged 15-19) Agile-based Software Engineering practices and enhance their ability to develop high-quality software. The 180 participants (75% M; 25% F) had diverse backgrounds and little or no previous software development experience. The camp lasted 20 hours and integrated components from two baseline camps (onsite and online). We randomly assigned the 60 teams to two groups following different hybrid work configurations and compared the mobile apps they developed. Moreover, we compared all the apps of the hybrid coding camp to those of the baseline camps. **Findings:** The quality of the hybrid, onsite, and online coding is similar. The products of the two hybrid work configurations have similar quality. One configuration places slightly more emphasis on the User Interface, whereas the other concentrates slightly more on programming logic. This work has direct implications for educators, who can use both configurations without affecting the overall quality of the product.

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1 INTRODUCTION

After the decline of the COVID-19 emergency and the many changes it brought to the general functioning of academic, work, and social interactions, the educational and productive environments evolved and embraced permanent changes. The so-called new normal embraced the advantages of remote and hybrid work, driven by technological advancements that delivered the processes and tools required to make this evolution possible (e.g., teleconference, multi-party meetings, collaborative tools) [2, 32]. The possibility of interacting remotely both in jobs and education was not only motivated by the COVID-19 outbreak. However, the events associated with the pandemic crisis accelerated the trend, with remote work becoming a necessity for many organizations worldwide. Among the most notable shifts was the rise of hybrid and remote work arrangements: Employers and educational institutions embraced remote work as an alternative for work interactions, opening the door to possibilities that were difficult otherwise (e.g., hiring a remote worker or attending a lecture with the instructor in another country) [33]. The previously rigid confines of physical spaces have evolved into more flexible models, enabling people to collaborate, innovate, and contribute from virtually anywhere with an internet connection. For example, a study published by Forbes reported that after the pandemic, around 40% of white-collar employees in the USA have the capabilities to work from home [23].

As businesses continue to embrace hybrid and remote work models for their many advantages, K-12 students need to be proficient in navigating this field. Fostering hybrid and remote work literacy aligns with broader educational objectives aimed at preparing students for success in the near future [6]. Beyond traditional academic subjects, today's students should develop a skillset to thrive in a distributed, interconnected, and collaborative world with a good command of the underlying technology. For example, remote work requires proficiency in digital communication tools (teleconference, instant messaging), project management platforms (activity planners, Kanban boards), and virtual collaboration technologies (Google Documents, collaborative software tools), all of which are integral components of contemporary workplaces. Moreover, in addition to knowledge of the enabling technology, embracing hybrid and remote work literacy requires constructing a new mindset [6], as remote work promotes distribution, diversity, and various perspectives, cultures, and communication styles within the workforce. Remote/hybrid work has the potential to overcome geographic and cultural barriers, allowing individuals from diverse backgrounds and locations to work and collaborate to accomplish common goals.

For this reason, all school levels play an instrumental role in fostering this new mindset among students, emphasizing the value of hybrid work, the knowledge of the enabling technology, and the diverse perspectives that pave the road for the construction and functioning of a globally distributed team. By embracing remote/hybrid working skills as an educational topic, instructors can plant the seed for this mindset in students and, with adequate practice, can equip them with the skills to collaborate effectively across geographic and cultural boundaries using the technology tools at hand [6].

In addition to the traditional K-12 curriculum, non-conventional learning experiences, such as coding camps and hackathons, bring together individuals from diverse backgrounds to tackle complex challenges collaboratively within a limited timeframe [29]. Educators can benefit from the experience of other educators when running hybrid initiatives, including pros and cons, best practices, overall lessons learned, and insight gained. However, there is a lack of evidence and guidance to support educators in organizing hybrid versions of these initiatives, which capitalize on the most important aspects of physical and virtual delivery formats [27].

Picking up from that need, in this paper, we describe and discuss the findings of a research work that aims to determine whether different hybrid work configurations during coding camps yield products of equal quality, elaborating on how different hybrid work configurations impact the final product. The findings of this study are relevant for educators who may have to select from various hybrid work configurations based on several factors. For instance, they might need to choose a configuration that allows fewer participants to be physically present in the classroom due to capacity constraints. Therefore, they need to understand whether different options lead to varying outcomes and, if so, to devise strategies to minimize these effects. This study occurred at a hybrid coding camp directed at upper secondary school students at the Free University of Bozen/Bolzano, Italy.

The rest of the paper is organized as follows: Section 3 provides an overview of related work; Section 4 provides background information on the hybrid coding camp design and the assessment framework. Section 5 describes the methodology. Section 6 details the results of this study. Finally, Section 7 concludes the paper.

2 RESEARCH QUESTION

RQ1 *How do different hybrid work configurations impact the final product teams develop during coding camps for upper secondary school students?*

3 RELATED WORK

Whether they are called *coding camps*, *hackathons*, or anything else with the same basic meaning [29], these non-conventional learning experiences bring together individuals from diverse backgrounds to tackle complex challenges collaboratively within a limited timeframe [9]. Coding camps provide a unique platform for experiential learning by immersing participants in a dynamic and hands-on environment. By working with peers with diverse expertise or in virtual/hybrid environments, participants can improve their teamwork and communication skills, which are crucial for success in academia and industry. A study by Porras et al. [29] analyzed 145 scientific papers (51 met all the required characteristics) to verify the usefulness of coding camps and hackathons in academic teaching and beyond. The research results underline the role of hackathon events and coding camps in education, not necessarily replacing traditional education but supporting it.

The COVID-19 pandemic has radically impacted the traditional onsite setup of coding camps, and publications have reported experiences of online formats focusing on specific issues that had to be addressed when moving coding camps online, including communication issues [16], a lack of a sense of belonging [25], a lack of engagement [30], and fatigue due to prolonged computer use [36].

Affia et al. [1] analyzed the integration of a series of online hackathon events. The results show that the online activities supported teamwork and collaboration, maintained student participation and interest in the course, and encouraged learning by doing.

Fronza et al. [9] compared different delivery formats for the same instructional strategy of a coding camp. Results showed that the online format succeeded in emulating the onsite development process, achieving the same quality of the developed product while keeping the same level of fun and engagement. Porras et al. [27] compared three delivery formats (i.e., fully onsite, hybrid, and fully online) to suggest the advantages and disadvantages of each [28]. Each course collects student feedback on the course implementation issues. The parameters for the evaluation were lectures (lessons), innovation activities, team forming, internal team activities, external team activities (e.g., towards teachers), and presentations. The results encourage hybrid approaches and blended learning.

In 2021, a systematic review found only one research work using a hybrid approach for organizing online hackathons and code camps [14]. Later, in 2023, another review [4] identified four main areas in hackathon research: purpose, format, processes, and outcomes. Hybrid activity takes shape in terms of processes. The review identified two research works focusing on the hybrid format. Based on an online event, one provides organizational guidelines to facilitate cooperation and knowledge sharing [5]; the other highlights hybrid entrepreneurial hackathons' potential as pedagogical and general-purpose innovation [19]. Another review published in 2023 [15] classified hackathons based on their focus and design characteristics (i.e., physical, virtual, hybrid) and discussed their advantages and disadvantages. In the considered set of papers, only one focused on physical and virtual participation [31]; another one considered two patterns to enable events where students participate on-site and use technology to create solutions or connect to experts from remote location [20].

According to a study conducted in 2023, students engaging in a hybrid hackathon expressed their preferences for in-person collaboration, but most chose to participate remotely [11]. However, the hybrid mode used in this study did not allow the simultaneous participation of some students remotely and some in person. Finally, in 2024, Levy and Hadar [22] conducted two studies to analyze how students learn and practice hybrid work in educational settings. To this end, they performed two studies to examine students practicing design thinking in hybrid mode and developing their empathy skills. The findings show the advantages of the hybrid delivery format in both cases, thanks to suitable support technology.

Therefore, the available literature lacks evidence and guidance to support educators in organizing hybrid versions of these initiatives.

Table 1: Elements of the hybrid instructional strategy compared to the face-to-face (F2F) and online formats. Strategies marked with an asterisk (∗) have been adapted from the online version. Table adapted from [9].

	Strategy	Session(s)	Length (min.)	XP Practice	F2F	online	Changes in the hybrid setting
	Manipulatable examples	1-5	–	User stories	✓	✓	–
	Focus on problem-solving	1-5	–	Small releases, testing	✓	✓	–
	Alert without imposing	1-5		Refactoring, testing	✓	✓	–
∗	We are here to help	1-5	–	Small releases, teamwork, on-site customer (i.e., one of the facilitators took the role of final customers, provided feedback, and refined requirements)	✓	✓	Two facilitators are in the classroom and *one online*. Teams ask for help from either the online facilitator or the classroom facilitators/tutors, through team members participating remotely or in-person, respectively.
	Block-Based Programming	2-5	–	Continuous integration, refactoring, testing	✓	✓	–
∗	Teamwork	1-5	–	Collective ownership, pair programming, metaphor and coding standard	✓	✓	Each team was randomly assigned to two Groups having different hybrid work configurations (Table 2). When not in a plenary session, members who attend in person or remotely access the team's breakout room to collaborate.
∗	Game: Paper tower	2	18	Prototyping and iterating, quick collaboration, simple design, teamwork	–	✓	Teams can decide to build the tower in the classroom or let online participants build it, or even build multiple towers.
∗	Game: Color wheel	3	15	Simple design, teamwork, user stories	–	✓	Teams can decide to build the wheel in the classroom or let online participants build it, or even build multiple wheels.
	Game: Thirty items	4	15	Prototyping and iterating, quick collaboration, teamwork	–	✓	–
	Game: Boosting attention games	3-4	10	Teamwork, simple design	–	✓	–

4 BACKGROUND INFORMATION

This section describes the instructional strategy, the assessment framework, and the target audience of the hybrid coding camp, where we compared the hybrid work configurations. The coding camp was held at the Free University of Bozen/Bolzano (Italy). It aimed to teach upper secondary school students (aged 15-19) Agile-based Software Engineering practices and enhance their ability to develop high-quality software.

4.1 Coding camp design

We designed a hybrid coding camp by integrating components from the face-to-face [8] and online [9] delivery formats of the same coding camp.

The target audience, comprising upper secondary school students aged 15-19 with little to no software development experience, and the primary goal of introducing agile-based software engineering practices by creating mobile applications using Thunkable, remained unchanged. This section describes our coding camp by highlighting the changes with respect to the baseline instructional strategies [8, 9].

4.1.1 Instructional strategy. Similar to the face-to-face and online delivery formats [8, 9], the hybrid coding camp spanned twenty hours, with one four-hour session each day for five consecutive days focusing on the following topics:

- 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.

Table 1 summarizes the instructional strategy of the hybrid coding camp, which maintains one of the key characteristics of the baseline instructional strategies [8, 9], namely learning-by-playing: specific activities enable participants to apply their reasoning skills towards planning, managing, and empowering.

Each strategy listed in Table 1 fosters eXtreme Programming (XP) practices suitable for K-12 education [10, 18, 24], with participants applying these practices heuristically. Table 1 describes the adjustments to certain strategies (indicated with ∗) to suit the hybrid setting. Similar to the online version of the coding camp, each session included 20-30 minutes for games and subsequent discussions to clarify the meaning of each game. The remaining part of this section details the strategies marked with ∗ in Table 1.

We are here to help. Participants can request the facilitator's support by showing the app's current release and explaining their previously attempted solutions. Peer support is also available, where more experienced students act as tutors in the classroom [7, 21]. Each tutor is assigned three teams and regularly visits them. Tutors can ask for the facilitator's input for more technical questions. *Changes:* There are two facilitators in the classroom and *one online*. Teams can ask for help from either the online facilitator or the classroom facilitators/tutors through team members participating online or onsite, respectively.

Teamwork. We formed teams of three students attending different schools and assigned two females to mixed teams to prevent them from being in the minority [12]. The teams could choose a name and logo, define the app's goal, and collaborate by sharing the editor's screen or developing software parts individually. One week before the coding camp [3], we asked participants to prepare to use their cameras to enhance communication and improve the hybrid learning experience. We encouraged camera usage by proposing show-and-tell games. *Change:* We randomly assigned each team to two Groups corresponding to the different hybrid work configurations depicted in Table 2. In Group A, two members participated remotely on days 2-4, and one member participated remotely on day 5. In Group B, one member participated remotely on days 2-4, and two members participated remotely on day 5. All participants attended the first session in-person to facilitate team bonding, and team members took turns participating remotely and in-person. When not in a plenary session, members who attended in-person or remotely accessed the team's breakout room to collaborate.

Table 2: Hybrid work configurations of the two groups of teams. Each team member is represented by a circle, with ● indicating in-person attendance and ○ indicating remote attendance.

Session	Group A	Group B
1	●●●	●●●
2	●○○	○●●
3	○●○	●○●
4	○○●	●●○
5	●●○	●○○

Paper tower. Teams have 18 minutes to build the tallest free-standing tower using 20 A4 paper sheets that are readily available at each location. *Changes:* Teams could choose their strategy for building the tower. As shown in Figure 1, they could either have participants working together in the classroom or let online participants build the tower (e.g., to have less air movement that could cause the tower to fall) or even build multiple towers.

Figure 1: In the "paper tower" activity, hybrid teams collaborate to achieve the best outcome.

Color wheel. Teams have 15 minutes to create a color wheel using as many colors and objects from their surroundings as possible. *Changes:* Teams could decide to build the wheel in the classroom, let online participants build it, or even build multiple wheels.

Thirty items. Teams have 15 minutes to find 30 items that meet specific criteria (e.g., being shiny or broken) at the locations of all team members.

Boosting attention games. The game *who likes what?* is proposed in the first ten minutes of session 3 to encourage networking. The facilitator presents a bingo-like screen with 9 boxes containing various items such as hobbies, activities, sports, and entertainment. Participants can add a mark on each box if they appreciate the corresponding item. *Gimme five* is proposed in the first ten minutes of session 4 to increase engagement and foster teamwork. The facilitator explains the order in which students' screens are sorted on his/her screen so that the participants can "high-five" the persons sitting next to them in accordance with their screen arrangement.

4.2 Assessment framework

This work aims to determine whether different hybrid work configurations during coding camps yield products of equal quality. To this end, we used the assessment framework employed employed in [9] to compare the onsite and online coding camps that served as the baseline for the instructional strategy of this study. By doing so, we can compare the products created by the different hybrid configurations and ensure that the quality of the hybrid coding camp products is comparable to those of online and onsite camps.

The assessment framework includes the following five groups of metrics to analyze Thunkable projects from a Software Engineering perspective:

- **Size:** Number of Logical Lines Of Code (LLOC).
- **Complexity:** Cyclomatic Complexity (CC), i.e., number of decision points in the code plus one.

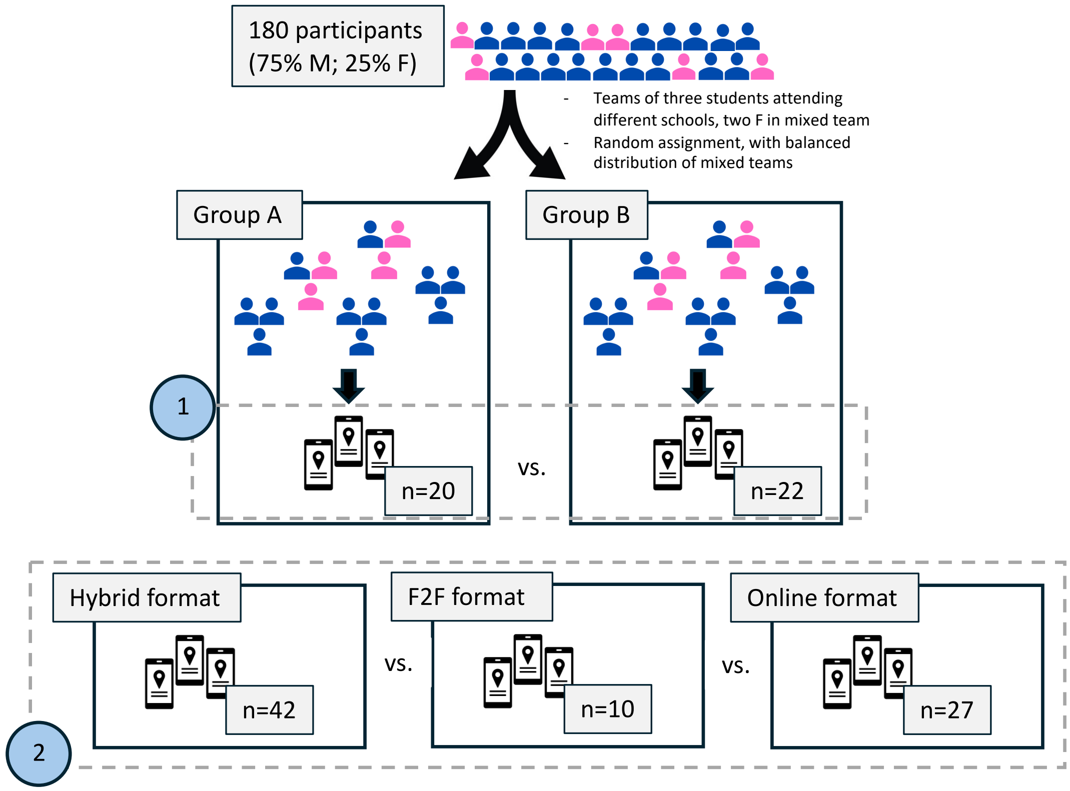

Figure 2: Methodology of this study.

- **Code smells:** Component names [34]; Superfluous stuff [34], duplication [17, 34], long method [17, 34], and meaningful variable names [13].
- **Component metrics:** 1) Number of components by functionality based on the Thunkable palette (i.e., authentication, data, image, layout, screens, sensors, user interface), 2) Total Number of Components (TNC): the sum of all the components by functionality, and 3) Total Number Of Unique Blocks (NOUB) [35]: length of the distinct list of blocks.
- **Computational concepts:** Count of six types of blocks (i.e., conditional, function, list, logic, loop, and variable).

4.3 Participants

Similar to the two baseline strategies [8, 9], our target audience comprises upper secondary school students aged between 15 and 19 years with little or no prior experience with software development. They may come from different schools (from non-vocational to computer science), i.e., they have diversified disciplinary backgrounds.

5 METHODOLOGY

The methodology of this study is presented in Figure 2. The coding camp hosted 180 upper secondary school students, of which 75% were male and 25% were female. The students came from 11 different schools, including computer science, scientific, vocational, and non-vocational schools, offering a group of participants with different backgrounds. All the participants had little or no previous software development experience, even the students from scientific schools who were still in the early stages of learning software development concepts. The coding camp was an extracurricular and optional activity for all participants.

As detailed in Section 4, we divided the 180 participants into teams of three students [26] attending different schools. To ensure that no female student was in the minority [12], we assigned two females to each mixed team. After creating 60 teams, we divided them into two groups - Group A and Group B - with a balanced distribution of mixed teams. Each group followed a different hybrid work configuration (Table 2):

- In **Group A**, all participants were present for the first session in-person to facilitate the socialization processes [27]. Then, two members of each team participated remotely on days 2-4, and one member participated remotely on day 5.
- In **Group B**, all participants were present for the first session in-person to facilitate the socialization processes [27]. Then, one member of each team participated remotely on days 2-4, and two members participated remotely on day 5.

In both groups, team members alternated to allow everyone to participate remotely and in person.

After completing the hybrid coding camp, we conducted a comparison (represented by the number "1" in Figure 2) between the mobile apps developed by the teams in Group A (n=20) and Group

B (n=22). The comparison was based on the metrics outlined in the assessment framework provided in Section 4.

Additionally, as represented by the number "2" in Figure 2, we compared all the apps of the hybrid coding camp (n=42 – we were unable to collect all team products due to health issues or incorrect sharing of Thunkable link) with those developed during the online (n=27) and face-to-face camps (n=10) to ensure that the quality of the hybrid coding camp products is comparable to that of the other delivery formats.

6 FINDINGS

This section describes the outcome of comparing the mobile apps created by teams in two different hybrid configurations at the hybrid coding camp. Additionally, we compare the products of the hybrid coding camp with those developed at the baseline face-to-face and online delivery formats. This comparison allows us to check that the quality of the hybrid coding camp products is comparable to those of online and face-to-face camps.

Figure 3 compares the *size and complexity* of the products developed in the three delivery formats of the coding camp: face-to-face (10 projects in total [8]), online (27 projects [9]), and hybrid (42 projects in total). The sample sizes vary, and the face-to-face coding camp has a limited sample size. However, the comparison suggests that the capacity of the teams in terms of the size and complexity of the products is comparable in the three delivery formats and does not decay because of the variation in the course delivery channel.

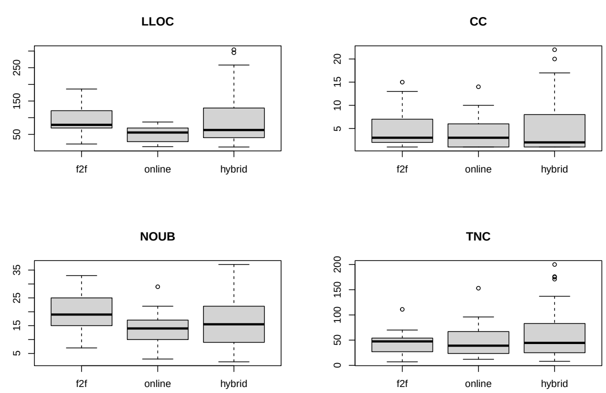

Figure 3: Size and complexity: face-to-face (n=10) vs. online (n=27) vs. hybrid coding camp (n=42).

Figure 4 compares the size and complexity of the teams' products in the two different work configurations (i.e., groups A and B). The products do not show major differences in terms of size and complexity. However, even though we found the difference statistically non-significant, it is worth noticing that, in group B (i.e., two students onsite plus one attending remotely), the developed applications have slightly higher complexity metrics (i.e., CC and NOUB). On the other hand, TNC is higher in configuration A, which suggests that this configuration may be more focused on designing and implementing the user interface.

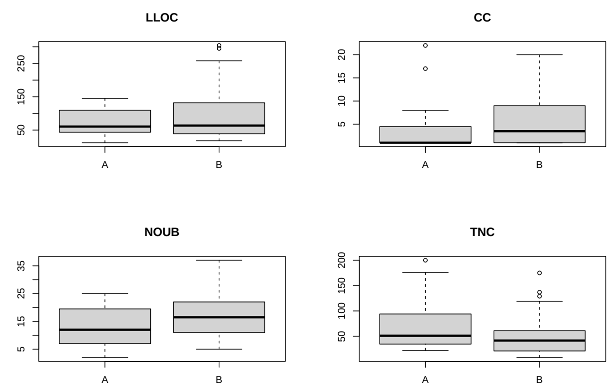

Figure 4: Size and complexity: comparison of the two hybrid work configurations.

Figure 5 shows the presence of *components* (based on the Thunkable palette) in the products of the three delivery formats of the coding camp. In the face-to-face coding camp, only three component types are displayed as they were the only ones in the palettes of App Inventor, used in the face-to-face coding camp, and Thunkable, used in the online and hybrid coding camps. The three formats do not show major variations, which was expected as the portfolio of topics offered remained consistent.

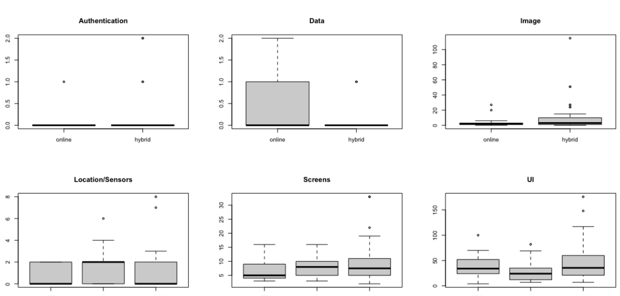

Figure 5: Components per type: face-to-face (n=10) vs. online (n=27) vs. hybrid coding camp (n=42).

The comparison of the two hybrid work configurations (Figure 6) shows a similar trend between the two groups. Group A products have slightly more screens and User Interface components, which may indicate that Group A places slightly more emphasis on the User Interface. However, these differences are not statistically significant.

Figure 7 compares the *computational concepts* of the three delivery formats. The trend offered by all three formats is similar, with the products of the hybrid coding camp having a slightly lower number of function and variable blocks.

The comparison of the two hybrid work configurations (Figure 8) shows that the teams in group B produced apps with a higher

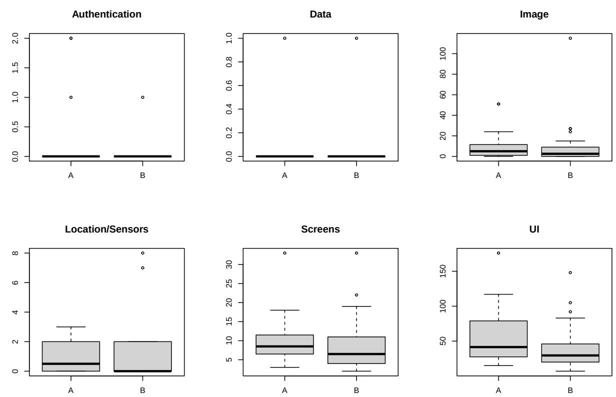

Figure 6: Components per type: comparison of the two hybrid work configurations.

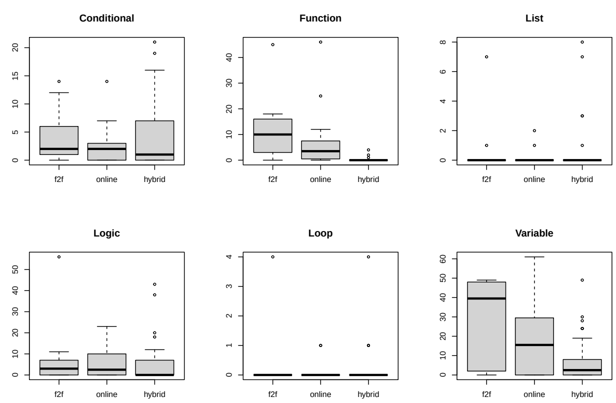

Figure 7: Computational concepts: face-to-face (n=10) vs. online (n=27) vs. hybrid coding camp (n=42).

number of conditional, logic, and variable blocks, which may indicate that Group B concentrated slightly more on programming logic.

Figure 9 compares the *code smells* of the hybrid coding camp products with the two baseline delivery formats, online and face-to-face. The issue of having unnecessary blocks lying around (i.e., superfluous stuff) is more present in the products of the online delivery format, possibly due to the different programming environments used and the varying methods for removing unnecessary blocks [9]. This problem is less severe in the hybrid version and falls between the two extremes.

Duplication is a rather limited problem in the products developed in the online coding camp compared to the face-to-face version, possibly because an increased number of pair programming sessions has been observed, which might have contributed to reducing duplication [9]. In the online coding camp, pair programming sessions were increased by the necessity of sharing the screen to collaborate. In the hybrid version, instead, it was possible to work face-to-face,

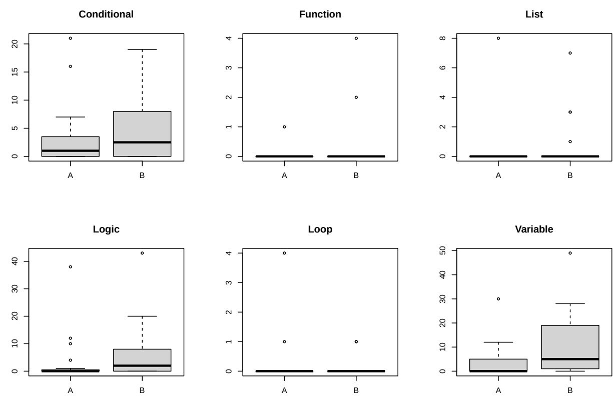

Figure 8: Computational concepts: comparison of the two hybrid work configurations.

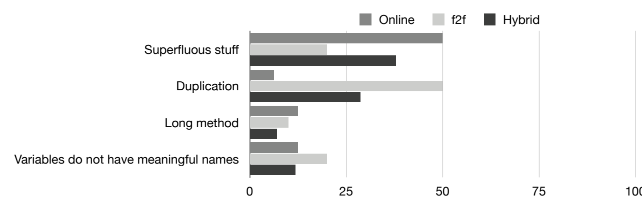

Figure 9: Code smells: face-to-face (n=10) vs. online (n=27) vs. hybrid coding camp (n=42).

using two computers and occasionally comparing code without necessarily focusing on the same code. The other two code smells (i.e., long method and variables with no meaningful names) exhibit a similar trend in all three delivery formats, with hybrid coding camp products approximating the face-to-face edition.

Comparing the code smells of the products in the two hybrid work configurations (Figure 10), we observe that the products in group A do not have long methods and have well-thought-out variable names, while products in group B are more affected by duplication. It is important to note that products in group A are smaller in size (as shown in Figure 4) and contain fewer variables (as shown in Figure 8). This may result in a higher possibility of handling code quality by keeping methods short or changing the initial names of variables. The other two code smells (i.e., duplication and superfluous stuff) exhibit similar trends in the two groups.

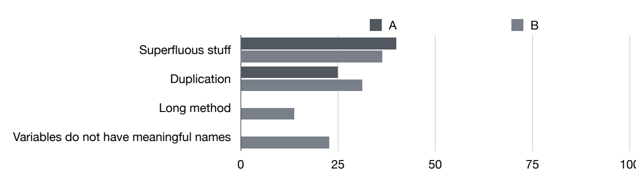

Figure 10: Code smells: comparison of the two hybrid work configurations.

7 CONCLUSION

In this article, we described the findings of a research work that aimed to determine whether different hybrid work configurations during coding camps yield products of equal quality.

To summarize the results, our answer to the research question is as follows: **RQ1** *How do different hybrid work configurations impact the final product teams develop during coding camps for upper secondary school students?* **Answer:** The quality of the products produced by the two configurations is similar. However, there is a slight difference in emphasis between the two groups. Teams in Group A, where only one of the three members attends in person, place slightly more emphasis on the User Interface. On the other hand, teams in Group B, where two of the three members attend in person, concentrate slightly more on the programming logic. In addition, our results indicate similar trends across all three delivery formats (i.e., the hybrid coding camp products and the two baseline camps, one in-person and the other online). Indeed, instructional design, course content, and engagement activities have been planned to capitalize on the most important aspects of physical and virtual delivery formats [27].

Even though replications of this study are needed to obtain more solid conclusions, our findings have direct implications for educational practices as they indicate that the configuration of group A allows the camp to run effectively with less physical space needed: only one-third of the participants are on-site, while the others can attend online. This setup still yields comparable results in terms of product quality compared to the other configuration, which requires a larger physical space to accommodate two-thirds of the participants attending in-person. It is important to note that this study is limited to a specific coding camp and a particular age group (i.e., upper secondary school students aged 15-19). As such, the findings may not be applicable to other educational settings, age groups, or types of camps.

The minor differences between the products of the two configurations allow us to provide educators with suggestions for balancing possible issues in each configuration. For example, as the results show, implementing Group A configuration requires strategies to let teams focus more on the programming logic by decreasing emphasis on the user interface.

The hybrid delivery format emerges as an excellent option for combining the advantages of online and face-to-face formats. Face-to-face experiences offer immediacy and social presence, which various communication and engagement activities extend to the online setting. On top of that, leveraging remote participants in a hybrid setting provides flexibility and autonomy for those working remotely. Future work needs to investigate possible differences in student satisfaction and preferences on hybrid work configurations, considering individual learning styles and backgrounds.

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