Exploring Effects of Online and Face-to-Face Teaching Formats on Students' Interest and Engagement

Kai Marquardt
Department for Informatics
Karlsruhe Institute of Technology (KIT)

Lucia Happe
Department for Interdisciplinary Didactics
Karlsruhe Institute of Technology (KIT)

ABSTRACT

The COVID-19 pandemic has highlighted the need for flexible teaching formats, particularly online education, as an alternative to traditional face-to-face (F2F) education. This study investigates the impact of teaching format (online vs. F2F) on secondary school students' interest and engagement. We conducted an exploratory analysis of survey data from 16 workshops (F2F: 12, online: 4) held between January and December 2022, with 129 participants completing the survey (F2F: 76, online: 53, age: 10-16). All workshops covered the same learning topics, provided by online courses developed to raise interest in computer science (CS). Our findings show that the teaching format had a negligible effect on interest development. Still, students in the F2F setting showed higher engagement levels than those in the online setting. Additionally, an analysis of the effect of age indicates that younger students are more engaged in online settings than their older peers. We also found indications for longer-running programs having a greater effect on personal interest development compared to one-day programs. This paper discusses the results and identifies implications for teaching practice and future research. Overall, the study highlights the need to balance the advantages and limitations of both teaching formats and suggests potential strategies to improve online engagement.

CCS CONCEPTS

• **Applied computing** → **Education**; • **Social and professional topics** → **Gender**.

KEYWORDS

Teaching, online, face-to-face, interdisciplinary curriculum, interest, engagement, e-learning, computer science education, STEM, K-12

ACM Reference Format:
Kai Marquardt and Lucia Happe. 2023. Exploring Effects of Online and Face-to-Face Teaching Formats on Students' Interest and Engagement. In *Proceedings of The 18th WiPSCE Conference on Primary and Secondary Computing Education Research (WiPSCE '23).* ACM, New York, NY, USA, 10 pages. https://doi.org/XXXXXXX.XXXXXXX

WiPSCE '23, September 27 – 29, 2023, Cambridge, England

ACM ISBN XXX-X-XXXX-XXXX-X/XX/XX…$XX.XX
https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

In today's fast-paced world, computer science (CS) has become one of the most sought-after fields of study, with a surge in job opportunities and salaries as technology advances. As a result, universities and colleges worldwide are witnessing an increase in the number of students interested in pursuing degrees in CS. However, this rising interest presents new challenges for educators. How can we ensure students are engaged and motivated to learn in CS courses? How can we adapt our teaching methods to meet the needs of a diverse student population, including those who cannot participate in CS courses in person?

One potential solution is using pre-designed digital courses for effective delivery in various teaching formats. These courses allow students to learn at their own pace while providing opportunities for interaction with peers and instructors through virtual communication tools. But do digital courses lead to higher engagement and interest levels among students? Previous studies have shown that interdisciplinary courses can engage a broader audience of students in CS study [17, 27]. One of the main reasons interdisciplinary courses can be beneficial in motivating diverse students to study CS is that they provide context for the material being taught. When CS is taught in isolation, it can be difficult for students to see the relevance of the material to their lives and interests. However, when incorporated into other fields, it becomes more relatable and meaningful to students [16, 30, 35]. An example of such an initiative is *RockStartIT* [17], which offers various digital interdisciplinary CS courses. However, such digital courses can be used entirely online or as study material in face-to-face (F2F) settings. How do different teaching formats, such as fully online versus F2F instruction, impact student engagement?

This study aims to answer these questions by investigating the effect of teaching formats on students' interest and engagement in CS courses. This paper presents findings based on survey data collected from 16 workshops conducted over one year. We examine the possible implications of different teaching formats (online vs F2F) in secondary education. Our findings will provide valuable insights into the impact of different teaching methods on students' interest and engagement in this increasingly important field.

2 RELATED WORK

Many studies have investigated the challenges and impact of different teaching formats on learning outcomes, competencies, and efficiency in higher education [1, 12, 22]. Still, there is limited research on the effects of these formats on the interest and engagement of secondary school students in computer science (CS). This gap in research is particularly relevant in the current era, where online and hybrid teaching has become a norm for many educational institutions. There is a need for a better understanding of how different

teaching formats can impact students' interest and engagement in CS. In recent years, the rapid development of technology has enabled the growth of online learning, providing students with the flexibility to learn at their own pace and convenience. However, concerns remain about the impact of online learning on student motivation, engagement, and interest [e.g. 2, 3, 11, 37]. This is especially interesting for fields such as CS, where the interested students are already less diverse.

Research on the effects of teaching formats indicates that there is no significant difference between online and face-to-face (F2F) instruction in terms of learning outcome [e.g. 4, 9, 10, 29, 32]. A study by Ebner and Gegenfurtner [9] found that online teaching was an appropriate supplement to F2F instruction, particularly for students who require locational flexibility, but the age was not specified. Another study by Gürsul and Keser [13] did even find higher learning achievements in a math course for online groups compared to the F2F control groups. Similar observations were made by Bi et al. [3] as they found significantly higher interest of online students in an English course than their F2F peers. But less research has been conducted on the impact of teaching formats on student engagement and interest in secondary school CS courses.

Regarding online teaching, concerns have been raised about the monotony of the student environment, the need for efficient content, and the potential for students to feel lonely [20, 36]. König et al. [24] emphasized the importance of blended learning, where online teaching supplements traditional F2F instruction, as online teaching can not replace the socialization aspects of the school environment. Particularly they pointed out the relevance of digital competencies of the teachers.

Research also suggests that there are no observable differences in the role of teachers in F2F and online teaching formats. In both formats, teachers assume similar roles, such as guiding and mentoring students, facilitating interactions, and providing feedback [5]. However, effective communication between tutors and students is crucial in online settings [33]. For example, Jaggars [18] found that college students would prefer online courses for more "easy" content, but F2F courses for more "difficult" content, because of "one-on-one help" [18, p. 12].

Collaboration in groups is another crucial element in the learning process, particularly in online learning environments [19]. Collaborative learning allows students to reflect on their learning experiences with peers, which can enhance their understanding and retention of the material. Adventure learning, a hybrid online authentic learning experience, has been proposed to increase student motivation and engagement in online learning environments [7, 8]. Adventure learning involves creating collaborative online spaces where traditional hierarchical classroom roles are blurred, and students' roles shift to become reflective practitioners, fostering novel ways of learning and teaching. This approach is implemented using authentic and engaging online content in a hybrid setting, potentially increasing learners' motivation [8]. Shantia [23] emphasized the importance of authentic learning, feedback, level of choice, and social networks in online settings.

When putting the literature body into the context of the current study, it is essential to consider that most studies focus on teachers' perspectives or higher education [28]. This highlights the need for studies like ours, where we want to shed light on how students in secondary school experience different teaching formats in CS classes in terms of interest and engagement.

3 RESEARCH METHOD

In this section, we outline how the workshops were structured, who participated in the study, how data was collected, and what analysis technique was chosen to approach our goal of investigating the effect of different teaching formats (online vs. F2F).

3.1 Research Question

Our leading research question was:

> **RQ:** How do the interest and engagement of students studying CS-related topics in online courses differ when support is provided face-to-face (F2F) versus online?

To answer this question, we also examined whether the teaching format affected interest development and how the online course engaged the students. For validation purposes, we also considered the gender ratio and duration of workshops, as it varied among different workshops. Finally, we investigated whether there was a difference in experiences between online participants and those who received support remotely online in a F2F class.

3.2 Workshops and Course Content

We collected data from 16 workshops between January and December 2022. All workshops were conducted by scientific staff familiar with the project and were in German. The workshops were conducted either in a F2F setting in a computer lab at the KIT or an online environment via conference tools such as Zoom or BigBlueButton. The duration of the workshops varied from one-day workshops lasting about two, three, or five hours, and multi-day workshops, repeated weekly as a two-hour workshop for six weeks. Otherwise, conditions in both workshop settings were kept as identical as possible. The scientific staff acted in both settings as supporting tutors to answer students' questions and engage in discussions. In online settings, the scientific team was available during the whole duration of the workshop, with micro and camera turned on. There was also an active effort to make students feel comfortable asking questions via voice or (private) chat and starting interactions. One of the scientific staff was present in every workshop.

In both settings, participants enrolled in online courses of the *RockStartIT - Save the Bees Expeditions* (freely available online: rockstartit.com), which cover different topics from CS in the context of bee mortality. In a total of six online courses (called *expeditions*), forming the *Save the Bees Expeditions*, students could explore the utility and joy of CS to solve big problems such as bee mortality. The six expeditions of the *Save the Bees* sequence cover CS topics from web development, data science, artificial intelligence (AI), and project management. Each expedition starts with a problem statement under the grand goal of saving the bees. Early in the process, students will experience technology as a helpful and fun tool to achieve such big goals. This way, CS is no longer introduced as an end in itself, but with a broader purpose, and in this particular case, with a personal, relevant touch through the higher-ordered goal of saving the bees. A variety of interactive elements (e.g. H5P

elements, the interactive database DB Fiddle, the Teachable Machine by Google, ...) guide the students on their journey, providing different levels of detail and difficulty to ensure active participation. Student groups in the six-week program usually went through all expeditions, including the *Web-*, two *Data Science-* and the *AI-Expedition* (except for the *Team Expedition*, which is the last and final of the *Save the Bees Expeditions*). In the one-day workshops, students usually completed two or three expeditions.

Those online courses were the main activity for the students during the workshop. This allowed us to have very similar conditions for both teaching formats. The workshop procedure was the same, independent of the setting or workshop duration. The workshop started with a short introduction round. Afterward, the students worked on the expeditions on their own. They were also encouraged to collaborate with other workshop students, to ask questions, and/or to start discussion.

3.3 Data Collection

To capture changes throughout the workshops and the potential impact of the teaching format of courses on students' interest and experience in CS, we used a pre-test-post-test study design [6]. We asked the participants to complete a survey at the beginning and end of the workshop. In the case of the six-week program, this was done only once at the beginning of the first workshop session and once at the end of the last workshop session.

We used a previous study questionnaire to assess the interest and engagement of students in our workshops [27]. The person-object theory of interest (POI) [25] builds the theoretical framework of the questionnaire. Based on the POI, we measure engagement in three dimensions: *interest*, *positive feelings*, and *future intents*. In this context, *interest* can be understood as the level of personal relevance and appreciation a person expresses towards the learning context. *Positive feelings* are expressed through fun and enjoyment towards the learning context, and *future intents* is defined by a raised drive and willingness to engage with the learning context again. The original questionnaire consists of 28 items, most scaled on a Likert scale from (1)-*"Strongly disagree"* to (5)-*"Strongly agree"*. Eighteen items were repeated identically in the pre-test and the post-test. For the current study, we were especially interested in the engagement of students directly related to activities in the course, which is measured by ten post-only items (see Tab. 1). The value for one dimension of engagement was then calculated for responses to multiple items related to the specific dimension.

Additionally, sociodemographic data such as gender (choices: *"female"*, *"male"*, *"not listed"*), age, and grade level were collected.

3.4 Participants

Over 160 students participated in the workshops. The final dataset included responses from 130 students (79 female, 50 male, and one non-binary) from German secondary schools. The mean age is 13.14, ranging from 10 to 16 years (see Fig. 1). Participation in the survey was voluntary. All participants were informed about their rights to participate in the survey study and confirmed a written declaration of consent.

Table 1: Post-only items of the survey

#1	It was fun to engage with the topics covered in the course	(PF)
#2	The course has aroused my curiosity	(PF)
#3	I would love to do a course like this again	(FI)
#4	During the course I had an aha moment	(FI)
#5	I would recommend such a course to others	(IN)
#6	During the course time flew by	(PF)
#7	I have/will talk to friends, parents, or siblings about things I experienced in the course	(FI)
#8	School would be more fun if we would cover things like this more often	(PF)
#9	My interest in computer science has increased since I took the course	
#10	I felt like I had learned something for myself	(IN)

PF - Positive Feelings, IN - Interest, FI - Future Intents

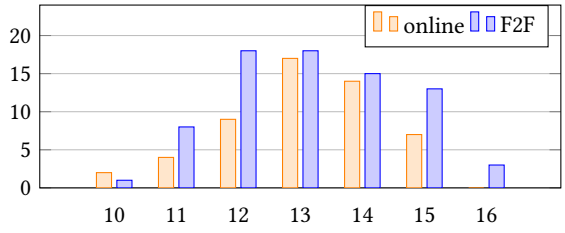

Figure 1: Age distribution

3.5 Data Analysis

We analyzed the data using descriptive statistics, including means (M) and standard deviations (SD), to examine the differences between the groups. First, we performed an exploratory analysis with descriptive statistics (means and effect sizes) to estimate the potential impact of different teaching formats on different groups [14]. Then, we used paired t-test and independent t-test analyses with 95% confidence intervals (CIs) and Cohen's d for effect sizes to compare pre-test and post-test results (within-subject analysis) as well as differences between different groups (between-subject analysis) [15, 26].

4 FINDINGS

We present our findings in five parts. First, we examine the general interest development in CS among students who received support solely through an online format, compared to those in a face-to-face classroom setting. Second, we delve deeper into how students experienced the course itself, exploring any differences in engagement and overall experience between the two teaching formats. Third, we will look closer at how online and F2F teaching formats are perceived differentiated by age. Fourth, we will examine the special case of a girls-only class that took part in the workshop in F2F as a study group without a tutor present and received support only virtually (having F2F access to peers but only online to tutor), and we will compare this to other online classes. Finally, we investigate the potential effect of the duration of the workshop on the

Table 2: Pre-test and post-test results for the three dimensions of engagement by teaching format (online vs. F2F)

		Positive Feelings			Interest			Future Intents		
		M	N	SD	M	N	SD	M	N	SD
Online	Pre	4.20	52	0.71	4.11	52	0.67	3.80	53	0.89
	Post	4.22	52	0.84	4.16	52	0.77	3.85	51	0.89
	Dif	0.02	-	-	0.05	-	-	0.05	-	-
F2F	Pre	4.28	71	0.75	4.03	74	0.64	3.70	75	0.88
	Post	4.38	73	0.56	4.17	74	0.57	3.85	74	0.77
	Dif	0.10	-	-	0.14	-	-	0.15	-	-

M - mean, SD - standard deviation, Dif - difference of pre and post means

course experience, comparing one-day to multi-day workshops. By considering these five aspects, we aim to provide a comprehensive analysis of the impact of teaching format on students' interest and engagement in CS courses.

4.1 The Effect of the Teaching Format on Interest Development

In this section, we aimed to investigate whether the teaching format impacted the interest development of the students. Tab. 2 shows results from pre-survey and post-survey, indicating that the differences in interest development between the teaching formats were minimal. The independent t-test analysis between F2F and online teaching formats indicates, that the changes in positive feelings (d=0.11, p=.541), interest (d=0.20, p=.290), and future intents (d=0.11, p=.560) were slightly higher for the F2F classes but not statistically significant. Still, there was a statistically significant difference in the post-only item *"My interest in computer science has increased since I took the course"*. Students in F2F formats reported significantly higher values (M=4.16) than their peers in online formats (M=3.63), t(86.14)=3.00, d=0.57, p=.002 (see Fig. 2), suggesting that the F2F format may have a more significant impact on increasing students' interest in CS compared to an online format.

Observation 1: While the teaching format may not strongly influence overall interest development, the data indicates a higher impact of F2F teaching formats on potential interest development.

4.2 The Effect of the Teaching Format on Students' Course Experiences

The study's results indicate that the teaching format had a measurable effect on students' course experiences, with the most significant difference observed in the future intents dimension. Figure 3a illustrates the three dimensions of engagement related to the experiences in the course. There was a small to medium but not significant effect of the teaching format on positive feelings associated with the course (d=0.34, p=.062) and on interest related to the course (d=0.32, p=.097) (see Tab. 3). However, the most notable effect was observed in the future intents dimension, with a significant medium impact of the teaching format t(85.43)=2.11, d=0.40, p=.038. The students from F2F settings exhibited a significantly

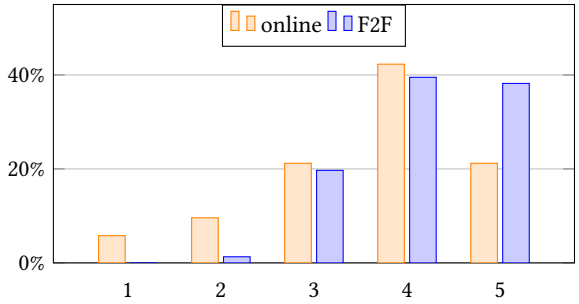

Figure 2: Frequency distribution for the survey item *"My interest in computer science has increased since I took the course"*

higher willingness to engage with the course topics again. This was particularly evident in their responses to the item *"I have/will talk to friends, parents, or siblings about things I experienced in the course"*, where students in face-to-face formats rated on average significantly higher (M=4.24) than students from online classes (M=3.89) t(126)=2.00, d=0.36, p=.047 (see Fig. 4). Results on the item *"School would be more fun if we would cover things like this more often"* also indicate that students in face-to-face formats enjoyed the course more (M=4.49) than students in online formats (M=4.13) t(126)=2.25, d=0.40, p=.026 (see Fig. 5).

Furthermore, the evaluation of the tutors by the students is presented in Figure 6, where a German grading scale ranging from 1 (best) to 6 (worst) was used. The statistical analysis revealed a significant medium effect of the teaching format on the tutor rating t(52.55)=-2.20, d=-0.49, p=.032. Specifically, students who attended F2F classes rated their tutors significantly better (M=1.09) than those who attended online classes (M=1.38), indicating that the teaching format may have influenced their perception of the tutor's performance. The findings are not negligible. As indicated by Cohen's d, the effect size is considered medium (d=-0.49), indicating a meaningful difference in the quality of teaching perceived by students in the two formats. This could potentially have important implications for the evaluation and improvement of online teaching practices and for decisions regarding the use of different teaching formats in the future.

Observation 2: The most prominent difference was related to future intents in activities of the course with a medium effect of the teaching format. Students from F2F settings show a significantly higher willingness to engage with topics of the course again than their peers in online settings.

4.3 The Effect of Teaching Format Taking Students' Age into Account

For the age-related analysis, we decided to divide our sample into two groups according to the German school system separation of lower and upper secondary education: grades 5-7 (f: 41, m: 22, age: 10-13, mean age: 12.03) and grades 8-10 (f: 38, m: 27, age: 13-16, mean age: 14.18).

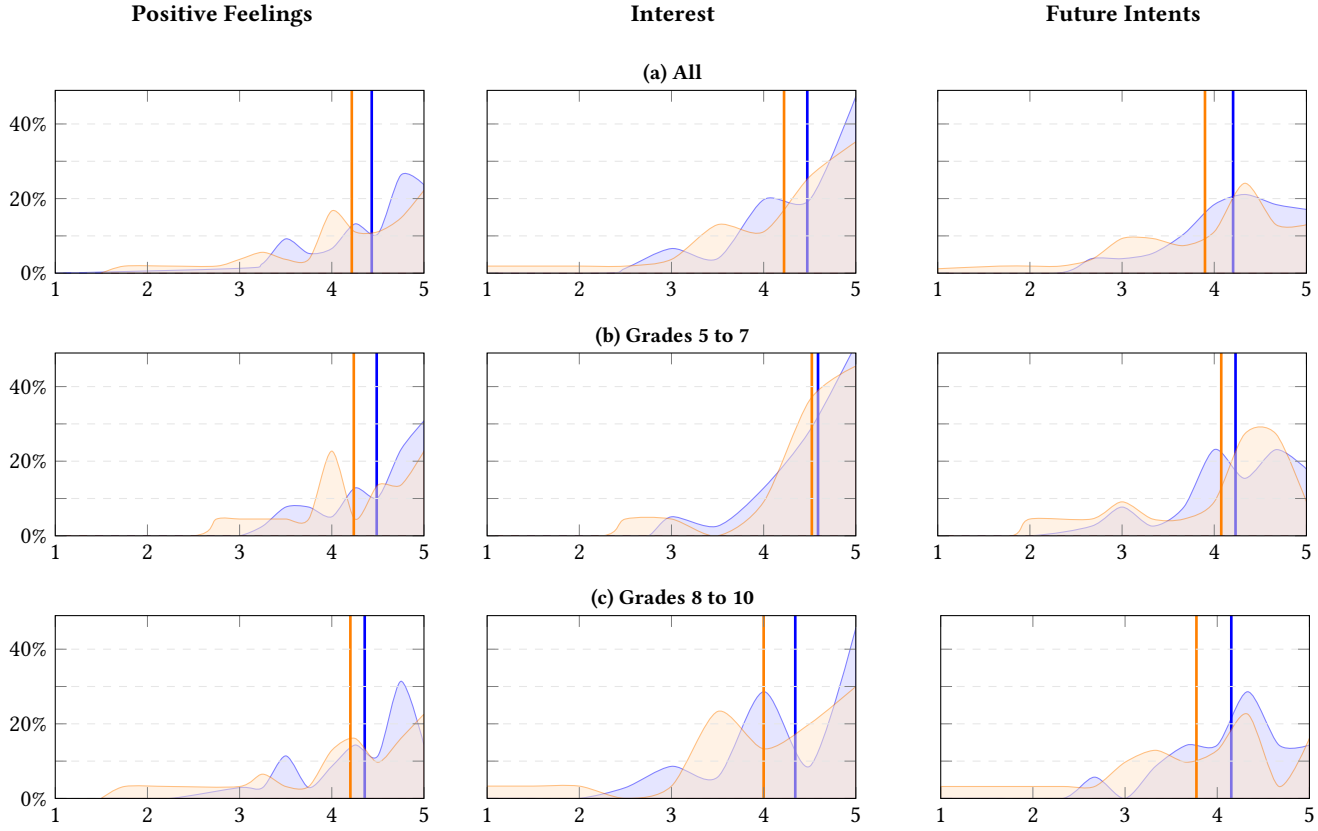

Figure 3: Distribution of students' positive feelings (1st col.), interest (2nd col.), and future intents (3rd col.) related to activities of the course by teaching format (F2F - blue, online - orange), and by groups (a, b, c). Vertical lines indicate means respectively.

Table 3: Independent t-test for F2F (1) to online (2) results for all students and grouped by grade level

		N_1	N_2	M_1	M_2	SD_1	SD_2	Cohen's d	95% CI Lower	95% CI Upper	p
all	Positive Feelings	75	53	4.43	4.22	0.54	0.76	0.40[1]	0.05	0.76	.062
	Interest	75	52	4.47	4.22	0.65	0.94	0.32[1]	−0.03	0.68	.097
	Future Intents	75	53	4.20	3.90	0.62	0.91	0.40*	0.05	0.76	.038
grades 5-7	Positive Feelings	39	22	4.49	4.24	0.53	0.68	0.42[1]	−0.11	0.95	.059
	Interest	39	22	4.59	4.52	0.55	0.66	0.11	−0.41	0.64	.336
	Future Intents	39	22	4.23	4.08	0.63	0.80	0.22	−0.30	0.75	.204
grade 8-10	Positive Feelings	35	31	4.36	4.20	0.56	0.82	0.22	−0.26	0.71	.184
	Interest	35	30	4.34	4.00	0.74	1.06	0.38[1]	−0.11	0.87	.065
	Future Intents	35	31	4.15	3.77	0.62	0.98	0.47*	−0.02	0.96	.035

M - mean, SD - standard derivation, *p<.05, [1]p<.1

For younger students (grades 5-7), Fig. 3b and Tab. 3 indicate a tendency for higher engagement of the students in F2F teaching formats compared to their peers in online teaching formats. Still, the differences are relatively small and were not significant. Only for positive feelings, there was a medium effect of the teaching format (d=0.42, p=.059), indicating that young students enjoy learning in F2F teaching formats over learning in online teaching formats. Responses on the item *"School would be more fun if we would cover things like this more often"* do highlight the difference t(59)=1.91, d=0.51, p=.031 (see Fig. 7).

Regarding older students (grades 8-10), they were significantly more engaged by F2F settings in terms of future intents than their

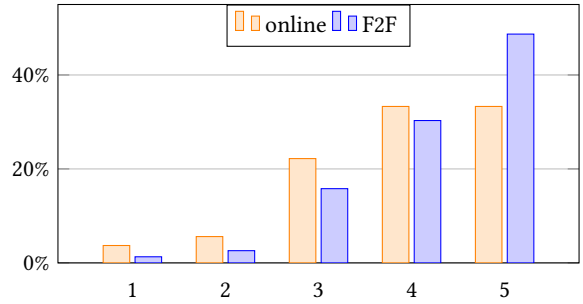

Figure 4: Frequency distribution for the survey item *"I have/will talk to friends, parents, or siblings about things I experienced in the course"*

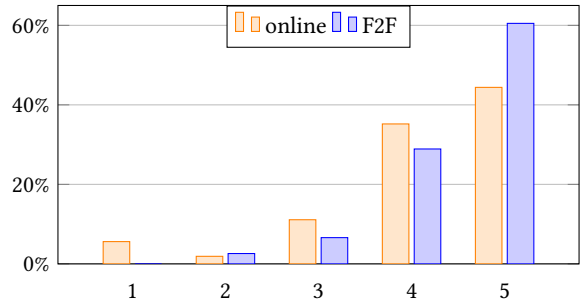

Figure 5: Frequency distribution for the survey item *"School would be more fun if we would cover things like this more often"*

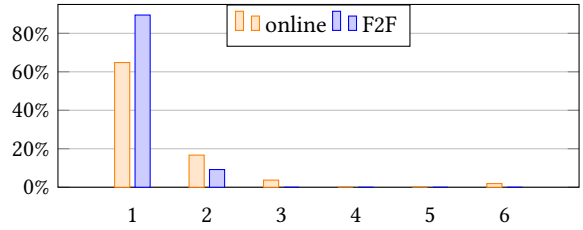

Figure 6: Frequency distribution for the survey item *"I rate the tutors as follows"*

peers in online formats t(64)=1.90, d=0.47, p=.031. The statistics of Tab. 3 and Fig. 3c do also indicate a similar trend for the other dimensions of positive feelings (d=0.22, p=.184) and interest (d=0.38, p=.065). The most significant differences were here on the item *"I have/will talk to friends, parents, or siblings about things I experienced in the course"* t(64)=2.05, d=0.32, p=.022 (see Fig. 8).

Contrary to our expectations, the mean values regarding online teaching formats indicate that younger students are even more open toward online teaching formats compared to their older peers. An additional independent t-test analysis focusing on online teaching formats was performed to investigate the effect of age on online teaching format acceptance. While for future intents (d=0.33,

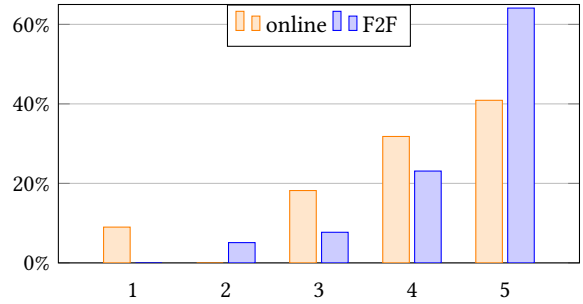

Figure 7: Frequency distribution for the survey item *"School would be more fun if we would cover things like this more often"* (grades 5-7)

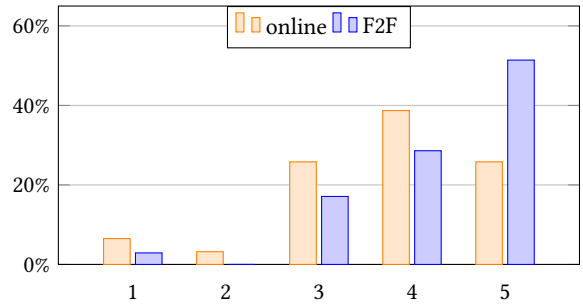

Figure 8: Frequency distribution for the survey item *"I have/will talk to friends, parents, or siblings about things I experienced in the course"* (grades 8-10)

p=.120) and positive feelings (d=0.05, p=.431), the effect of age was not significant, younger students (grades 5-7) did show statistically significant more interest in topics of the course than their peers in higher grades t(50)=2.04, d=0.57, p=.023.

Observation 3: The engagement in terms of future intents and interest in activities of the workshops was for younger students (grades 5-7) higher than for older students (grades 8-10).

4.4 The Effect of Students' Peer Study Group Experience when Support by Tutor is Provided Remotely

In this section, we analyze a unique setting where a group of students were physically together in a classroom, but the tutor was present only remotely. This allowed us to sneak a peek at the effectiveness of distributed peer-to-peer education models. The group of students, in this case, were all girls, and we compared their experiences with the experiences of girls in online teaching formats.

Tab. 4 shows the mean values for students' course experiences. Surprisingly, the full-online group showed slightly higher engagement than the girls-only F2F group with remote tutor support. However, the differences in their experiences were not statistically

Table 4: Mean values for girls in online and F2F settings with support provided remotely only

	Positive Feelings			Interest			Future Intents		
	M	N	SD	M	N	SD	M	N	SD
Online	4.22	25	0.62	4.34	25	0.76	3.85	25	0.79
F2F	4.21	28	0.87	4.11	27	1.09	3.94	28	1.03

M - mean, SD - standard deviation

significant. The descriptive statistics indicate that the girls in a F2F group with remote tutor support showed lower interest in the course topics compared to the full-online group (d=-0.38, p=.182). However, it is important to note that in a specific case where the tutor was present only remotely, the students did not utilize the remote support, resulting in minimal support. Therefore, it is possible that the lack of impact on course experiences was due to the low utilization of remote support rather than the mode of support itself.

Overall, this case study suggests that the effectiveness of distributed peer-to-peer education models depends on various factors, such as the subject matter, the student group, and the type of support the tutor provides. While having a tutor present remotely can be an effective way to provide support, it may not be as effective as having a tutor physically present in the classroom. Further research is needed to understand the optimal conditions for distributed peer-to-peer education models.

Observation 4: The analysis showed that when the tutor was present remotely and students studied in a peer group setting, there was no significant difference in their course experiences compared to fully online courses.

4.5 The Effect of Workshop Duration on Students' Course Experiences

In this section, we aimed to investigate the impact of workshop duration on students' course experiences. To do so, we compared the experiences of students who attended multi-day workshops in the F2F teaching format with those who attended one-day workshops in the F2F teaching format.

Our analysis revealed no statistically significant difference regarding positive feelings (d=0.16, p=.244) , interest (d=0.11, p=.629), and future intents (d=0.33, p=.373) between the two groups. However, the results showed that students in the multi-day programs (M=4.41) reported a significantly higher increase in their interest in CS compared to their peers in one-day programs (M=3.98). This difference was statistically significant with a medium effect size, based on the results of the item *"My interest in computer science has increased since I took the course"* t(73)=2.41, d=0.56, p=.009 (see Fig. 9).

These findings suggest that the workshop's duration might positively impact students' long-term interest in the field. The multi-day programs, which allowed students to spend more time immersed in the material and engaged with the course, seem to have a more

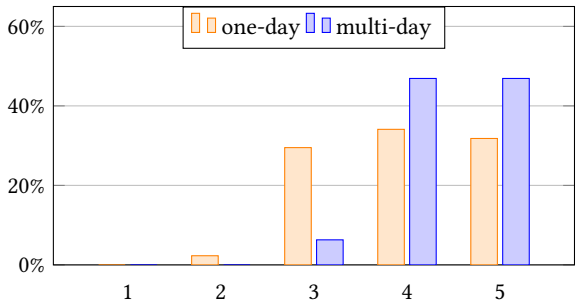

Figure 9: Frequency distribution on the survey item *"My interest in computer science has increased since I took the course"* for one-day and multi-day workshops in F2F teaching format

significant impact on students' interest in CS.

Observation 5: Students in longer programs reported a higher increase in their interest in CS compared to those in shorter programs.

5 DISCUSSION

The findings presented in this study reveal some interesting insights into students' experiences in different teaching formats. Firstly, the study indicates that students generally have positive experiences with online and F2F teaching formats, but there are differences in their perceived levels of positive feelings, interest, and future intents. Specifically, F2F formats result in overall higher engagement according to positive feelings, interest, and future intents, while online formats are more convenient and flexible for students. In a F2F classroom setting, students can interact with their teachers and peers in real-time. This interaction can help to build a sense of community and foster a collaborative learning environment, which was also indicated by a student quote, who explicitly pointed out *"the group dynamic"* as one strength of the workshop. In F2F settings, students can ask questions, receive immediate feedback, and engage in discussions with their peers. This type of engagement can help to deepen students' interest in the subject matter and improve their overall learning experience [19, 39]. Several students did also explicitly and positively highlight the job of the tutors in the feedback form, indicating the importance of direct, personal teacher support for successful learning environments:

> *"The supervisors were very nice and helpful"*

On the other hand, online teaching can provide students with greater flexibility and convenience, as they can access course materials and lectures from anywhere with an internet connection [9]. However, online teaching may also lack the personal interaction of F2F teaching, which can sometimes lead to feelings of isolation and disengagement [20]. Furthermore, the quotes provided by some of the online participants highlight the value of collaborative design and independent learning with support available when needed, as suggested by a quote from one of the participants:

> *"We might have been better off doing one or more tasks together"*

Students may also find it more challenging to ask questions or seek teacher feedback in an online setting. These findings suggest that a hybrid teaching format that combines the best of both worlds may be the most effective approach, offering the benefits of F2F interaction alongside the convenience and flexibility of online learning, as expressed by these two quotes by the online students.

> *"I liked that we were able to work out the topics on our own and still always had help available to us"*

and

> *"I really found it cool that you could decide on your own how you wanted to proceed"*

That being said, effective online teaching strategies, such as interactive online discussions, peer-to-peer collaboration [19, 39], and personalized feedback [21, 23], can help to bridge the gap between online and F2F learning experiences and keep students engaged and interested in their studies. As mentioned by Kassop [21], online environments could even provide advantages regarding student discussion involvement. For example, through asynchronous online discussion boards, where "many online students have indicated that this is the first time they have ever "spoken up" in class and that they enjoy the opportunity" [21]. One strength of online environments is to provide a safe space where every student can feel free to express themselves without being under pressure, as the following quote of a 13-year girl indicates:

> *"I thought it was great that we were given the freedom to do everything on our own"*

Even though this student participated in a F2F workshop, she clearly indicated the preference to work on her own.

Secondly, we could observe that younger students (grades 5-7) were, on average, more engaged in online teaching formats than older students (grades 8-10). This was against our expectations since we would have expected that F2F interactions might be more relevant to younger students to get engaged than to older students. A similar observation was made by Doering et al. [8] for a hybrid setting, where younger students were more motivated than their older peers. Overall, our study suggests that the age of the students is an essential factor to consider when evaluating the effectiveness of different teaching formats. The data presented only relate to students' experiences of different teaching formats based on their age, not their levels of peer orientation. Peer orientation may be related to age, but further information or research would be needed to make definitive conclusions. Educators need to consider these differences and tailor their teaching strategies accordingly to support their students' learning and engagement best. Additionally, further research is required in order to understand better the underlying mechanisms driving these age-related differences and to identify ways to optimize teaching formats for students of all ages.

Thirdly, the study found that the remote presence of a tutor did not have a significant impact on students' course experiences, as students did not make use of the support provided remotely, suggesting that the personal touch of F2F interaction may be more important than having a tutor available remotely. This finding suggests that more research is needed to understand how to support students in online and hybrid learning environments effectively and how to promote interactions and engagement among students and instructors, as also mentioned by Price et al. [33].

Fourthly, the study suggests that longer workshop duration can positively impact students' interest in computer science, even if they do not necessarily result in improvements in other dimensions of course experiences. This finding highlights the importance of considering the length and structure of courses and workshops when designing educational programs. It suggests that longer-term programs may be more effective at fostering sustained engagement and interest among students. This is in line with previous research on the topic of situational interest [31, 34], that repeated stimulation is essential in fostering individual interest.

Additionally, we want to share a challenge regarding digital learning materials we could observe during the workshops: students showed on average very low reading readiness, which makes it very challenging to transport large amounts of information in online courses. On the one hand, multiple lines of the text seemed to affect students' motivation negatively, and on the other hand, when students began to skip information texts, it resulted in frustrations during the activity tasks, because they were then missing the relevant background. So it is necessary to consider diverse reader levels in the effective design of digital learning materials.

Overall, the findings of this study have important implications for educators and institutions looking to design effective educational programs and support student learning in online and hybrid environments, including the importance of collaboration, the challenges of reading and processing large amounts of information, and the need for effective information design. Based on these findings, several recommendations can be made:

Recommendations for Educators:

(1) **Combine Teaching Formats:** Consider a hybrid teaching format that combines F2F interaction with the convenience and flexibility of online learning. More F2F interactions integrated into online teaching formats create a personal touch that can enhance students' course experiences.
(2) **Longer Courses:** Design longer-term educational programs that foster sustained student engagement and motivation. This is particularly important for promoting interest change in students, as our findings suggest that longer programs have a higher effect on this dimension of course experience.
(3) **Collaboration:** Provide opportunities for collaborative design and independent learning with support available to help students engage more effectively with the material. Independent learning can also be enhanced with support from instructors or peers, which can help students feel more engaged and motivated.
(4) **Effective Design:** Invest in strategies to effectively support students in online and hybrid learning environments and promote interactions and engagement

Table 5: Mean values for girls

	Positive Feelings			Interest			Future Intents		
	M	N	SD	M	N	SD	M	N	SD
Online	4.25	32	0.77	4.25	44	0.96	3.96	45	0.95
F2F	4.34	45	0.61	4.50	32	0.64	4.10	32	0.73

M - mean, SD - standard deviation

among students and instructors. For instance, instructors can use strategies such as discussion forums or video conferencing to facilitate student interactions and provide timely feedback to enhance engagement. Effective information design should also be considered to help students process and retain large amounts of information more effectively.

These recommendations highlight the importance of balancing the convenience and flexibility of online learning with the personal touch and engagement of F2F interaction, providing opportunities for collaborative design and independent learning, and investing in strategies to support students effectively in online and hybrid learning environments. Still, despite all the challenges of online learning, the courses had a positive impact, as expressed by the following student quotes:

> *"I took part in this course because I am very interested in animals and the environment, and I want to prevent the extinction of bees. I also took part because I didn't know anything about computers and IT and so on, but now I know a bit better."*

and

> *"A great future day! Thanks for that!"*

6 THREATS TO VALIDITY

Overall, while the study provides valuable insights, it is crucial to consider potential limitations and threats to validity that arise from our study design when interpreting the results.

Gender Imbalance. Our online courses had a higher number of female participants (n=46) compared to male participants (n=8), while in F2F settings, we had a higher number of male participants (n=42) compared to female participants (n=33). This gender imbalance could raise the question of whether this imbalance solely causes the observed differences between F2F and online teaching formats in our study. We addressed this issue by performing an analysis that excluded male participants' responses. Tab. 5 shows mean values for the two groups of girls related to their experiences of the course. The analysis showed that while the differences were not significant, the descriptive statistics still indicated a slightly higher engagement by girls in F2F teaching than girls in the online teaching format. This should be considered for future research.

Duration and Class Size. The duration of the courses and class sizes were not kept constant, which could be a potential threat to the study's internal validity. However, this is a common limitation in educational research, as controlling all variables in real-world settings is challenging.

Age. Since the most noticeable difference regarding age in online teaching formats was in terms of interest in the course topics, one possible interpretation could be that the course topics are more attractive to younger students than to older ones. We also performed a t-test analysis for age in F2F teaching formats to validate this interpretation. Here the effect of age on interest in the course topics was more minor and not statistically significant (d=0.38, p=.055). So the difference in online teaching formats can not be explained solely by the course topics. However, still, it highlights the need for more studies considering the implications of age for different teaching formats.

Other Limitations. The results presented in this paper are based on data collected from multiple different workshops, which may introduce validity threats arising from the potential impacts of different settings. Still, according to the theory of repeated case study design [38], we want to use this to generalize our findings beyond a single case. In the future, we plan to investigate the influence of different environments further. Secondly, the answers provided by students in the survey are subjective and may be influenced by their surroundings, which may not accurately reflect reality. Finally, our sample size is relatively small, and more studies with larger sample sizes and different sub-groups are needed to validate our findings.

7 CONCLUSION

The use of digital courses in education offers many advantages for students, but the importance of human interaction and support in the learning process can not be overstated. As social beings, humans thrive on interaction and communication. This is particularly true in the realm of education, where students often rely on feedback and guidance from instructors and peers to succeed. However, in the current era of digital learning, students also value the ability to learn at their own pace and on their own schedule.

Well, it turns out that students actually like seeing their teachers in person. Who would have thought? In all seriousness, this study investigated the effect of teaching formats on students' interest and engagement in computer science (CS) courses. Our findings suggest that while the teaching format had a negligible impact on interest development, F2F instruction combined with digital self-paced courses led to a higher level of engagement than online instruction with the same course. This highlights the importance of considering the impact of teaching formats on student engagement and has important implications for CS education.

Our study also acknowledges the recent shift towards online education due to the COVID-19 pandemic and suggests that online learning environments may offer unique opportunities for enhancing student engagement with CS. Digital courses in F2F settings that are pre-designed to be used effectively can offer the best of both worlds: students can learn independently at their own pace, but they are not alone. However, this does not mean that full online learning is entirely useless - there are unique opportunities for enhancing engagement in online environments that future studies have yet to evaluate.

However, our study has several limitations and threats to validity, including using subjective survey responses and a relatively small sample size. Future studies with larger sample sizes and more diverse student populations are needed to validate our findings and explore strategies for enhancing engagement in online learning environments.

Overall, our study contributes to the growing body of research on teaching formats in CS education and emphasizes the need for educators to consider the impact of different teaching formats on student engagement. In conclusion, as educators strive to promote CS education and bridge the gender and diversity gap in the field, it is vital to consider the impact of different teaching formats on student engagement. By exploring the effectiveness of different strategies and approaches, we can create more engaging and effective learning experiences for students in both F2F and online settings.

ACKNOWLEDGMENTS

This work has been in part supported by Vector Stiftung, Project "Mädchen für Informatik begeistern" at Karlsruhe Institute of Technology (KIT), by the COST Action CA19122 – European Network for Gender Balance in Informatics (EUGAIN), and by the Federal Ministry of Education and Research (BMBF). We also want to thank Anne Koziolek and Ingo Wagner for their continuous support of our work.

REFERENCES

[1] Patricia Ananga and Isaac Kofi Biney. 2017. Comparing face-to-face and online teaching and learning in higher education. *MIER Journal of Educational Studies Trends and Practices* (2017), 165–179.

[2] Zulaikha Mohd Basar, Azlin Norhaini Mansor, Khairul Azhar Jamaludin, and Bity Salwana Alias. 2021. The effectiveness and challenges of online learning for secondary school students–A case study. *Asian Journal of University Education* 17, 3 (2021), 119–129.

[3] Jingxuan Bi, Mohammad Javadi, and Siros Izadpanah. 2023. The comparison of the effect of two methods of face-to-face and E-learning education on learning, retention, and interest in English language course. *Education and Information Technologies* (2023), 1–26.

[4] Petr Coufal. 2022. Comparison of face-to-face and online computer science education in high school. *International Journal of Education and Information Technologies* 16 (2022), 148–153.

[5] Laura Alonso Díaz and Florentino Blázquez Entonado. 2009. Are the functions of teachers in e-learning and face-to-face learning environments really different? *Journal of educational technology & society* 12, 4 (2009), 331–343.

[6] Dimiter M Dimitrov and Phillip D Rumrill Jr. 2003. Pretest-posttest designs and measurement of change. *Work* 20, 2 (2003), 159–165.

[7] Aaron Doering. 2006. Adventure learning: Transformative hybrid online education. *Distance Education* 27, 2 (2006), 197–215.

[8] Aaron Doering, Cassandra Scharber, Eric Riedel, and Charles Miller. 2010. "Timber for President": Adventure Learning and Motivation. *Journal of Interactive Learning Research* 21, 4 (2010), 483–513.

[9] Christian Ebner and Andreas Gegenfurtner. 2019. Learning and satisfaction in webinar, online, and face-to-face instruction: A meta-analysis. In *Frontiers in Education*, Vol. 4. Frontiers Media SA, 92.

[10] Barry Fishman, Spyros Konstantopoulos, Beth W Kubitskey, Richard Vath, Gina Park, Heather Johnson, and Daniel C Edelson. 2013. Comparing the impact of online and face-to-face professional development in the context of curriculum implementation. *Journal of teacher education* 64, 5 (2013), 426–438.

[11] Michelle K Francis, Stephanie V Wormington, and Chris Hulleman. 2019. The costs of online learning: Examining differences in motivation and academic outcomes in online and face-to-face community college developmental mathematics courses. *Frontiers in psychology* 10 (2019), 2054.

[12] Gopala Ganesh, Audhesh Paswan, and Qin Sun. 2015. Are face-to-face classes more effective than online classes? An empirical examination. *Marketing Education Review* 25, 2 (2015), 67–81.

[13] Fatih Gürsul and Hafize Keser. 2009. The effects of online and face to face problem based learning environments in mathematics education on student's academic achievement. *Procedia-Social and Behavioral Sciences* 1, 1 (2009), 2817–2824.

[14] Patricia Haden. 2019. *Descriptive Statistics.* Cambridge University Press, 102–132. https://doi.org/10.1017/9781108654555.006

[15] Patricia Haden. 2019. *Inferential Statistics.* Cambridge University Press, 133–172. https://doi.org/10.1017/9781108654555.007

[16] Lucia Happe, Barbora Buhnova, Anne Koziolek, and Ingo Wagner. 2021. Effective measures to foster girls' interest in secondary computer science education. *Education and Information Technologies* 26, 3 (2021), 2811–2829.

[17] Lucia Happe and Kai Marquardt. 2023. RockStartIT: Authentic and Inclusive Interdisciplinary Software Engineering Courses. In *Proceedings of the ACM/IEEE 45th International Conference on Software Engineering: Workshops Proceedings.*

[18] Shanna Smith Jaggars. 2014. Choosing between online and face-to-face courses: Community college student voices. *American Journal of Distance Education* 28, 1 (2014), 27–38.

[19] David Jaques and Gilly Salmon. 2007. *Learning in groups: A handbook for face-to-face and online environments.* Routledge.

[20] Hyun-Chul Jeong and Wi-Young So. 2020. Difficulties of online physical education classes in middle and high school and an efficient operation plan to address them. *International journal of environmental research and public health* 17, 19 (2020), 7279.

[21] Mark Kassop. 2003. Ten ways online education matches, or surpasses, face-to-face learning. *The Technology Source* 3 (2003).

[22] Mansureh Kebritchi, Angie Lipschuetz, and Lilia Santiague. 2017. Issues and challenges for teaching successful online courses in higher education: A literature review. *Journal of Educational Technology Systems* 46, 1 (2017), 4–29.

[23] Shantia Kerr. 2011. Tips, tools, and techniques for teaching in the online high school classroom.

[24] Johannes König, Daniela J Jäger-Biela, and Nina Glutsch. 2020. Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany. *European journal of teacher education* 43, 4 (2020), 608–622.

[25] Andreas Krapp. 2007. An educational–psychological conceptualisation of interest. *International journal for educational and vocational guidance* 7, 1 (2007), 5–21.

[26] Daniël Lakens. 2013. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in psychology* 4 (2013).

[27] Kai Marquardt, Ingo Wagner, and Lucia Happe. 2023. Engaging Girls in Computer Science: Do Single-Gender Interdisciplinary Classes Help?. In *ICSE '23: Proceedings of the 45th International Conference on Software Engineering Association for Computing Machinery, New York, NY, United States.* accepted.

[28] Florence Martin, Ting Sun, and Carl D Westine. 2020. A systematic review of research on online teaching and learning from 2009 to 2018. *Computers & education* 159 (2020), 104009.

[29] Hannah T Nennig, Katrina L Idárraga, Luke D Salzer, April Bleske-Rechek, and Roslyn M Theisen. 2020. Comparison of student attitudes and performance in an online and a face-to-face inorganic chemistry course. *Chemistry Education Research and Practice* 21, 1 (2020), 168–177.

[30] Wan Ng and Jennifer Fergusson. 2020. Engaging high school girls in interdisciplinary STEAM. *Science Education International* 31, 3 (2020), 283–294.

[31] David Palmer, Jeanette Dixon, and Jennifer Archer. 2017. Using situational interest to enhance individual interest and science-related behaviours. *Research in Science Education* 47, 4 (2017), 731–753.

[32] Jasmine Paul and Felicia Jefferson. 2019. A comparative analysis of student performance in an online vs. face-to-face environmental science course from 2009 to 2016. *Frontiers in Computer Science* 1 (2019), 7.

[33] Linda Price, John TE Richardson, and Anne Jelfs. 2007. Face-to-face versus online tutoring support in distance education. *Studies in higher education* 32, 1 (2007), 1–20.

[34] Jerome I Rotgans and Henk G Schmidt. 2017. Interest development: Arousing situational interest affects the growth trajectory of individual interest. *Contemporary Educational Psychology* 49 (2017), 175–184.

[35] Mariam Salloum, Daniel Jeske, Wenxiu Ma, Vagelis Papalexakis, Christian Shelton, Vassilis Tsotras, and Shuheng Zhou. 2021. Developing an interdisciplinary data science program. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education.* 509–515.

[36] Sandra Phek-Lin Sim, Hannah Phek-Khiok Sim, and Cheng-Sim Quah. 2021. Online learning: A post COVID-19 alternative pedagogy for university students. *Asian Journal of University Education* 16, 4 (2021), 137–151.

[37] Emily Stark. 2019. Examining the role of motivation and learning strategies in student success in online versus face-to-face courses. *Online Learning* 23, 3 (2019), 234–251.

[38] Roel Wieringa and Maya Daneva. 2015. Six strategies for generalizing software engineering theories. *Science of computer programming* 101 (2015), 136–152.

[39] Anne Yates, Louise Starkey, Ben Egerton, and Florian Flueggen. 2021. High school students' experience of online learning during Covid-19: the influence of technology and pedagogy. *Technology, Pedagogy and Education* 30, 1 (2021), 59–73.