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Oral Exams in Shift to Remote Learning

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ABSTRACT

In this experience report paper we present our experience with the development of oral assessments as final examinations in three introductory computing courses. The choice of this type of summative assessment was prompted by the emergency remote instruction instituted in the middle of the Spring 2020 semester, across colleges and universities in the U.S., due to the coronavirus pandemic. The principles that guided our oral assessment design were: to develop a more comprehensive measure of student competence and mitigate exam cheating; to facilitate communication and workplace skills through student-teacher interaction; and to alleviate negative emotions associated with traditional summative assessments.

We report on the oral assessment features and logistics. To gain insights into the impact of this form of assessment, we conducted a student survey to learn about their emotional reactions and perceptions of assessment effectiveness. Mean scores of positive emotions (enjoyment, hope, pride, relief) were higher than negative emotions (anger, anxiety, hopelessness) across all three courses. Students found the personalized, interactive nature of the exam helpful in advancing their learning and communication skills. Many believed the oral exam to be a more accurate assessment of their knowledge than traditional methods. Additionally, feedback from the two instructors who implemented the oral assessments indicates that they enjoyed the experience and will use the lessons learned to improve the use of oral assessments in the future.

CCS CONCEPTS

• **Social and professional topics → Student assessment**.

KEYWORDS

oral assessment; student emotions; introductory computing courses

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1 INTRODUCTION

Plagiarism in introductory programming courses has been a recurring challenge [1, 2, 4, 17]. The switch to remote learning in the middle of the Spring 2020 semester due to the coronavirus pandemic left many educators without the option for in-class proctored exams. Our approach to control plagiarism within the context of remote learning was to replace traditional in-class final exams with oral assessments, which allowed students to demonstrate their problem-solving ability, programming skills, and conceptual understanding through interview-style virtual meetings with the instructor.

Students who learn programming often experience negative emotions like anxiety and continued frustration that may influence their self-efficacy beliefs [10]. Insights gained from understanding the emotions students experience during an oral assessment may help teachers and researchers design oral assessments and learning activities that could mitigate the effects of negative emotions and create conditions for higher levels of comfort for students. Wilson and Shrock's [19] study of predictive factors that promote success in an introductory college computer science course found that student comfort level with asking and answering questions and participating in programming activities was "the best predictor of success." This finding motivated us to design summative oral assessments with the students' emotional response in mind: how can we make students feel less anxious and intimidated when asking or answering questions and when explaining their problem solving and programming experience?

The rest of the paper is organized as follows. We review previous works related to oral assessments in STEM education and to student emotional reactions in introductory computing courses. We then describe the experience of designing and implementing a summative oral assessment, including course context, design principles, and sample assessment questions. In Section 4 we present quantitative and qualitative results from a students survey to understand student reactions. After we analyze and reflect on our experience in Section 5, we summarize our conclusions.

2 RELATED WORK

Earlier studies on oral assessments in engineering programs suggest their positive effects on reducing plagiarism [13, 14]. More recently, Zhao's study on oral examinations in a junior-level thermodynamics course in mechanical engineering [21] found that students had positive views of the oral exams and that they felt supported and their effort appreciated. Comparing oral tests with other forms of assessment in a first-year undergraduate mathematics course, Iannone and Simpson [9] reported that student outcomes were broadly similar, and students appreciated how the oral assessment gauged their understanding and "made them think about the material, encouraging them to understand things" [9, p. 186]. Students

also raised anxiety and "nerve-racking" concerns. These findings resonate with Huxham et al.'s [8] analysis of oral versus written assessments in a biology course. In their analysis the authors noted that oral assessments evaluate learner's understanding, develop oral communication skills, and are more difficult to cheat in. The study also found that students performed better in oral compared to written tests. However, an important theme in the students' feedback concerned feelings of anxiety and stress.

Little is known about oral assessment in undergraduate computing programs. Motivated by reducing plagiarism in a system analysis and design course, Martin Dick [3] studied student interviews as a means of assessment. He found that the use of interviews during the semester for two stages in the development of team projects eliminated the student practice of copying assignments and disguising plagiarism by making minor changes. Other positive findings were the immediate feedback students received and the opportunity they had to practice and develop communication skills. On the negative side, students found the interview stressful and expressed their strong dislike for such form of assessment. Interested in improving the effectiveness of providing student feedback, East and Shafer [5] studied the implementation of in-person grading by using personal and private meetings between instructor and student to discuss and evaluate student's work. Students who participated in in-person grading sessions expressed their preference for this assessment method, which they found useful and made them feel comfortable.

More recently, Peter Ohmann [15] found that the students and instructors who participated in a final oral exam in a CS 0/1 course in Fall 2017 had positive reactions about their experience, and students demonstrated a deeper level of engagement with the material. Regarding barriers to the implementation of oral exams, Ohmann cited difficulties with scaling the exam to a larger class, especially when single instructors do not have tutors or teaching assistants' support. Preventing students from distributing exam questions to peers was another drawback, given that individual sessions were scheduled over a five-day period.

In their study of conceptual learning in computer science, Eckerdal et al. [6] found that "there was no lack of emotional reactions in learning threshold concepts" (p. 131) and urged educators to recognize students' strong feelings as normal, whether negative (frustration, anxiety) or positive (excitement, confidence). Kinnunen and Simon [10]) conducted qualitative research on student emotional experiences related to three stages of doing introductory programming assignments: getting started, encountering difficulties, and dealing with difficulties while doing the assignments. Using data from open-ended interviews, they discovered impactful emotional reactions related to these stages, ranging from feeling despair and experiencing puzzlement to experiencing frustration and anger. These emotions, both positive and negative, were shown to lead to self-efficacy judgments. A larger scale quantitative examination of emotional reactions to programming projects in an introductory programming course found that students' emotions correlate with student performance [12]. The study also found that feelings of frustration and inadequacy in early experiences negatively impact student later performance in the course.

3 ORAL ASSESSMENT

3.1 Goals

As in-person instruction was abruptly moved to online in mid-semester in Spring 2020, we faced the challenge of designing assessments that are suitable for remote learning. The overall goal was to enable students to demonstrate problem-solving skills and good programming habits, as well as understanding and application of concepts, in a low-stress setting. More specifically, our oral assessment aimed to achieve the following goals.

3.1.1 Develop a more comprehensive measure of student competence and mitigate exam cheating. Comprehensive open format questions, which have shown to be more reliable than multiple-choice questions [11], can be easily adapted to an oral format. Such free response questions provide opportunities for students to better demonstrate their competency in conceptual understanding and practical coding skills. An oral exam for computing subjects could reduce cheating (e.g., use of outside help or code copying) as the student and teacher interact in real-time.

3.1.2 Facilitate demonstration of communication and workplace skills through active student-teacher interaction. Oral assessment through one-on-one video conference meetings requires verbal and visual communication between the student and the teacher. In traditional in-person written exams, most students are reluctant to raise questions during the exam or discuss their solution afterward with the teacher. In an oral assessment the student and teacher are naturally engaged in active communication, which provides the opportunity for question clarification, real-time feedback, or solutions discussion. This interview-style experience may also help students meet the demand for communication skills in their future workplace.

3.1.3 Alleviate negative emotions associated with traditional summative assessments. Traditional formats of summative assessments such as written final exams are known to cause anxiety and continued frustration, which may influence students' self-efficacy beliefs [10, 12]. Students often experience negative emotions before, during, and even after the exam. We hoped to alleviate the effects of such negative emotions by creating conditions that instill a sense of comfort for students through oral assessment.

3.2 Course Context

Our oral assessment was conducted in three computing courses taught by two instructors (also among the co-authors of this experience report) at a teaching-focused college in a U.S. research university. Each course has a cap of 20 students. Two courses, Introduction to Programming (18 students) and Data Structures Fundamentals (20 students), are major requirements in two undergraduate programs, B.A. Computer Science and B.S. Computer Information Systems. The third course, Introduction to Data Science (13 students), is an elective course. Introduction to Programming is a prerequisite for the other two courses. All three courses use Python as the programming language.

Because the college is primarily a commuter college and over 90% of the students have jobs off campus, classes are scheduled once a week for three hours. Assessment methods in these three courses range from formative quizzes, weekly low-stakes and collaborative lab assignments, individual homework assignments, weekly

reflections, small team projects, and in-class midterm (in two of the courses) and final exam. After the University switched to remote learning in mid-March, class meetings used Zoom sessions.

3.3 Assessment Design

To recast the in-class final exam (paper and pencil, closed books and notes) to fit a Zoom-based modality, we opted for a student-teacher, one-on-one oral assessment approach, within a context that paralleled Zoom-enabled learning activities: direct verbal communication, full access to the computing tools and other platforms (e.g. Jupyter Lab, bash shell, Atom text editor, Python run-time environment), shared screen, and chat texting.

Competence-based Measure

Our traditional paper exams have a variety of questions. They are typically ordered from what we think are simpler assessment items to those that use a free response type to allow students to express more mature forms of reasoning through design, testing, implementation, and explanation activities. We believe that the oral exam is a richer alternative to existing free response type of questions used in our paper exams. During the oral exam in the introductory programming and data structures courses, students are prompted to design, test, implement and explain a programming solution, which allows a more accurate evaluation of students' competency. In the intro data science course, students are asked to perform data analysis tasks, including data transformation, statistical analyses and visualization, on a real-world data set and communicate these solutions effectively.

To ensure variability across problem statements and questions in each course, while maintaining a certain level of problem solving equivalency, we used generative or parameterized problem statements or questions to reduce cheating among students. Asking additional questions specific to the student work, or follow-up questions to the student's answer also contributed to having a true measure of student understanding.

Real-time Active Student-Teacher Interaction

The oral assessment format modeled a Q&A session. Prompted by the instructor, who introduced the problem verbally and via chat, the assessment comprised frequent exchanges between the student and instructor. Guided by those exchanges, students engaged in a sequence of programming tasks that were conceptually and technically similar across the oral assessments in the same course.

The interaction between the instructor and the students was crucial for the success of the assessment as well as the students' positive experience. We encouraged students to ask questions for clarification, and they were asked to think-aloud particularly during coding activities. Students were provided with immediate feedback to their answers and, when they were stuck, they were given hints to apply a different approach. The instructors also tried to identify suitable moments to briefly explain wrong or incomplete answers. Similar to a job interview, the oral exam requires a student to demonstrate a richer set of skills in real-time rather than simply write down answers on paper.

Stress-Alleviating Question Formats and Grading Rubrics

Our past experience with in-class written exams has been shaped by the view that these examinations may lower students' negative emotions if we create conditions for exam-enabled learning experiences [20]. For example, we allow students to prepare and bring to class "cheat sheets," which we call writing-to-learn review sheets. We also encourage students to ask questions, which, when appropriate, we discuss with the entire class. The student-teacher interactive session of an oral exam has inherent qualities that afford students to learn while taking the exam, and may alleviate students' negative emotions.

The grading rubrics focused on the process of problem-solving, rather than merely about the correct answer. Among the three courses, 75%-80% of the questions were active coding problems constructed with multiple smaller steps. The remaining 20%-25% were conceptual questions that were to be asked either individually or in conjunction with the coding activities. Certain help that students received from the instructor did not factor into the grade. Students did not get penalized if they asked clarifying questions or, they made syntax errors they debugged successfully. However, if they were corrected after repeated attempts, or needed hints when they couldn't make progress, they would receive a 10%-30% penalty for that particular question.

3.4 Sample Assessment Questions

The oral assessment in the introductory programming and data structures courses had the same set of high-level tasks (Table 1). What differentiates individual assessments is the problem given at the beginning of the examination session.

Table 1: High-level tasks in introductory programming and data structures fundamentals courses

Document the problem statement by writing the function header and docstring comment (parameters and return value)
Write test cases with appropriate function calls
Discuss the solution idea and outline the design of the computational steps
Write the function definition guided by the design descriptions and using incremental development
Test, debug, fix errors while using the Atom editor and bash shell

The problem statement is parameterized by the input data structure, output data structure, and an input-output transformation based on a map, filter, or reduce pattern, or various combinations of these patterns. The generative nature of the problem allowed us to create a set of four different problems for each course. Two examples of problem statements are given Table 2. We denote within [] problem characteristics (operations, values) that can be instantiated differently.

The programming questions in introductory data science course ask students to perform data analysis on given data sets, some of which may share common columns so they can be merged. The questions are generative as shown by the example below, in which the value in the square brackets [] can be changed depending on the data. The hints provided by the instructor, shown in curly brackets {}

Table 2: Parameterized questions in introductory programming and data structures courses

You play a game in which you score points. You keep track of the scores to find out how many times you scored the same number of points. Modify your solution to know how many times you scored points [greater than] [limit].
You are interested in how many reviews your favorite brands of sneakers have, and want to find the brands with the [highest] number of reviews. What if you want to track the number of stars in each review?

Table 3: Generative questions and parameterized hints in introductory data science course

Identify the missing values in the [social support] column of the data frame.
What is the [minimal value] for the [social support] column? And what [country] is that?
Sort the data frame based on [social support] in [descending] order.
How many unique values are there for the [region] column? What is the [max] [happiness score] for each region? {Hint: Use pivot table to show the different [regions].}
Find the [happiness score] and the [national GDP] of [Canada]. {Hint: Need to merge the two data frames with an outer join on [country].}
Create a [scatter plot] graph that shows relationship between [happiness score] and [social support].

can also be parameterized according to the corresponding questions. For example, given two data sets, for world happiness [7] and world countries [18], a question sequence is shown in Table 3.

3.5 Assessment Logistics

Students were asked to submit their time preference for the 30-minutes exam time slot, and instructors communicated the schedule to students. Almost all of the exam sessions in the same course were conducted on the same day, with the exceptions of two sessions that were scheduled in the next two days because of time conflicts. To prepare, students were given an outline of the assessment tasks, including sample task and question examples. They were aware of the scope of the content, technical skills, and level of complexity of general tasks. For example, in the introductory data science course, students were told the type of data sets that would be used for the data manipulation questions. In the data structures course, the instructor described the type of problems for which students would represent various input instances using list and dictionary data structures and transform them through mapping, filtering, or reducing techniques into different data structure output instances.

The assessment was conducted over Zoom meetings. Students were required to have the video camera on and to share the screen of their computer. The exam questions and tasks were communicated verbally and through the Zoom's chat to help with understanding and thinking about the questions or to provide additional information. With students' consent, the meeting sessions were recorded to allow instructors to review and analyze the session when needed.

4 STUDENT FEEDBACK AND RESULTS

4.1 Student Survey

We conducted an online survey to understand students' emotional response to the oral exam format and to gather feedback for future improvement of our assessment design. We adapted the Achievement Emotions Questionnaire (AEQ) devised by Pekrun et al. [16] to measure emotions that students experience when studying or taking an exam. Our adapted version uses items from the following exam-related emotion scales: enjoyment, hope, pride, anger, anxiety, hopelessness, and relief. Students responded using a 1-7 agreement scale. Table 4 displays the items used in the survey, grouped by the emotion scale.

Table 4: Survey items by composite

Emotion	AEQ* #	AEQ Exam-Related Survey Item
Enjoyment	5	I enjoy taking the exam
	11	I am happy that I can cope with the exam
Hope	6	I am very confident
	12	I think that I answer the questions well
Pride	7	I feel proud
	13	I think that I can be proud of my knowledge
	17	I am very satisfied with myself
	20	I'm proud of how well I mastered the exam
Anger	8	I am angry
	14	I think the questions are unfair
	19	I am fairly annoyed
	21	I get angry about the overall exam format
Anxiety	9	I am very nervous
	15	I worry whether I will pass the exam
Hopelessness	10	I feel helpless
	16	I start to realize that the questions are much too difficult for me
Relief	18	I feel very relieved

*Column two displays item numbers from Pekrun's instrument Achievement Emotions Questionnaire [16]

In the selection of items from Pekrun's instrument, only those related to student exam emotions during or after the exam were utilized. From that pool, items intended to measure affective and cognitive elements of the exam-related emotion were considered for inclusion. For brevity, the survey was trimmed to 1-4 items per scale. An agreement scale was also used to gather student perceptions on whether the oral exam assessed their preparation fairly, allowed demonstration of programming skills, were satisfied with their performance, and whether they liked the oral exam. The survey also contained two open-ended questions: (1) Describe 1-2 aspects you like and/or dislike about the oral exam. (2) Do you prefer the oral format over the (traditional) midterm format? Why?

4.2 Participants

The survey was administered within 30 minutes of taking the oral assessment in all three courses. Two of the courses were taught by one instructor and the third by a different instructor. Both instructors are faculty members at the University and have many years of

experience in teaching computing courses. Data were available from 49 out of 51 students; a response rate of 96%. Participant demographics were representative of students in this region and university, with approximately one-quarter female and three-quarters male. The vast majority, about 95 percent of students, self-identified as White and a small minority identify as Asian, Black, Latinx, or another race/ethnicity.

4.3 Quantitative Descriptive Results

The AEQ is scored by summing up the corresponding items for each emotion and calculating the average score for each exam emotion construct. Once computed, the means of the constructs were compared to see if students, in general, experienced more positive emotions (emotions linked with academic success) as compared to negative emotions (e.g., those linked with lower self-efficacy). Figure 1 shows the mean of the exam emotion constructs across all students. The negative emotions (anger, hopelessness, and anxiety) all received lower mean scores, ranging from 1.49 to 3.34, as compared to the positive emotions (hope, pride, enjoyment, and relief) which ranged from 5.78 to 6.08. This contrast between positive and negative emotions was present within each of the three courses.

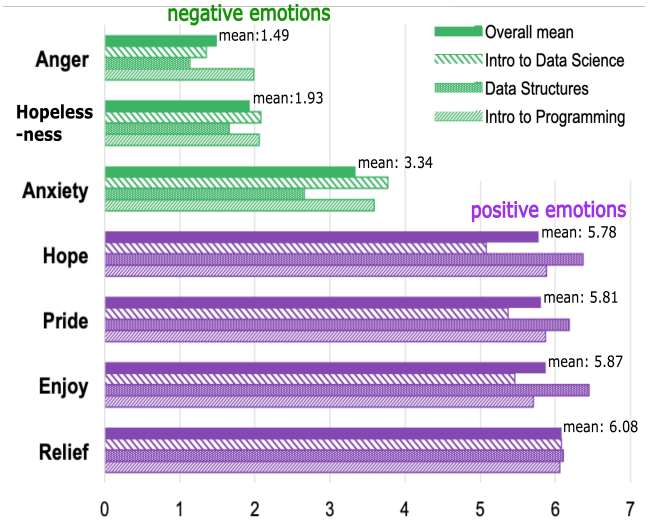

Figure 1: Exam emotion mean scores, overall and by course

The agreement scale was also used to gather additional information on student perceptions. As displayed in Table 5, on average, students were in high agreement (mean above 6.47) that the oral exam assessed their preparation fairly, allowed demonstration of programming skills, and were satisfied with their performance. Students, on average, agreed that they liked the oral exam, but to a slightly lesser extent with a mean of 5.84.

4.4 Qualitative Descriptive Results

Student open-ended responses were coded using an iterative process where emerging themes were identified, cross-checked, and counted. Responses were also reviewed for disconfirming evidence. Several main themes emerged.

Table 5: Descriptive statistics on survey questions

Survey question (Do you agree that ...)	Mean	SD
Oral exam assesses your preparation in the course fairly	6.47	0.89
Oral exam allows you to demonstrate your programming skills	6.41	1.24
You are satisfied with your performance during the exam	6.29	1.24
You like the oral exam as a means of assessment	5.84	1.50

4.4.1 Students found the interactive nature of the oral exam helpful and enjoyable (n=17). They enjoyed working one-on-one with the professor. In particular, they found the professors helpful in creating a more relaxed testing environment which provided opportunities for feedback and ultimately advanced their understanding of the material. For example, students said:

- For me, I enjoy the social aspect of the exam; it's encouraging to speak with the teacher instead of worrying about the test by yourself.
- I like the aspect of oral exam, because I had to interact with the professor while in the exam and, wherever I was lacking, the professor helped me out to make me understand what I am doing wrong.

They expressed appreciation for the assistance when they got stuck and some seemed to genuinely enjoy the opportunity to connect with professors.

- I liked having a conversation with [the professor] throughout the exam. I was much less nervous once it actually started, and she was very encouraging the entire time.

Ultimately, it was clear that the students valued the personalized guidance offered through the oral exam format.

- I liked that I was working one-on-one with the professor instead of working independently because it is a lot easier to construct what you are thinking about when you have somebody guiding you.

4.4.2 Many of the students had not taken an oral exam before and thought it was stressful (n=14). That said, they also remarked that the instructors put them at ease. In their words:

- I slightly dislike the feeling of pressure because I feel like I'm holding back someone, just [the professor] watching me struggle. But, overall, I like the involvement; where you can ask questions along the way and the pair programming feel of the oral exam. I would prefer it in-person though hopefully.
- I overall liked it. It was just a little nerve wracking because I wasn't sure what to expect.

4.4.3 Several other important nuances were revealed about students perception of the oral exam experience. They are summarized in Table 6 alongside sample responses.

The exam was short, with students disagreeing as the whether the exam length was a benefit or limitation (n=10). Some students liked the fast pace and digging deeper into one topic versus working on multiple small problems. Others wished the exam were longer. As two students with differing viewpoints put it: (1) Due to the

Table 6: Qualitative themes from open-ended responses

Theme	Sample Quotes
Appreciated opportunity to ask clarifying questions (n=4)	It was nice that I could discuss answers and get immediate clarification
Comprehensive assessment of knowledge (n=2)	I like how it tests you on your overall knowledge instead of cramming some practice exam questions before a big test
Increased confidence (n=3)	It boosted my confidence in my programming skills
Felt casual, informal (n=3)	I like how I felt like I was having a normal conversation
Parallels real-world situations (n=2)	Things I like about the oral exam: simulates real-world programming situations

length of the exam I did not feel like I was losing energy; (2) Dislike: it was short.

In two courses, students experienced a traditional format midterm and the oral final exam. When asked to compare the assessments, 66 percent (n=23) preferred the oral exam, 26 percent (n=9) had no preference and 9 percent (n=3) preferred the written exam (Note: One student did not respond). When asked to explain, students voiced similar advantages and disadvantages to oral exams. Those who preferred written exams mentioned that the traditional exam format provided more time to think about their responses.

5 ANALYSIS AND REFLECTION

A common theme arising from studies of oral assessments in engineering [13, 14], mathematics [9], biology [8], and computing [3, 5, 15] highlights that students find these assessments useful and authentic. Students also appreciate that they have the opportunity to participate in productive conversations and demonstrate conceptual understanding and disciplinary skills. Findings are mixed, however, regarding emotional reactions students have during oral examinations. We were pleasantly surprised to learn that students in the three introductory computing courses in which we introduced oral summative assessments experienced more positive emotions than negative emotions. We designed the content and format of the exam to mirror familiar in-class activities with which students had extensive practice during the semester. However, we did not know to what extent the assessment tasks would give students a sufficient level of comfort such that they could fully focus on understanding the questions and engaging in the problem solving and programming tasks. The survey results are promising and convinced us to continue with this form of examination in the following semesters.

Managing the half-hour oral exam sessions in all three courses was possible because of the small class size, limited at 20 students. Our past experience with final written exams in these courses is that it takes 9-10 hours per course to finish grading. Preparing the exam questions adds 3-4 more hours. Time commitment for conducting the oral sessions, by the end of which we also knew the student grade, was comparable to grading the written exams. Formulating the generative problem/question statements took less time than preparing a written exam. Both instructors were much more pleased with examining the students orally than grading written exams. We should note that the instructors appreciated and enjoyed their interaction with the students. Scaling summative oral assessments to classes larger than 20 would require additional instructional staff, such as teaching assistants, who will need to be adequately prepared. Scalability of oral assessments is further constrained if the exam duration is more than half hour to meet some students' need for more time.

One contributing factor to the students' positive emotional response could be the close student-teacher relationship established during the in-person instruction from the early weeks of the semester. The two female instructors are both experienced teachers, who have implemented student-centered instructional strategies in their in-person courses. Reproducing such a close connection in a fully virtual learning environment would require new ways of building trust relationships with online means. Such changes may impact students' experience during the oral assessment.

We believe oral assessment is also a suitable approach for formative assessment. Students found the interactive nature of the exam very helpful and enjoyable, while still feeling the stress of taking the exam. Including multiple low-stakes oral evaluative interviews during the semester would be a good way for the instructor to monitor student learning, provide immediate feedback, and improve social connections that might be weakened in remote learning. We plan to experiment with short formative oral assessment in the future semesters.

6 CONCLUSIONS

In this experience report paper, we described a summative oral assessment that we designed and implemented in three introductory computing courses that were taught remotely in the second half of the Spring 2020 semester due to the coronavirus pandemic. We also presented results from a student survey we adapted from Pekrun et al.'s Achievement Emotions Questionnaire [16] to understand emotional reactions students experienced during and after the exam. Student feedback suggests that oral assessments are promising alternatives or additions to existing forms of assessment. We believe that the student-teacher interactions during the exam session alleviated negative emotions (anger, hopelessness, and anxiety) and were conducive to increased positive emotions (hope, pride, enjoyment, and relief). Another positive result was students' high agreement that the oral exam was fair and helped them demonstrate their programming skills. Moreover, from the student open-ended responses we learned that they enjoyed the interactive nature of the exam and, despite experiencing some level of stress, students thought the instructors made them feel at ease.

Reflecting on our experience with administering the oral assessment, we identified three issues that deserve further consideration: overcoming scalability constraints by preparing teaching assistants; the mediating role that student-teacher relationship plays in linking assessment-related emotions and student achievement; and expanding the oral modality to frequent low-stake formative assessments. In the end, we view oral assessments as promising tools that help leverage learning conversations and interactions between students and instructor, which, in turn, should model and prepare students for professional practice.

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