The Online Course Was Great: I Would Attend It Face-to-Face

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The Good, The Bad, and the Ugly of IT in Emergency Remote Teaching of CS1

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ABSTRACT

We describe how we redesigned, because of the 2020 COVID-19 pandemic, the CS1 course for Math undergraduates to be held online yet reflecting the face-to-face (F2F) experience as much as possible. We present the course structure, the IT tools we used, and the strategies we implemented to preserve the benefits of a synchronous experience. We discuss the positive and negative aspects that emerged from the students' opinion qualitative analysis. We use the COI framework as a lens to explain what worked, what did not, and what can be improved to strengthen the perception of a F2F experience and mitigate the "presence paradox" we found: despite students being enthusiastic about the online format, most would still prefer a F2F course.

CCS CONCEPTS

• **Social and professional topics → CS1**; • **Applied computing → Distance learning**.

KEYWORDS

emergency remote teaching, distance education, online learning, synchronous learning, CS1, non-majors, COVID-19

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1 INTRODUCTION

One of the challenges of the modern university is the ability to match the skills needs expressed by the labor market while maintaining its original trait as *universitas*, where both teachers and learners collaborate in the knowledge production, in that never-ending dynamics where the teacher's experience and students' fresh energy make any course instance both unique and a building block of the democratic society[1]. One of the main ingredients of this *universitas* is the lecture, where student's active participation (with questions, comments, different opinions) orientates the (usually standard) material towards a non-standard organization of the subject matter. A lecture, delivered *and* attended at the same moment (synchronously), is when the interaction between students and instructors also produces new material on the spot.[2]

We consistently maintained this view over the years, even for an introductory, technical course such as "CS1 for Math majors". Nonetheless, we were confronted with the COVID-19 emergency, which forced us to move online all the teaching on short notice. Well aware that it is not possible to simply transpose online a course designed to be face-to-face (F2F), we used the one week we had before the beginning of the lessons for a drastic redesign. Even though delivering an online *synchronous* course can be challenging, we were determined to provide a remote-only deployment—including all lab work—that could stand the comparison with a F2F course by preserving teachers' presence and students' participation.

Having feedback on remotely connected students' engagement and understanding was much harder. The unforeseen emergency made it infeasible to set up quantitative, experimental research; instead, we choose a qualitative approach that is particularly suited when "we may not fully understand a phenomenon—or even what the important phenomena are in a situation" [24, p. 172].

Concretely, in this work, we address the following questions. (RQ1) Could *consumer technologies* be successfully used to move online a F2F CS1 course on short notice? (RQ2) What are the effects of our design choices—made to preserve the advantages of a F2F experience—on the students' experience? (RQ3) What worked, what did not, and what can be improved to provide a fulfilling online synchronous experience?

2 REVIEW AND RELATED WORK

Online learning has grown dramatically and has been extensively studied by educational researchers. Asynchronous formats offer flexible scheduling, thoughtful participation, richer and inclusive interchanges. By contrast, synchronous approaches offer greater spontaneity and social interaction [20].

The research found that synchronous approaches provide "learning opportunities to collaborate [...and] better course and program

*A preliminary, short poster on this research has been presented at ITiCSE 2021 [21]
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[1]We cannot argue here on this vision, which goes back to Humboldt, and has been elaborated by J.H. Newman, Jaspers, Heidegger, or Habermas, among the many others.
[2]It is worth citing the "conversational framework" from D. Laurillard, which argues learning is "a continuing iterative dialogue between teacher and student" [15].

completion rates for students who participate in synchronous interactions with their teacher and peers rather than relying solely on asynchronous communication" [4, p. 15]. Bower recognizes that synchronous learning "can allow remote participants to experience an instructor's lesson, ask and answer questions, offer comments in class and generally allow engagement 'in a similar manner to on-campus students' [. . .], providing them with both access to knowledge and social interaction." According to [13], "most studies [outside CS: like medicine, physics, engineering] found that video lectures are at least as beneficial for learning as live lectures [. . .], even though students might prefer live lectures [. . .]." However, in their multi-year study on an Algorithms and Data Structures course, they found that students who preferred to attend F2F lectures outperformed in attendance rate and grades those who favored watching recorded lectures.

Online learning poses challenges for both students and instructors. According to [19], students face a sense of isolation, the need for self-discipline, and are required to develop technological literacy. Instructors who engage in synchronous online teaching need skills to establish relationships without using paralinguistic features and gestures. Also, paralinguistic clues are not available for students not sharing their webcam, so instructors cannot use those clues to check students' understanding. The webcam is considered a fundamental tool to reduce the sense of isolation and develop rapport. Another essential tool is the chat, which is helpful for checking class comprehension by quick polls or short student answers [19, p. 146-148]. Moreover, "[s]ocial presence and responses can be facilitated by a variety of emoticons and voting features providing a mix of communication and participant management modes" [4, p. 19].

Generally, web conferencing use in online education has been positively correlated with student satisfaction, higher marks, and better learning experience [3], also inside computer science [2, 5].

While many blog posts [11] have discussed *CS emergency remote teaching* over the past year, giving teaching advice, there is still not much research published on this specific topic in literature.

On the one hand, CS educators seem to have been more prepared than other educators for the online transition, probably because of their familiarity with technology [7, 18]. On the other hand, they expressed concerns regarding online teaching—both abstract and mathematical concepts in CS and practical and collaborative activities like programming projects, fearing a fallback to more traditional and transmissive teaching styles [7].

Challenges for community colleges during pandemic [23] include difficulty providing essential services (computers, healthy food, places where to concentrate), need for teachers' professional development, difficulty adapting hands-on labs and courses never taught online before, caring for students with special needs, avoiding plagiarism. Authors claim that some students strongly prefer F2F because of these limitations. However, the pandemic has also been an opportunity to update curriculum, methodologies, assessment. Our qualitative analysis is in line with these observations.

3 CONTEXT

At the University of Bologna, CS1 for Math is a mandatory course for first-year students in Mathematics. It is an introduction to programming in Python with no prerequisites.

As for most CS1 courses, its goal is to teach, in an integrated way, both programming skills and their linguistic expression in the chosen programming language. Students should fully understand local and global scopes, aliasing, and side effects and develop a simple but accurate (albeit not complete) model of a Python abstract machine. Emphasis is placed on a good programming style. CS1 for Math is 80 hours, 30 of which are supervised lab sessions (1-2 times per week), delivered in four 2-hours slots per week. On each lab, homework is assigned and is due at the beginning of the following lab. The course is offered once a year by four instructors: one professor and three TAs. Enrollment is around 180 students.

A significant portion of students finds the course difficult because it deviates from the other courses offered for Math majors, being more experimental and without "definitions, lemmas and theorems."

In the previous years, CS1 had a traditional organization—formal lectures at the hand-written blackboard, supported, when needed, by the projection of a programming IDE; BYOD (*Bring Your Own Device*) lab work with pair-programming, with no replications.

CS1 was about to start when the first wave of COVID-19 struck Italy at the end of February 2020. All instructors were asked to move online the first lectures and deploy the remote-only classes on a week's notice. CS1 started on March 2$^{\text{nd}}$, 2020, broadcast from the instructors' homes. While the course contents remained essentially unchanged, the organization was radically rebuilt to support fully remote and synchronous teaching, including all labs.

During online lectures, attending students varied between 180 and 200 (with a decrease to around 160–170 during the last two weeks of lectures).

3.1 Technologies and Methodologies

Lectures and labs were broadcast using *MS Teams*, a video conferencing tool used as a standard at our university, plus Moodle-based platforms to disseminate the learning resources. Teams allowed for integrated broadcast[3] of audio, video, the shared instructor's screen, and for a public chat. We used a private *Telegram* chat for real-time synchronization between the instructors, especially during labs.

During lectures and labs, instructors always encouraged students to ask general questions (or to comment) as they liked, either on audio, by writing in the chat, or by publicly sharing their screen. We felt the need to structure the interaction explicitly: rules that are natural in presence—both because of non-verbal communication and students' previous experience with F2F lectures—must be precisely defined in online settings. Therefore, we iteratively built and shared explicit rules and hints on how to interact with instructors during lectures, labs, and asynchronously.

3.1.1 Lectures. The main instructor shared a screen divided into two halves. The left part was a *MS PowerPoint* canvas, where the instructor would type as on a blackboard. The canvas could be initially empty or present some content (e.g., snippets of code, short titles, or brief enumerations), which was *not enough* for understanding the subject. During the lecture, the canvas evolved into a more self-contained (though not complete) resource, later uploaded to the Moodle platform, together with any Python code shown or

[3] Broadcasting from home, instructors used the laptop's built-in camera to capture the instructor's head and maintain a "postage-stamp"-sized video feed, more to enhance the sense of connectedness than as a tool for content transmission [16].

constructed during the lecture, for offline use. The right part of the screen was a window of a Python IDE, where code could be presented and run as needed. We used Thonny [1] because it is easy to install and use for moderately complex programs, it is consistent across different OSs, and it has extensive logging capabilities. Despite Thonny's debugging facilities, the instructor insisted, instead, on using the online tool *Python Tutor* [10], which allows for a visualization of the internal state evolution, especially helpful with mutable values. A browser window with Python Tutor would replace one of the two halves of the screen when required. This arrangement was used consistently during all the lectures.

The instructor used a graphic tablet and digital ink software to make notes or handwritten drawings over the screen. Such annotations were later integrated into the MS PowerPoint canvas. The main instructor kept the live chat of the course on a second non-shared screen. Typically, all the instructors used an additional device for their private synchronization chat.

The professor held the lectures. The TAs were always present during the theory classes, giving support mainly in three ways. (i) In the course chat, they answered about materials and organizational issues, and also provided answers to trivial questions about class topics. (ii) In the private instructors' chat, they report back to the professor any student questions he had missed while conducting the lesson, mitigating the instructor blindness and ensuring that no student felt ignored, nor that any relevant issue remained unaddressed. (iii) At the same time, they summarized or rephrased important concepts live in the course chat to ensure that no one would miss any crucial element, emphasizing the importance of a topic and supporting understanding of a challenging concept.

Students asked their questions mainly in chat. After the lesson, instructors remained online for some minutes to answer more questions or discuss with the students. Occasional email exchanges occurred during the course.

3.1.2 Labs. In our view, one of the advantages of a *synchronous* approach is to bring instructors' experience and guidance in crucial moments of learning like application and exploration. Therefore, we accepted the challenge of keeping all the labs as synchronous activities. Laboratory lessons were given by one of the TAs, in turn, and were also attended by the other instructors. During labs, after a brief theory recap, programming exercises were assigned. A request for help in the public chat was followed by a private chat (or call, always using Teams) between one of the instructors and the student. The student could share her screen with the instructor helping her. Students were encouraged to use Thonny for solving the in-class problems. Students had to upload homework assignments (simple programs) on a Moodle platform with the *CodeRunner* plugin for the automatic assessment through test cases [17]. At the beginning of the following lab, solutions to those exercises were discussed.

3.2 Teachers-researchers

The main instructor is a senior professor of CS, with several years of experience in CS1 for Math and consistently good feedback from students. The TAs are either Ph.D. students or post-docs in CS, all with a research interest in CS education. After the lectures, the main instructor and the TAs had detailed debriefings. The debriefings were very helpful in improving the course delivery, both because of the challenge of emergency online implementation and because the main instructor does not usually have any colleagues observing the lectures.

4 METHODS

Qualitative research is common in social sciences and other disciplinary education research (such as Math and Physics), far less in Computer Science Education Research [12]. We follow the recent advice on qualitative methods for CSEd research [24].

4.1 Data collection

At the beginning of the course, we obtained from all participants their informed consent, approved by the "Council of Math Degree."

Halfway through the course, we organized a focus group with ten students, randomly selected among the most active—and so, we believed, more inclined to share comments and proposals. The suggestions from the focus group influenced some changes made in the course (especially in the organization of lab lectures: see Sec. 5.3).

Moreover, the discussion brought us to design a questionnaire, submit a preliminary version to the focus group students, and then ask the whole class to fill in the final version.

The questionnaire was delivered as an anonymous Google Forms module. Three weeks after the last lecture, a message explaining motivations for helping instructors in the research was sent to all the 274 students who joined the online platform. Reminders were sent in the following weeks, and a link to the questionnaire was published in every online space related to the course.

We received 113 fillings. However, three of them were duplicated and were discarded, leaving 110 fillings. We collected students' insights by the questionnaire through close-ended and open-ended questions, together with (anonymous) demographics.

Among all the questions (see [22] for an English translation), we focused on 15 open-ended ones related to the contrast between online and F2F, other broad aspects of the course, and some specific but crucial elements of our 2020 implementation. We use a short tag to identify each question quickly. To those who already attended previous years, we asked what they found better (WHAT_BETTER) and what worse (WHAT_WORSE) this year. We asked all students what they found effective and what ineffective both during theory lectures (THEORY_OK, THEORY_BAD) and labs (LAB_OK, LAB_BAD). We asked if they believe CS1 fits more than other courses to online education (CS_FIT_ONLINE) and then to motivate why they would choose to attend F2F (WHY_PRES) or online (WHY_ONLINE). We asked students why they would (WHY_SHARE) or would not (WHY_NOT_SHARE) share their screen during labs. We then asked about two specific aspects of our course: how to decide the time assigned to each lab exercise (LAB_TIMES) and whether they found having TAs even during lectures useful (TAs_THEORY). We asked for suggestions on how to encourage students to participate and ask for help (MORE_HELP) and general suggestions for improving the course (SUGGEST).

4.2 Participants

By chance, exactly 55 students identified themselves as male and 55 as female. The students in the course go from 18 years old of the youngest (born in 2001) to 45 of the oldest (born in 1974). The median is 19 years old, representing the age of 69% of the students, followed by 20 years old, covering 13% of them. In our sample, 77 students did not have previous programming experience; 26 students studied programming in high school and the others in different contexts (private course, self-taught, and so on). Regarding the amount of theory and laboratory lessons they attended, from 0 (did not attend any) to 5 (attended all), 80% attended all lectures and labs (5), 10% almost all (4), while only a few attended none (0).

4.3 Data analysis: inductive categorization

We all authors together analyzed the open-ended answers. We performed an inductive categorization [24, p. 191] of the answers by identifying and assigning (*coding*) each filling of that question to *one or more* categories. Categories were not chosen *a priori* but instead constructed in a grounded fashion [6]: they emerged by data and were refined, re-discussed, and merged until reaching a complete consensus between researchers.

In the next section, as far as space constraints allow, we will report excerpts from students' answers to 'provide a "prototypical" semantic unit that illustrates, concretizes, and in this way represents the entire category' and support the trustworthiness of our categorization [24, p. 186, 199].

4.4 Theoretical framework: COI

After the *coding* process, we found that the Community of Inquiry (COI) framework [9] is helpful to make sense of our categories and insights. COI describes the essential elements (called *presences*) of a successful online higher education: *cognitive presence* (construction of knowledge through discourse and reflection), *teaching presence* (design, facilitation, and direction of learning processes), and *social presence* (learners' ability to feel affectively connected with peers).

5 FINDINGS

We analyze and discuss the most relevant aspects that emerged from the day-to-day work and analysis of students' opinions.

5.1 Individual assistance and live tutoring

To provide the individual support that students usually get during in-presence laboratory sessions, we designed a simple interaction protocol to ask for assistance. Beyond the help in overcoming programming difficulties, we wanted to make students feel less isolated and more connected with instructors. A student had just to ask for help in the course chat, and the first instructor available would "Like" that message to let the other instructors know that the request had been taken care of. Then, the instructor would send a private message to the student, initiating individual assistance.

In the question on what worked during the labs (LAB_OK), 43% of respondents (32 out of 74) praised the assistance given by the TAs (being always present, competent, supportive, and different in their style). At the same time, there is no mention of the TAs' assistance in the symmetrical question on what did not work (LAB_BAD).

The TAs' presence during the theory classes (see 3.1.1) was highly appreciated: in the specific question (TAs_THEORY), 92% of respondents (101 out of 110) found the TAs' presence useful or very useful.

In summary, the TAs' availability to provide support[4], their number, their summaries, and re-elaborations of crucial concepts, as well as their helpfulness and closeness, were much appreciated.

We recognized that students perceived TAs as both "deskmates" (filling the lack of F2F classmates) and an integral and competent part of the teacher's presence and support. This idea emerges from answers like *"The TAs help the professor with the many questions since there is no deskmate to ask"*, *"The opportunity to ask for help for a specific doubt without having to interrupt the lesson and putting at ease the shyest people"*[5], *"The TAs have always been friendly, helpful and competent"* and also *"They offer human contact with almost peers"*. This ambivalent perception about TAs is an example of how *teaching* and *social presence* could affect each other positively [8].

5.2 Live-built materials, LMS and auto-grading

As described (see 3.1.1), slides were built or completed during lectures, based on interactions (both chat messages and voice interventions) with students, to promote active learning, foster interest, and highlight the importance of participation. Programs were written and executed live, alongside the slides.

When asked about what they found effective in theory classes (THEORY_OK), students expressed positive feelings about the live construction of teaching materials. On a total of 82 answers, 52% of respondents liked one or more of these aspects: (i) live programming examples, (ii) live-built slides during the lecture, (iii) instructor handwriting on the shared screen. As a possible drawback, live-built slides cannot be available before the lesson, as few students requested in SUGGEST.

The Learning Management System (LMS) Moodle was useful to organize materials across lessons, and upload slides, programs' code, and homework after every class. We used the CodeRunner plugin to enrich the assignments with automatic tests and grading. Tests results provided students with progressive, specific information about their code. This strategy allowed us to give students constant feedback about their homework, otherwise impossible for just four instructors with more than 200 students. It is worth noting that providing an adequate number of auto-graded exercises each week took much time, effort, and precision.

Results show 44 positive answers across four questions. The most relevant categories are: 'Materials available online' (17 in THEORY_OK), 'Home assignments with automatic tests' (12 in LAB_OK), and 'Solutions available online' (4 in LAB_OK).

5.3 Time management in labs

In redesigning the laboratory routine, we initially decided not to allot prefixed times for autonomous activities. First, we believed that prefixed times, established by instructors and equal for all, were not inclusive. Second—coherently with our premise—we wanted the laboratory classes to evolve also from participants' contributions. Therefore we devised an *ad hoc* interaction protocol. For

[4]This finds evidence in literature: from Bowers' review [4, p. 16], it is crucial to hire teaching assistants to respond to text chat, managing issues not related to core aspects of the lesson. Moreover, increasing the ratio of TAs to participants helps minimize disruption and "can also lead to a richer learning experience for students."

[5]This is confirmed by other works. For Bower, "students who have the choice of attending face-to-face or remotely, often choose to participate remotely [...] because they can unobtrusively contribute to the lecture discussion via text chat" [4, p. 15].

every autonomous activity, the first student completing it should write "Done" on the course chat, and the coursemates that followed should just "Like" that message. For each activity, depending on its difficulty, the instructors would evaluate how many "Done" were sufficient to end the autonomous work and start the discussion. This "quorum" mechanism gave us the (false) impression that we had the pulse of the situation, relying on quantitative information to assess better when to move forward.

Students in the focus group expressed tepidly about the quorum mechanism, and many of them said they would prefer a fixed time for every activity. At the time, we naively attributed this preference to the downtime experienced by skilled students. Nonetheless, in the remaining laboratory lessons, we decided to test prefixed times for autonomous activities. In the questionnaire, we asked students for their preference and their motivation.

The preference for prefixed times (across questions FIXED_TIMES and LAB_BAD) is based on two opposite perspectives. The quorum mechanism displeased the more skilled students. 36 respondents perceived it as a waste of time (*non-inclusive vision*, contrasting ours). More surprisingly, it displeased the fragile students, too. 17 respondents perceived it as an anxious run-up to the execution speed of the best colleagues. Remarkably, according to 17 students, the instructor would know the ideal resolution time of each exercise, hence assuming there exists an objective one. Communicating this univocal time would be the most "democratic" way to allow students to measure themselves against their limits and without looking at others (i.e., at the increasing number of "Done" in the course chat).

The strong preference for prefixed times and this latter misconception show that it is crucial to systematically share the didactic choices with students, especially in an online learning context[6]. Moreover, being able to count "Likes" inspired us with excessive and unfounded confidence and resulted in an abuse of the quorum mechanism that displeased most students. However, it remains an open problem to figure out and balance the different competence levels of such a large class.

5.4 Sharing the screen

During lab lessons, it was hard for the instructors to note if a student needed help. Contrary to what happens in the lecture hall, where instructors can look at students' screens, the only way to understand if someone needed help was when they explicitly asked. We asked the students if, during labs, they would share their screen with *instructors only* (SHARE_SCR). The preference is clear: 85 (out of 110) would share the screen to get assistance, 25 would not.

The main motivations of those in favor were (i) the opportunity of receiving more effective and even unsolicited assistance—e.g., when the student would not know what to ask for or is too shy to ask for help; (ii) the idea that sharing the screen is *"just the same thing as it is in the classroom"*.

Among students against sharing their screen, the bigger cluster fears for privacy (*"I don't want to be observed while I could also mind my own business"*). As a possible solution, a screen sharing system could warn students in advance that an instructor will look at their monitor, just as students in the classroom realize that instructors are approaching their station. Moreover, a system that lets share just the IDE should be used.

5.5 Presence paradox

One of the most interesting aspects that emerged from the analysis of students' opinions is the coexistence of two antithetical judgments on the course. First, the end-of-course questionnaire revealed a high level of satisfaction for almost all the students[7]. Moreover, by looking (in all the questions presented in Section 4) for *explicit and strong* statements in favor of the course, we found that 64 out of 110 respondents highly valued the online course. For instance, when asked for suggestions to improve the course (SUGGEST), one student answered *"No, the course was perfect like that!"*.

However, when asked if they prefer distance or F2F learning if they had a choice, 68 chose F2F, 42 distance. In particular, half of those strongly in favor of the online mode replied that they would choose the F2F course. The reasons for preferring F2F are primarily related to the lack of interaction with instructors and peers. The reasons are either didactic (*"Being able to talk F2F with the teacher allows me to explain myself better"*) or socio-relational. On the other hand, who chooses the online mode gave logistical reasons[8].

We believe this "presence paradox"[9] is the effect of our effort to provide an online synchronous experience as rich as the F2F one.

6 DISCUSSION

Using a movie metaphor, we will discuss what we believe to be "The Good," "The Bad," and "The Ugly"[10] of our course online adaptation.

The Good is that students highly appreciated the course. They praised mostly those aspects that favored synchronous interactions (e.g., live-built slides, live programming examples, individual support from TAs during labs, and course chat interactions) and leveraged technology to mitigate online learning drawbacks (e.g., TAs presence and support during theory lessons, LMS for sharing materials, homework automatic testing).

The Bad is mainly related to instructors' misconceptions (overreliance on quantitative tools to track live the completion of exercises and manage lab times accordingly) and students' misconceptions (overconfidence in instructors' ability to help in any situation).

The Ugly concerns human aspects of F2F not to be lost, like the instructors being able to see students' screens during labs and proactively help them (but with attention to privacy). Moreover, instructors need to be more explicit about didactic choices, which are harder to understand online. Finally, most of our students would choose a F2F course, especially for the unmediated social interactions (didactic and socio-relational) with instructors and peers.

Conclusively, the strong and appreciated *teaching presence* is one of the key factors—the most recurrent one in students' answers—related to high course satisfaction. At the same time, the lamented lack of social interactions is a direct symptom of a poor *social presence*. We hypothesize that this deficiency is the primary cause of

[6]According to [19, p. 150], online education "need[s] to provide exceptional levels of student support", by explicitly explaining the didactic relevance of the tasks.

[7]An external, university-level evaluation reported that 94% of students expressed high satisfaction with the course (N=165).

[8]Other works confirm it: reasons for choosing online courses are mainly practical—flexible schedules, costs, time, no need to commute (see e.g. [2, 4, 14, 20]).

[9]Paraphrasing the "Synchronicity Paradox" of [14]: students seem to desire synchronicity, despite being attracted to online courses mainly because of asynchronicity.

[10]Referring to the 1966 movie "The Good, the Bad and the Ugly" by Sergio Leone.

students preferring F2F and also the cause of most misconceptions we found. First, students' "isolation" may have generated the wrong perception, hence the anxiety, that most of their coursemates had already finished the exercise (see Sec. 5.3). Also, the strong *teaching presence* not counterbalanced by a robust *social presence* may have generated the misconception of omniscient and omnipotent instructors, partly deresponsibilizing the students.

About *cognitive presence*, it is worth pointing out that an introductory and most technical course—whose primary goal is literacy in the basic CS concepts—does not focus on critical analysis of knowledge. That said, our students positively received the strategies that could foster *cognitive presence* by favoring reflection (i.e., CodeRunner testing, live construction of materials, program reading and comprehension, time for questions and alternative solutions).

7 VALIDITY AND LIMITATIONS

The validity of qualitative research is inevitably tied to the *trustworthiness* of the presented analysis. We four authors, all computer scientists with experience in education, actively coded and discussed all the open-ended answers together. Provided examples are representative of the kind of answers we received and coded. The large sample forms a solid base for the analysis.

Generalizability is the main issue of qualitative research; therefore, our claims must be read *in context*. This kind of research has the potential of "making explicit the anomalies, problems, and contradictions" [24, p. 179] in a specific situation, like the ongoing pandemic. Another obvious limitation, mitigated by anonymity, is the *social desirability* of answering positively on a questionnaire provided by the course instructors themselves.

8 CONCLUSIONS AND FUTURE WORKS

We presented how *consumer* technology and tools could be assembled to successfully move online a F2F CS1 course, thus answering positively to our (RQ1). In particular, we evaluated the impact of the technologies against students' perception using the COI framework—(RQ2) and (RQ3). We maintained that the online, synchronous experience must reflect the F2F experience—although not necessarily with the same tools, methodologies, behaviors. While we managed to preserve *teaching presence*, the *presence paradox* indicates that improvements are still necessary, mainly to help students experience *social presence* too, even online. For example, we could foster casual interactions in the course meeting room while waiting for the lesson, facilitate social connections with more structured activities (like remote pair programming), or introduce homework peer correction. We plan to introduce and evaluate such activities in future implementations of CS1 for Math.

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