2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #36790

Peer oral exams: A learner-centered authentic assessment approach scalable to large classes

Marko V. Lubarda, University of California, San Diego

Marko V. Lubarda is an Assistant Teaching Professor in the Department of Mechanical and Aerospace Engineering at the University of California, San Diego. He teaches mechanics, materials science, design, computational analysis, and engineering mathematics courses, and has co-authored the undergraduate textbook Intermediate Solid Mechanics (Cambridge University Press, 2020). He is dedicated to engineering pedagogy and enriching students' learning experiences through teaching innovations, curriculum design, and support of undergraduate student research.

Dr. Alex M. Phan, University of California, San Diego

Dr. Phan received his Ph.D. in Mechanical Engineering from the University of California San Diego with a specialization in medical devices. He is currently an instructor for the Department of Electrical and Computer Engineering focusing on hands-on education.

Dr. Maziar Ghazinejad, University of California, San Diego

Maziar Ghazinejad is an Associate teaching professor in Mechanical and Aerospace Engineering Department at UC San Diego. He received his Ph.D. in mechanical engineering from UC Riverside in 2012 and holds M.S. degrees in mechanical and electrical engineer

Dr. Nathan Delson, eGrove Education

Nathan Delson, Ph.D. is a Senior Teaching Professor at the University of California at San Diego. He received a PhD in Mechanical Engineering from MIT and his interests include robotics, biomedical devices, product design, engineering education, and maker spaces. In 1999 he co-founded Coactive Drive Corporation (currently General Vibration), a company that provides force feedback solutions. In 2016 Nate co-founded eGrove Education an educational software company focused on teaching sketching and spatial visualization skills.

Dr. Saharnaz Baghdadchi, University of California, San Diego

Saharnaz Baghdadchi is an Assistant Teaching Professor at UC San Diego. She is interested in scholarly teaching and uses active learning techniques to help students achieve an expert-like level of thinking. She guides students in bridging the gap between facts and usable knowledge to solve complex engineering problems.

Prof. Curt Schurgers, University of California, San Diego

Curt Schurgers is a Teaching Professor in the UCSD Electrical and Computer Engineering Department. His research and teaching are focused on course redesign, active learning, and project-based learning. He also co-directs a hands-on undergraduate research program called Engineers for Exploration, in which students apply their engineering knowledge to problems in exploration and conservation.

Minju Kim, University of California, San Diego

Minju Kim is a postdoctoral scholar at the Engaged Teaching Hub at the UCSD Teaching+Learning Commons. Minju received her Ph.D in Experimental Psychology at UC San Diego. With Engaged Teaching Hub, Minju has designed TA training materials for oral exams and have conducted quantitative analysis on the value of oral exams as early diagnostic tool (Kim et al., ASEE 2022). Minju is interested in designing assessments that can capture and motivate students' deep conceptual learning, such as oral exams and the usage of visual representations (e.g., diagrams and manual gestures).

Josephine Relaford-Doyle, University of California, San Diego
Dr. Carolyn L. Sandoval, University of California, San Diego

Dr. Sandoval is the Associate Director of the Teaching + Learning Commons at the University of California, San Diego. She earned a PhD in Adult Education-Human Resource Development. Her research interests include adult learning and development, faculty de

Dr. Huihui Qi, University of California, San Diego

Dr.Huihui Qi is a Teaching Assistant Professor at the University of California, San Diego.

Peer oral exams: A learner-centered authentic assessment approach scalable to large classes

Abstract

In this evidence-based practice paper, we report on peer oral exams, a cross between oral exams and peer assessment, as implemented in a high-enrollment undergraduate computer programming course for engineers. The idea was to leverage the educational and implementational advantages of both evidence-based approaches simultaneously. Oral exams, for instance, have been argued to promote conceptual understanding, self-reflection, communication competency, and professional identity formation in students – but their deployment in large classes is resource-demanding and nontrivial, stifling their broader adoption. Peer assessment, on the other hand, is highly scalable and affords students many potential educational benefits of its own, including the benefits of peer-enhanced learning, more developed evaluative skills, a greater sense of belonging, improved self-efficacy beliefs, and higher levels of intrinsic academic motivation. The merging of the two evidence-based assessment approaches promises a scalable assessment modality hybridizing the pedagogical dimensions of the former two assessment practices. Our study of students' surveyed perceptions about peer oral exams offers perspectives on the qualities and potential role of peer oral exams in educational practice and suggests directions for future educational research.

Introduction

The rapidly evolving professional ecosystem of the Fourth Industrial Revolution is placing high demands on STEM education at an unprecedented rate [1], [2]. Principle among these demands is the call for outfitting students – the future workforce – with so-called 21st-century skills [3]. Most notably, these include skills of abstract thinking, critical reasoning, technical communication, teamwork, lifelong learning, creativity, and leadership. A critical line of response to equipping students with these skills has been pedagogical advances and instructional innovation at the course and curriculum levels. Student-centric, active-learning, and experiential educational practices – such as flipped classes, project-based courses, undergraduate research, and work-integrated learning – have emerged as effective tools for supporting students' professional skill development in line with expectations of the modern workplace [4]–[12]. Innovation in assessment systems has likewise contributed to addressing the emergent educational challenges associated with Industry 4.0 by leveraging the influence of assessment on students' approaches to learning and engagement with course content and learning objectives [13]–[16]. Examples of innovative and ever-evolving assessment practices include formative concept-based testing, portfolio evaluation, research or design appraisal, comprehensive skill assessment, self-assessment, peer assessment, student-designed assessment, and oral examination [17]–[23].

The present work introduces into assessment practice peer oral exams, a melding of two evidence-based educational practices – oral exams and peer assessment. Earlier work has already

presented a convincing case in support of oral exams, outlining their potential to encourage deep learning [24]–[27], promote student-faculty connection [28]–[34], develop students' technical speaking skills [35], [36], [30], [37], [30], [38], and combat cheating [23], [31], [39]–[44], [34]. Scaling oral exams to large-enrollment classes, however, can be prohibitively expensive in terms of time commitment, scheduling requirements, and the number of instructional assistants needed for the examination process [28], [36], [37], [45]–[47]. As a solution to the scalability problem, we propose the merging of oral exams and peer assessment, which yields a new assessment modality unifying the merits of both practices. The highly scalable practice of peer assessment has a long history in higher education, with well-documented benefits to student motivation, knowledge retention, academic performance, and reflective and metacognitive skill development [48], [49], [20], [50]. The present paper provides an account of the design, implementation, and student reception of peer oral exams in an undergraduate computer programming course for engineers, and explores the potential educational benefits and dimensions of the assessment practice in relation to 21st-century skill development.

Related research and practice

Learner-centered education

A push toward learner-centered education has been a signature of educational trends in pedagogical practice over the past two decades [7]–[9]. Instructional innovations, technological developments, and educational research and theory set the groundwork for increasingly student-focused instruction and learner-centered classrooms within institutions of higher education around the world [51], [52], [9]. Familiar examples of innovative pedagogical methods that have gained broad adoption include flipped classrooms and peer-instruction [53]–[55], hands-on and project-based courses [56], [57], active-learning activities [4], [6], [10], [11], gamified assignments [58], [59], student-generated tests [22], [60], [61], peer review [19], [20], [50], and authentic assessments [62]–[64]. Developers, practitioners, and advocates of student-centered instruction have long underscored the educational benefits such instruction imparts to students, such as improved attitudes toward the subject, increased engagement, greater sense of ownership in learning, and better academic performance [20], [51], [57], [63].

Authentic formative assessments

Central to the philosophy of student-focused education are authentic and formative assessments [62], [64]–[66]. Authentic assessments are aimed at creating a testing environment which closely models real-world professional settings in which students are expected to be able to deliver following graduation or the completion of the course [62], [64]. Formative assessments, on the other hand, are those geared toward supporting the learning process and the development of students' skills throughout the course [16], [65]. Authentic formative assessments are therefore designed to provide for a genuine and practically relevant testing experience for students, while also serving their formative function. The latter typically encompasses (*i)* motivating students to study more in preparation for the exam, (*ii*) helping students to solidify and expand their knowledge during the examination process, and (*iii*) enabling them to better direct their learning based on the experience and feedback subsequently received [64]–[67].

Oral exams

The old assessment approach of oral examination, obsolete in many places of the world, is gaining considerable renewed attention, having been cast more recently in the light of learner-centric philosophy [23], [35], [37]. Authentic because it is rooted in the practice of discourse, formative because it is highly engaging and feedback-oriented, oral assessment has been hailed as 'assessment for 21st century learning' [27], [68]. Among the recognized and researched benefits of oral exams are their potential to (1) encourage higher-order thinking, deep learning, and conceptual understanding [24]–[27], [47], (2) promote reflective and metacognitive practices among students, important for efficient self-regulated learning [30], [64], (3) aid the development of students' oral communication skills [36], [30], [37], [30], [38], including their understanding of disciplinary terminology and ability to articulate arguments and provide clear and coherent explanations [35], [69], [70], (4) foster professional identity formation [18], [37], [70], (5) cultivate meaningful student-faculty relationships and sense of belonging [28]–[34], and (6) reinforce academic integrity and ethical reasoning [23], [31], [39]–[44], [34].

Despite the pedagogical appeal of oral exams, educators are often hesitant to adopt them as an assessment modality because of discouraging implementation challenges and concerns over implicit bias and student stress [23], [36], [37], [71], [25], [32], [45]. Foremost among the implementation challenges is scaling oral exams to high-enrollment classes [28], [36], [37], [45]–[47]. Providing instructional assistants (IAs) with proper assessment and implicit-bias training programs [47], [72] and involving them in the administration of oral exams has been proposed to address the exorbitant time and effort required to administer individual oral exams to all students [31], [38], [47], [72]. Even with IA support, oral examination of all students individually can be an ambitious undertaking requiring several days to complete and extensive scheduling and logistic support [31], [38], [73]. Group oral exams have been proposed as a solution to further cut down the demand on administrative time and resources, while also promoting peer learning and inclusion [36], [74]–[76].

Peer-review sessions

Peer-review sessions, like oral exams, are a learner-centered pedagogical practice aiming to promote a culture of discourse, feedback, reflection, and self-regulated learning, while helping to develop students' interpersonal skills and growth mindset essential for the 21st century workplace [19], [20], [50]. Different models of peer review exist and have been extensively reported in the literature [77], [78]. These commonly go by the names of peer evaluation, peer assessment, peer grading, peer review, peer-feedback sessions, peer instruction, and peer coaching. Though face-to-face interaction is not an essential requirement for the first four listed, all commonly or typically involve live communication and feedback.

Motivation

The idea for peer oral exams in which students are the central and sole participants originated from the instructor's experience with conducting conventional instructor-led oral exams in an earlier offering of the same course (Winter Quarter 2021) [34]. These oral exams consisted of students displaying the code they developed for homework and answering questions about it

posed by the examiner. In reviewing students' code and discussing it with them, the instructor, much to his delight, learnt of a number of until then unfamiliar to him MATLAB built-in functions and capabilities, new syntax, clever alternative solutions to problems, and even learning strategies and resources students used to come into the knowledge of new information and coding approaches, some of which were not taught in lecture or covered in the textbook. The instructor was compelled on pedagogical grounds to share certain aspects of the code examinees presented to him with the rest of the class; he concluded, if oral exams afforded him – as examiner – an opportunity to become more aware of diverse coding styles, solution approaches, and learning preferences of students, then students should similarly benefit from taking part in the engaging role of peer examiners. Moreover, peer oral exams are easily scalable since the instructional team does not take direct involvement in them; hence, several such exams can be organized during an academic term, which has the effect of significantly increasing quality dialogic interaction time among students at little administrative expense. Besides enhancing learning, increased interaction time was also seen as a means to promote a sense of community among learners during a time of physical isolation and remote course delivery imposed by the pandemic. For the above reasons, the instructor decided to pilot peer oral exams in the next offering of the course (Spring Quarter 2021).

Several differences ought to be noted between peer review, as conventionally implemented, and peer oral exams to further emphasize the motivation for the latter. Firstly, in peer review, students in reviewer roles typically evaluate or write a critique of the work of their peers before meeting with them, whereas during the meeting, they go through the work with them, giving their critique or explaining their evaluation and offer pointers for improvement [78], [19], [77]. In peer oral exams, on the other hand, the objective of the peer examiner is to dynamically probe the peer examinee's knowledge and understanding, or, technically speaking, to interrogate the fellow classmate and extract from them relevant information bit by bit, as in conventional instructor-led oral exams [23], [28], [30], [31], [36], [70], [71], [79]–[81]. Thus, peer oral exams are intended to give more authority to the peer examiner to explore the examinee's thinking process, the rationale behind their programming choices, and even the resources used to acquire the knowledge to deliver the solution. Secondly, because peer oral exams are 'exams' by designation, their significance as one of the course activities is in students' minds likely elevated, so students in either role are probably more inclined to approach the activity with greater consideration or thoughtfulness. Calling such exams alternatively by the names of 'peer oral quizzes' or 'peer oral assessments' is likely to produce a similar effect. Lastly, peer oral exams allow the students to target their peers' knowledge of low- and high-level programming constructs and principles. This process gives them greater agency in deciding where to take the conversation and greater adaptability in evaluating their peer's state of knowledge, in comparison to more conventional implementations of peer review.

Implementation Details

Peer oral exams, as defined in this pilot study, are oral exams conducted entirely by learners, where students alternate roles of exam taker and examiner. We report on our implementation of peer oral exams in a large-enrollment remotely delivered computer programming course for

engineering analysis. The peer oral exams took place in the seventh and tenth week of the academic quarter and were preceded by instructional-team-led oral exams in the fourth week (Table I). The oral exams in the fourth week were an opportunity to model the kind of structured interaction between examiner and examinee, involving the adaptive probing of deeper levels of knowledge and provision of feedback, that will be expected during the student-led peer oral exams in later weeks. Written guidelines were developed and provided to students to further assist them in effectively conducting peer oral exams, both as exam takers and examiners.

Table I. Timetable of assessment activities and survey events

Week	Assessment activities and survey events
1	Beginning-of-quarter survey
4	Oral exam led by instructional team
5	Post-oral-exam survey
7	First peer oral exam
8	Peer-oral-exam survey
10	Second peer oral exam
11	End-of-quarter survey

The instructional-team-led oral exam and the two peer oral exams were each worth 5%, for a total of 15% of the overall course grade. These exams were aimed at testing students' understanding of central programming constructs and principles in the context of their weekly homework assignments. Together with homework, which accounted for the remaining 20% of the course grade, these low-stakes oral assessments were in part envisioned as preparation for the higher-stakes written exams: the first and second midterm exam (worth 15% each) in Week 6 and 8, and the final exam (35%) in Week 11.

Each peer oral exam was divided into two separate parts to allow every student in the class to engage in both examiner and examinee roles. While matching students for the assessment activity can be easily accomplished through a typical learning management system, we opted instead to use an in-house developed protocol accounting for students' weekly schedules. Students first sign up for the peer oral exam through a Google Form in which they specify free times in their weekly schedules when they would likely be available to take part in the peer oral exam. Our automated pairing system then pairs students for the exam in such a way as to minimize scheduling conflicts. The system also sends two automatic emails to each student respectively informing them of their selected peer examiner and peer examinee, each peer's contact information (email address), basic expectations, and potential times that would likely work well for the peer oral exam for each party. While the peer examiner of each student was generally different from their peer examinee, the algorithm used to match students only took into consideration students' schedules and did not preclude the possibility of repetitive matching.

All oral exams were virtual and facilitated by the Zoom telecommunications-and-screen-sharing software. As this was a pilot implementation, the scoring of instructor-led and peer oral exams in was based exclusively on participation and adherence to the guidelines. In Week 4, the instructor and instructional assistants probed the students' knowledge, helped them recognize areas of improvement, and gave them brief pointers on how to better their coding. About a week in advance of the peer oral assessments in Weeks 7 and 10, students were given a list of possible

questions to ask their peers, while also being instructed to develop a dozen of their own questions as a valuable exercise in reflection on the main learning objectives of the course. Students then independently conducted the assessment process and used Zoom to record their peer oral exam sessions. The recordings were submitted to the instructional team via the learning management system for potential review. The scores for the activity were then assigned by the instructional team. Students did not take part in the scoring process. Instead, emphasis was given to the transfer of knowledge and coding experiences between students through dialog. Students' role was thus restricted to testing each other's understanding of the code and to exchanging feedback orally. The peer oral exams, together with the oral exams administered by the instructional team earlier in the academic term, amounted to an expected 90 minutes of dialogic engagement for each student in the remotely offered course, which is expected to have significantly increased quality interaction time and knowledge transfer among learners.

Research Methodology

To explore the potential benefits of peer oral exams and how well students received them, we used a survey instrument consisting of four questionnaires: a beginning-of-quarter questionnaire, post-oral-exam questionnaire, post-peer-oral-exam questionnaire, and end-of-quarter questionnaire. Surveys were conducted in the first, fifth, eighth, and eleventh week of the academic term. The questionnaires were implemented in Google Forms and involved Likert-scale and free-response questions. Students were invited to complete each questionnaire through an electronic class announcement sent via the learning management system. Completion of the questionnaires was voluntary and anonymous, and all gathered data was de-identified prior to analysis.

Descriptive and inferential statistical analysis is used to better understand students' perceptions of peer oral exams and how these perceptions correlate with gender identification. Dimensions of peer oral exams are further explored by performing inductive thematic analysis of students' free responses to open-ended survey questions.

Results

There were 141 students enrolled in the MATLAB programming course (46 females, 95 males), of which 114 (80.9%) completed the beginning-of-quarter questionnaire, 76 (53.9%) the post-oral-exam questionnaire, 69 (48.9%) the post-peer-oral-exam questionnaire, and 50 (35.5%) the end-of-quarter questionnaire. All the questionnaires contained Likert-scale questions shown in Tables II-V, with the offered multiple-choice response options being: *Not at all*, *Slightly*, *Moderately*, *Significantly*, and *To a great extent*.

For the purpose of analyzing differences in perceptions between male and female respondents using the Wilcoxon-Mann-Whitney (WMW) test, the following ranks are assigned to the five-point Likert scale response options: *Not at all* = 1, *Slightly* = 2, *Moderately* = 3, *Significantly* = 4, and *To a great extent* = 5.

Beginning-of-quarter survey

In the first week of the quarter, students were asked to share their expectations about oral exams by providing responses to the five-point Likert-scale questions shown in Table II. The survey

response rate was 80.9%. A little above a quarter of the respondents expressed skepticism that oral exams will positively contribute to the academic integrity of the course, while the remaining respondents expressed either a moderately strong or very strong belief that oral exams will have a positive effect in this regard (8/19/35/27/11%). Respondents indicated feeling slightly less strong about the potential of oral exams to promote the development of their technical speaking skills (6/31/30/26/7%) and subject mastery (13/19/33/30/5%). The possibility of undue stress being caused by oral examination was a moderate to high concern for many (5/14/36/27/17%), while potential examiner bias was less so (18/31/28/15/8%). Most students indicated feeling quite comfortable speaking to a professor, though certainly not all (6/28/32/20/14%).

Table II. Beginning-of-quarter survey.

#	Question	Not at all/ Slightly	Moderately	Significantly/ To a great extent
1	Do you believe oral exams will contribute positively to the academic integrity of a course?			
2	Do you feel oral exams will help you improve your technical speaking skills?			
3	Do you believe that having oral exams in a course will help you master the subject material better or provide extra incentive to do so?			
4	Do you worry about oral exams because they will cause you undue stress?			
5	Do you worry about oral exams because they will be subject to bias from the person conducting the exam?			
6	Do you feel comfortable talking to a professor?			

Survey response rate: 80.9%. Percentages in the table are rounded to nearest whole number.

The beginning-of-quarter survey also gathered student gender data. The WMW test reveals statistical differences in the response distribution to several survey questions at the 5% significance level between male and female participants. Male students tended to feel significantly more strongly (13/9/34/37/6%) than female students (12/37/32/17/2%) that oral exams will help them master the subject or incentivize them to do so ($z = 2.69$, $p = 0.0072$). Female students tended to indicate greater concern that the oral exams will cause them undue stress (2/14/33/21/29%) than males (7/13/38/31/10%), though the difference was not statistically significant at the 5% level ($z = –1.52$, $p = 0.1275$). Survey results however indicate male students felt far more comfortable (3/18/29/28/22%) than their female classmates (10/44/36/8/3%) talking to a professor ($z = 4.63$, $p < 0.0001$).

To the open-ended question: “Do you have any other thoughts you would like to share with us about oral exams?”, fifteen students responded, the majority (8/15) expressing some form or degree of apprehension towards oral examination. One student wrote: “Can be uncomfortable for some students and can create a disadvantage for more reserved students.” Another added: “I'm a person who has a hard time communicating, I believe it will be give me too much stress.” The role of oral exams in promoting communication and sense of connection was commented upon too: “Because we are in a pandemic, this seems like a good way to fill in a communication gap.”

The remaining comments were positive towards oral exams and of generic content (3/15), or neutral and of miscellaneous content (4/15).

Post-oral-exam survey

Following oral exams administered by the instructional team in Week 4, students were invited to complete the post-oral-exam questionnaire (Table III). The response rate was 53.9%. Responses indicate most survey participants felt strongly that they performed well on the oral exam (11/3/22/30/34%). Their overall sentiment that the oral exam appropriately tested their knowledge of the subject was highly positive (3/5/19/38/35%). Most participants felt moderately or strongly that the oral exam required a greater level of conceptual understanding in comparison to a written exam, while a quarter of them did not (6/19/33/32/10%). The majority of respondents agreed they prepared differently for the oral exam compared to the written exam, though a sizeable fraction differed (14/25/32/22/8%). The sentiment that preparation for the oral exam bolstered understanding of the subject matter was widespread (3/15/35/30/16%). Similarly widespread among participants was the opinion that the oral exam helped them identify concepts they still struggle with (3/14/29/38/16%). Students were to various degrees more nervous for the oral exam than for a written exam (14/13/32/19/23%), though most reported being able to overcome nervousness during the exam (4/15/31/27/23%). Respondents overwhelmingly agreed

Table III. Post-oral-exam survey.

#	Question	Not at all, Slightly, Moderately, Significantly, To a great extent
1	Do you feel you did well on the oral exam you just took?	
2	Do you feel the questions appropriately tested your knowledge of the subject (irrespective of whether you did well or not)?	
3	Do you feel the oral exam requires a higher level of conceptual understanding compared to the written exams?	
4	Did you prepare differently for the oral exam compared to a written exam?	
5	Do you feel that preparing for the oral exam improved your understanding of the subject matter?	
6	Do you feel that taking the oral exam helped you realize which concepts you still struggle with?	
7	Were you more nervous for this oral exam compared to a written exam?	
8	Were you able to effectively overcome nervousness during the oral exam?	
9	Do you feel the examiner treated you respectfully and fairly?	
10	Do you feel the examiner cared about your learning in the course?	

Survey response rate: 53.9%. Percentages in the table are rounded to nearest whole number.

that their examiner treated them respectfully and fairly (0/3/3/24/71%) and cared about their learning (4/1/8/29/58%). No statistically significant differences in response distributions were found at the 5% level between male and female students.

The questionnaire also included the free-response question: “Do you have any other thoughts you would like to share with us about this oral exam? What went well? What could be improved?”. Ten responses were collected, all signifying students’ receptiveness to the assessment modality. Three responses highlighted the power of oral exams to test true understanding, with one student elucidating: “I enjoyed the oral exam because it forced me to really understand my code and why I did a certain thing.” Another remarked: “The student realizes how well they actually understood the concepts.” The remaining comments expressed students’ satisfaction derived from the interaction with the examiner (2/10) and students’ perception that the exam was fair (4/10).

Post-peer-oral-exam survey

Two peer oral exams were held in the second half of the quarter, in Weeks 7 and 10. Upon completion of peer oral exams in Week 7, students were invited to complete the peer-oral-exam questionnaire (Table IV). The response rate was 48.9%. Participants agreed on average to a

Table IV. Post-peer-oral-exam survey.

#	Question	Not at all/ Slightly	Moderately	Significantly/ To a great extent
1	Do you feel the peer oral quiz helped you learn the material?			
2	Do you feel that taking the peer oral quiz helped you realize which concepts you still struggle with?			
3	Did you feel nervous talking to your peer assessor?			
4	Did you feel nervous talking to your peer assessee?			
5	Do you feel your peer assessor treated you respectfully and fairly?			
6	Do you feel that as peer assessor it was easy for you to remain fair and unbiased?			
7	Did you find the peer oral quiz to be fair and accommodating to you?			
8	Do you feel the peer oral quiz contributed to a sense of community in the course?			
9	Do you feel the peer oral quiz positively impacted your motivation and engagement in the course?			
10	Do you feel the peer oral quiz contributed positively to academic integrity in the course?			
11	Do you feel the peer oral quiz enriched your course experience in a beneficial way?			
12	Do you recommend peer oral quizzes for this course when it is taught remotely?			
13	Do you recommend peer oral quizzes for this course if it were taught in person (i.e., after COVID-19 is over)?			

Survey response rate: 48.9%. Percentages in the table are rounded to nearest whole number.

moderate extent that the peer oral exam helped them learn the relevant course material (8/23/38/28/3%). They similarly agreed that the peer oral exam helped them identify concepts which they had not adequately understood (12/17/37/28/6%). Most participants indicated feeling slightly to moderately nervous talking to their peer examiners (27/28/28/11/6%) and peer examinees (31/32/24/6/6%). Participants strongly believed their peers treated them respectfully and fairly during the oral exams (3/2/5/31/60%). Responses indicate students believed they were able to easily remain fair and unbiased when acting as examiners (2/3/18/38/39%). Respondents largely agreed the peer oral exam was fair and accommodating (0/8/15/48/28%). There was a widely shared sentiment that the peer oral exam contributed to a greater sense of community (5/15/26/36/18%), positively impacted motivation and engagement (11/20/23/33/14%), and benefited academic integrity in the class (6/12/27/37/18%). The view that the peer oral exam provided for a richer course experience was similarly shared by many (7/16/27/36/13%). Overall, students who completed the questionnaire expressed encouraging support that peer oral exams be offered in future remote offerings of the same course (6/16/24/36/18%), as well as in-person offerings (12/16/30/31/11%).

Disaggregating the response data by gender and running WMW tests reveals female students (8/25/33/17/17%) felt significantly more nervous talking to their peer examiner than did their male (37/30/25/8/0%) classmates ($z = –3.29$, $p = 0.0010$), and also more nervous (24/28/24/8/16%) than males (35/35/25/5/0%) when talking to their peer examinee ($z = –1.81$, $p = 0.0707$). Males, on the other hand, felt significantly more strongly (7/15/15/48/15%) than females (15/27/35/12/12%) that the oral exam positively impacted their motivation and engagement in the course ($z = 2.25$, $p = 0.0243$).

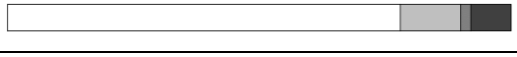
Six survey participants responded to the open-ended question: “Do you have any other thoughts or concerns you would like to share with us about the peer oral quiz? What did you like? What could be improved?” Two responses point out that the peer-assessment experience of one student is highly dependent on the meaningful engagement of the other student involved, regardless or role, with one responder writing: “It's a cool idea. The problem I have is that if my assessor doesn't have any advice to say to me or my assessee doesn't understand their code, there's no benefit to me.” The remaining responses express that the peer oral exams could benefit from clearer instructions on the examination procedure. One such response reads: “I think the peer oral quiz tends to be more disorganized than a regular instructional team led quiz.”

End-of-quarter survey

At the end of the course, students were issued a final summative survey, shown in Table V. The response rate was 35.5%. Most respondents agreed that oral exams contributed to their learning (8/18/46/24/4%), positively influenced their learning approach (6/26/28/34/6%), and increased their motivation to learn (12/18/34/26/10%). Respondents largely shared the impression that oral exams moderately to highly contributed to academic integrity in the course (8/10/18/46/18%). Many participants agreed oral exams helped improve their technical speaking skills (10/14/34/30/12%). Oral exams were noted to have caused some undue stress among students (16/46/14/18/6%), but also helped them deal with nervousness more effectively (18/34/32/14/2%). Respondents largely found oral exams fair and accommodating to them

(0/4/24/46/26%). The sentiment that examiner bias was manifest was mostly absent (78/12/2/8/0%). Respondents perceived having oral exams in the course as beneficial, whether the course is offered remotely (14/16/18/48/4%), or in person (18/20/22/38/2%). Participants indicated a moderate preference for oral exams over written exams (16/16/24/24/20%).

Table V. End-of-quarter survey.

#	Question	Not at all/ Slightly	Moderately	Significantly/ To a great extent
1	Did the oral exam(s) help you master the subject material better or provide extra incentive to do so? Did they contribute positively to your learning in the course?			
2	Did the oral exam(s) influence your approach to learning in a positive way?			
3	Did the oral exam(s) increase your motivation to learn?			
4	Do you feel the oral exam(s) contributed positively to academic integrity in the course?			
5	Do you feel that the oral exam(s) helped improve your technical speaking skills?			
6	Did the oral exams cause you undue stress?			
7	Did the oral exam(s) help you with how to better deal with nervousness?			
8	Did you find oral exam(s) to be fair and accommodating to you?			
9	Do you believe that there was inappropriate bias from the person conducting the exam?			
10	Do you feel it is beneficial to have oral exam(s) for this course when it is taught remotely?			
11	Do you feel it would be beneficial to have oral exam(s) if this course were taught in-person (i.e. after COVID-19 is over)?			
12	Do you prefer oral exams over written exams?			

Survey response rate: 35.5%. Percentages in the table are rounded to nearest whole number.

As in previous surveys (Tables II-IV), male students expressed experiencing less stress (18/57/14/11/0%) in comparison to female students (14/33/14/24/14%), though unlike previously, the difference was only borderline significant ($z = –1.92$, $p = 0.0546$). Differences in responses to other questions were not found to differ between male and female students at the 5% significance level.

The end-of-quarter questionnaire included an additional four free-response questions: (1) “What were the best aspects of the oral exams? What did you like?”; (2) “What are the areas for improvement in the oral exams?”; (3) “Did you notice a difference between an oral exam administered by an instructor versus a TA, tutor, or peer, or between different TAs/tutors/peers, and if yes what were these differences?”; (4) “Do you have any other thoughts you would like to share with us about the oral exam(s) you have taken in this course or about oral exams in general?” The questions garnered 29, 21, 22, and 9 responses, respectively, or, 81, collectively.

On the large set of responses, thematic analysis was performed. Each response was associated with one or more themes, categorized by question, and presented in Table VI. Any response to the generic free-response question 4, answering to one of the specific free-response questions 1-3, was taken in the analysis for a response to the latter. The frequency of themes encountered in the responses of survey participants to each of the three questions is displayed in Table VI.

Table VI. Thematic analysis of students' responses to open-ended questions

Category	Theme	Codes	Freq.
Best aspects of oral exams (33 responses)	Peer learning	Learning new solution approaches/coding styles from peers, easier to exchange knowledge with peer, agency	10
	Sense of connection	Chance to meet classmates, connecting with new people, friendly interaction	7
	Engagement in discourse	Practice technical speaking, learning through conversation, communicating thought process	7
	Focus on understanding	Exam tests true understanding, not memorization or ability to reproduce	7
	Fair/accommodating assessment	Reduced stress, informal/not intimidating, accommodating	7
	Feedback/reflection	Receiving feedback, preparing questions as examiner	3
	Increased motivation/ encouragement to learn	Motivation to understand/demonstrate mastery	1
	Promotes academic integrity	Lessens cheating	1
Areas of improvement for oral exams (23 responses)	More open discussion	Allow for free-format conversation and sharing	5
	Clearer procedures	More guidance on how to conduct peer oral exams	4
	Too long	Peer oral exams are unnecessarily long (20 min. each role)	4
	Difficulty in preparing suitable questions for peers	Can't know what peer's code will look like, so questions prepared in advance may not be applicable	2
	Meet more classmates	Connect with more people, form groups greater than two, avoid having examiner also for examinee	2
	Scheduling	Scheduling difficulties/conflicts, peer does not show up	1
	Connection preferences	Allow pairing for exam based on experience level or other attributes	1
	Too stressful	Undue stress/anxiety	1
Differences between oral exams administered by instructor versus TA or peer (25 responses)	Less stress with peer	Easier to talk to peer, reduced anxiety	8
	Insignificant difference	Same/similar experience or benefit	6
	Peers challenge you more	More difficult questions from peers, more thorough quizzing, more material covered	4
	More awkward with peers	Smoother examination with instructor or TAs, more pauses/hesitance with peers, unsure what to do	2
	TA goes deeper	TA dwells longer on a question, more follow-up questions	1
	Harder to coordinate times with TA	TA availability was not as flexible as that of peers, less available slots for oral exam with TA	1

Of the open-ended responses answering to the first question related to best aspects of oral exams, the largest number (10) was associated with the theme of peer learning (Table VI). "*Being able to learn new types of coding approaches*," one student indicated as the best aspect. "*We learned from our peers*," another explained. Sense of connection was another recurring theme (frequency = 7). "*I liked meeting new people and learning about functions that I wouldn't have known on my own*," one response reads. "*Open conversation about the code as well as connecting to other students in the course*," reads another, also inclusive of the third theme, engagement in discourse. Six more responses incorporated this theme, one of which reads: "*The ability to communicate my thought process*." As one of the best aspects of oral exams, students equally often quoted that it was understanding-focused. Exemplifying this fourth theme is the response: "*It tested overall understanding and not just troubleshooting ability*." Seven other responses were in connection with the fairness of oral exams, the fifth theme under the first category. Students remarked that the oral exams were friendly and accommodating, with one student noting: "*I liked that it was more of a discussion than an exam which reduces stress*." Another three responses touched on feedback and reflection, the sixth theme, one such response reading: "*I like being the assessor and thinking of questions to ask because that also helped me learn the material more.*" One respondent wrote: "*I liked how it encouraged and basically forced me to understand the material both as a test taker and tester*," which response is associated with the seventh theme of increased motivation or encouragement to learn. Another student brought up the last theme of academic integrity, commenting: "*Being asked about your code and explaining the way we did in quizzes with TA and peers, in my opinion, encourages better knowledge and lessens cheating*."

Another set of themes emerged in the analysis of students' responses to the second open-ended question on areas of improvement (second category, Table VI). The theme most represented among responses to this question (frequency = 5) pertained to the desire of students to be able to engage in discussion as they choose, rather than in the peer-assessment format defined. One student expressed their views as follows: "*I wish we could exchange our idea for coding, not just asking questions.*" Clear procedures on how to conduct the peer oral exam surfaced as a relatively common theme as well (frequency = 4), with students citing being unsure what to ask their peers, what exchange is allowed, or how to submit recordings. Another four responses suggested that the peer oral exams (20 minutes for each role) were unnecessarily long (third theme in the second category). The inability to anticipate their peer's code was noted by two students to have prevented them from asking questions they prepared in advance (fourth theme). One student proposed: "*Having the person who is being assessed share their code before the quiz so it's easier for the assessor to come up with questions.*" A desire to meet more classmates (fifth theme in the second category) was articulated in two responses, with the suggestions that more than two peers be involved in peer oral exams. Students also suggested that precautions be taken to prevent the occurrence of the same student being assigned to another as both peer examiner and peer examinee. Although such cases are rare, they are not precluded by our scheduled-based student-matching algorithm, and this is something that can be improved. Scheduling was indicated in one response as an area of improvement as well (sixth theme), citing the frustration of having a peer not show up. Allowing peers to connect for peer oral exams based on performance (experience level or other attributes) was suggested in another response

(seventh theme). One student's response quoted high stress due to the oral exams (eighth theme in the second category).

Six themes were abstracted from the responses to the third open-ended question about differences between oral exams administered by the instructor versus the TAs or peers (third category, Table VI). Less stress during the interaction with a peer was the most frequently occurring theme, with which 8 responses were associated. "*There wasn't much of a difference, other than the nervousness with the professor and a bit less nervousness with peers*," one student communicated. "*I felt more calm during pure quizzes than with the TA*," another commented. Six students stated that the oral exam and peer oral exam were very similar (second theme in the third category). Four responses expressed that more difficult questions came from their peer examiners than from the instructor or TA (third theme in the third category). One student wrote: "*These quizzes we did with peers were, covered more material, and in a way the questions developed by students were sometimes more difficult which, is good*." Awkwardness during peer oral exams was another theme, found in two responses. "*The peer oral exams were a little more awkward/had the more pauses in between questions while people were thinking of what to ask*," explained one participant. Another indicated that the depth of questioning (fifth theme) differed between teaching assistants and peers: "*TA's ask fewer questions but dwell on a question longer*." Coordinating oral exam times was harder with TA than with peers, according to one student (last theme).

Discussion

Deeper learning

The analysis of student perceptions of peer oral exams reveals that many students appreciated the aspects of peer learning typically associated with peer assessment, such as autonomy ("*I liked that the students ran the oral exams*," one student wrote), sharing of solution approaches, and peer feedback [48], [78], [82]. Students' responses to Likert-scale and open-ended questions (Tables IV-VI) paint peer oral exams as a learner-centered practice that was well received by students and conducive to their learning, skill development, and satisfaction. Such favorable perceptions are predicted by research to result when peer assessment is situated in a problem-based learning context which requires students to engage their higher-order cognitive skills, such as critical thinking, analytic reasoning, creativity, evaluative judgment, and mindful communication [18], [83]. We believe this was the case in our implementation of peer oral exams, which students largely described in their survey responses as focusing on the understanding of solution approaches and programming concepts (fourth theme, Table VI), as opposed to simple declarative or procedural knowledge.

Earlier work likewise underscores the potential of oral assessment to encourage deep learning and concept mastery [24]–[27]. This potential is in part due to the well-documented influence assessment has on students' study and test-preparation strategies, i.e., the backwash effect [27], [64], [84]. But it also derives from the intimate reciprocal relationships and interactions between speech and other cognitive faculties and processes which enable us to engage in abstract thinking, interpretation, evaluation, reflection, and internalization - all of which contribute to the

building of conceptual knowledge [85]–[89]. On top of the backwash effect and language-thought reciprocity, the social context of oral exams potentiates deep learning through its conscious and unconscious influence on the students' awareness, receptiveness to new information and views, and readiness to engage in deeper-level processing [90]–[93]. The construction of knowledge is naturally aided and supplemented when the process is extended outside oneself (intrapersonal learning) to include others (interpersonal learning), especially peers (peer learning) [93]–[96].

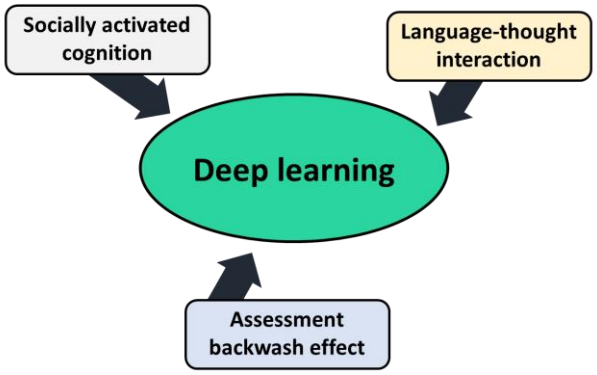


Figure 1. Illustrative summary of three distinct, though interrelated components factoring into deep learning and germane to peer oral assessment.

While dialog is an important part of social learning, social interaction has been shown - even in the absence of verbal communication - to stimulate deep learning processes [97]. Similarly, speech - a hallmark of interpersonal communication - can be readily exercised outside a social setting, as discourse with self (intrapersonal communication, vocalized or unvocalized). With this separability of speech and social interaction in mind, in Fig. 1 we highlight, by way of summary, three distinct, though interrelated components factoring into deep learning and germane to the context of (peer) oral assessment: (1) socially activated cognition, (2) language-thought interaction, and (3) assessment backwash effect.

These three components which are thought to encourage deep learning are seen reflected in our students' responses to survey questions. Concerning the language-thought relationship and its effect on deep learning, one student wrote that the best aspects of (peer) oral exams were: "*The different way we can interact and sometimes it really show how we master if we can talk about it.*" Thematic analysis identifies the theme 'engagement in discourse' as arising relatively frequently in students' free responses answering to the open-ended question on the best aspects of oral exams (Table VI). In this connection, students' perceptions of the influence of (peer) oral exams on the development of their speaking skills, as captured through their responses to the Likert-scale questions, indicated moderate conviction that the assessment practice positively affected them in this regard (Tables II and V). Their Likert-scale responses also indicated they felt (peer) oral exams helped them, to a moderate to significant extent, realize concepts which they still struggle to fully understand (Tables III and IV). Students' responses to related questions pertaining to conceptual understanding and subject mastery more broadly, were similarly encouraging, suggesting that the dialogic nature of assessment (and peer engagement) incentivizes and supports their efforts toward the two learning goals (Tables II, III, V). These

findings, however, should be taken with caution, given the lower response rates on surveys conducted later in the academic term (see next section on threats to validity).

Beyond the language-thought interaction stimulated by dialog, social connection appears to have positively affected students' course experience, as respondents generally found that peer oral exams favorably contributed to a sense of community in the course (Table IV). Connection to community - a basic human emotional need - is known to positively affect motivation and self-efficacy through a desire for mutual engagement, shared experiences, recognition of achievements, and identity assertion [98]. Encouragingly, many students have indicated that peer oral exams positively impacted their motivation and engagement in the course (Table IV). Further research involving motivational analysis would help resolve and confirm the contributing factors.

As to the backwash effect, survey respondents agreed to a moderate extent that they prepared differently for the (peer) oral exams in comparison to written exams, and that the former influenced their approaches to learning in a positive way (Tables III and V). Such views by students imply that the piloted assessment practices of oral and peer oral exams are a promising means for shaping students' learning habits and guiding their learning toward deep conceptual understanding.

Assessment fairness

Earlier literature highlights the potential problems of implicit examiner bias, lack of fairness, and excessive student stress potentially affecting the assessment practice, which could lead to unfavorable student experiences and inequitable educational outcomes [23], [37], [25], [79]. In the implementation of oral and peer oral exams described in this study, survey participants overwhelmingly found oral exams with and without peers to be fair and accommodating to them, and indicated feeling respectfully treated and that they did not perceive inappropriate bias from the examiner at a concerning level (Tables III and IV). Similarly, despite beginning-of-quarter anxieties (Table II), participants found oral exams not excessively stressful, with peer oral exams being regarded as the least stressful experiences (Tables III-V). Of course, some degree of stress is expected with all performance-based assessments, and should not be regarded as necessarily bad, given its potential as a negative activating emotion to improve student determination to learn and stimulate learning efforts [99].

Demographic group analysis reveals few significant differences in the Likert-scale responses among students of different gender. These differences particularly concern the impact of oral assessment on stress and motivation levels of male and female students (Tables II-V). Despite these differences, both female and male respondents strongly agreed in overwhelming proportion that they found oral assessments to be fair and accommodating to them. These findings support the view that oral exams, including peer oral exams, have the potential to serve as fair and equitable assessment practices, complementing more traditional assessment methods, such as written exams [34], [47], [79], [81]. Further study is necessary to investigate the factors affecting students' perceptions of assessment fairness, such as the low-stakes nature of oral exams as implemented in our course, the fact that the instructor and TAs underwent training in oral

assessment best practices as described above and in previous work [47], [72], and the fact that the instructional team provided modeling and written guidance for students on how to conduct oral exams before they had to do it for the first time themselves.

Lastly, in discussing fairness of assessment, we point to the fact that students' peers are generally a richer and more diverse population than the instructional team, which numbers only a few persons. More critically, the instructional team profile may reflect outstanding institutional inequities in racial-ethnic, gender, and other representations, which could have a negative effect on some students' perceptions of the fairness of assessment and overall course experience. For example, only about 15-20% of engineering faculty in the US are women, which can unfavorably translate to students' oral assessment experience if it is only professors serving as examiners [100]. Though the student body may suffer from a similar representation imbalance, the scalability of peer oral exams allows for multiple such exams to be organized at tolerable expense with different examiner-examinee peer combinations for an overall more diversified and potentially more equitable student assessment experience involving face-to-face interaction.

Academic integrity

Survey respondents agreed moderately to significantly that the peer oral exams, and oral exams with the instructional team, positively contributed to academic integrity in the course (Tables IV and V). Such favorable perceptions of improved academic integrity may be in part due to the face-to-face interaction and dynamic questioning characteristic of the oral assessment practice, which render typical cheating modalities, such as copying, impractical. Owing to this quality, oral exams have been praised as assessment instruments highly resistant to cheating and enjoyed broad adoption as a remedial intervention suitable for remote instruction during the COVID-19 pandemic, when academic integrity violations were dramatically rising [101], [102]. Nevertheless, other aspects of (peer) oral exams may have contributed to shaping students' views about their impact on academic integrity, possibly even more (Fig. 2).

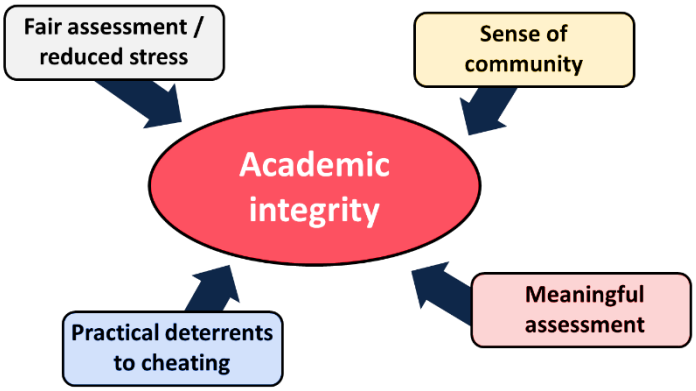


Figure 2. Illustrative summary of components supporting academic integrity and closely related to peer oral assessment.

One such aspect is their perceived fairness. Students completing the surveys were overall welcoming of (peer) oral exams, did not find them unduly stressful, expressed the exams supported their learning, and recommended them for future use (Tables III-V). Thus, the principal reasons for academic cheating, as identified by integrity research [103], [104], namely,

stress overload, perceived exam unfairness, unsupportive learning environments, unrealistic expectations, and fear of failure, were largely absent in the context of low-stakes formative (peer) oral exams, as implemented.

Moreover, students' impressions that oral exams with peers contributed to a sense of community in the course (Table IV) further suggest that the immediacy of interactions and connections afforded by the assessment modality led to an enhanced sense of social and academic belonging among students (reduced sense of detachment and despondence), and thus a higher likelihood of adherence to community principles [105]–[109]. Students' positive perceptions that their examiner cared, following the instructional-team-led oral exams (Table III), may likewise have contributed to strengthening academic integrity in the course, as respectful caring relationships generally signify a disinclination to cheat and betray [106]–[108], [110], [111].

Students' characterization of (peer) oral exams as assessments focused on evaluating deeper levels of understanding (Table VI) hints at another aspect of oral exams potentially impacting academic integrity - their meaningfulness. It has been argued that meaningful assessment engenders greater motivation among students to learn and showcase their knowledge, creativity, and originality before the instructor and peers, which in turn curbs cheating [112]–[114]. This motivation is closely related to the intimate desire of students to develop their academic and professional identities, which necessarily entails valuing authentic authorship and original thought, taking pride in one's own work, and empowering one's own character through a commitment to intellectual honesty and professionalism [103], [104], [115].

Areas of improvement

Students voiced appreciation for the dialogic nature of oral assessment, while a number of them also recommended that peer oral exams be not so much structured as exams, with clear examiner and examinee roles, but permit the sharing of ideas in a more flexible, open-discussion format. We agree there is merit in this proposal, and we will look to relax some of the constraints on dialog in future implementations, while ensuring the peer activity is still seen by students as an assessment requiring as much due preparation, the exercise of evaluative judgment, and thoughtful and effective provision of feedback.

Suggestions that peer-oral-exam procedures be made clearer for more smooth conduct were likewise relatively common among students' written responses. Guidelines will accordingly be revised to eliminate students' doubts and uncertainties as to their roles, assessment objectives, and overall expectations.

Making oral exams shorter was also recommended by a few respondents. The optimal duration of peer oral exams depends on exam objectives and content- and course-specific circumstances, as well as the frequency of oral exams in the course, and will be taken up further in future work.

Sharing code with peers in advance of the peer oral exams was proposed as well by a few students, who argued that this would help them tailor more appropriate questions for the exam. This is a good point and can easily be addressed in future implementations of peer oral exams.

Involving more than two students in the peer oral assessment was suggested as a means of connecting more classmates together. Group feedback discussions are common in peer assessment, and the extension of peer oral exams to more than two peers is an appealing idea. For instance, matching two peer groups would be a realization of this, where one group is charged to examine the other through adaptive questioning and role sharing.

One respondent indicated that the benefit of engaging in peer oral exams extends only insofar as the peer examiner is able and willing to offer constructive feedback, and insomuch as the peer examinee understands their own code and can participate in a meaningful discussion over it. Students' expressions related to this one have been reported in earlier empirical studies dealing with peer assessment [116]. While the quality of a student's peer-assessment experience understandably depends on the ability and preparation of their fellow peer, it has been argued that there is still value to peer assessment even if students of differing levels of achievement or subject proficiency are matched [49]. Designing peer assessment for increased student satisfaction is a topic of ongoing discussion revolving around considerations of learning objectives, assessment structure, and preparational activities, including feedback training [77], [78].

Relatedly, it was suggested by one student that pairing by preferred attributes be implemented. The practice of pairing peers based on ability level, gender, minority status, etc., has been explored in computer programming (e.g., for pair programming) and other courses in the past, and some variants of it may be considered for peer oral exams in the future.

Scheduling challenges were brought up by one student and are briefly discussed in the next subsection on the scalability of peer oral exams.

Variance analysis of Likert-scale survey data disaggregated by gender showed that female participants tended to experience greater levels of stress than male participants when it came to oral assessment. This finding is in agreement with earlier research describing distinct experiences of female learners under different testing conditions [117], [118]. Despite the statistically significant difference in experienced stress levels between the two gender groups, the experienced stress by females on the instructional-team-led and peer oral exams ranged on average from slight to moderate, with the peer oral assessment regarded as the more comfortable of the two. As discussed above, some stress may be beneficial as it has the potential to serve as an activating agent [99]. Still, some students indicated experiencing significant stress. To what extent this was due to the particular implementation details of the oral exams, and to what extent it was due to their unfamiliarity with the oral modality of assessment, or potential anxiety associated with social interaction in general, or yet other factors, remains to be answered. Efforts to address the challenges of potential undue student stress in the context of oral exams and other testing environments are ongoing with the aim of tailoring inclusive, equitable, supportive, and growth-oriented assessment experiences for all students [27], [46], [47], [119].

Scalability

Our piloted implementation of peer oral exams in a class of 141 students serves as a proof-of-principle demonstration of the high-level scalability of such assessment, in conjunction with their

other pedagogically desirable features, such as the potential to promote deep learning, foster a sense of community, contribute to assessment fairness, and support academic integrity. The high scalability derives, on the one hand, from peer oral exams being exclusively student-led, and, on the other hand, from the availability of widely accessible information and communications systems and technologies (computers, high speed internet, learning management system, Zoom videoconferencing software) facilitating automatic pairing of students for peer oral assessment, remote real-time audiovisual connection between peers, recording of the assessment sessions for documentation purposes, and electronic submission of relevant files and recordings for credit. Thus, the practicability of implementation of peer oral exams as described is largely independent of class size.

While awarding credit to students for submitting required files and peer-oral-exam recordings (as evidence that they have completed the activity) can likewise be entirely automated, we have opted to have the teaching assistants manually check submissions via the learning management system and award credit based on completion and adherence to the guidelines on preparation and conduction of oral exams provided to the students beforehand. This manual verification did not take much time or resources, as the teaching assistants were merely tasked with casting an eye over the submissions to potentially catch if anything was out of place, i.e., they did not review the recordings at length or provide detailed feedback. Consequently, their efforts on this task did not comprise a considerable expenditure.

Adopting the approach of no instructional-team involvement in peer assessment (apart from initial guidance), which is quite common in educational practice [19], [77], allows multiple instances of peer oral exams to be organized in an academic term. A desired level of peer-to-peer dialogic interaction in support of students learning outcomes with respect to specific course content can thus be readily achieved.

Conversely, if the instructional team would opt to view the recordings in full and offer personalized feedback to students, which has high pedagogical merit, a practical limit on the scalability of peer oral exams would be necessarily imposed. The maximum class size in which peer oral exams would be practicable would strongly depend on the appropriated resources for the course - primarily the number of teaching assistants hired and their assigned workloads.

Finally, we comment on the effects of class size on scheduling. Generally, the higher the enrollment, the greater the probability that any two paired students will have unresolvable scheduling conflicts, preventing them from connecting for the peer oral exam at any suitable time. While in our experience, involving a class of 141 students in which peer oral exams were organized twice, such scheduling conflicts were minimal (we are only aware of one peer pair encountering scheduling difficulties), we propose as a possible solution the re-pairing of students in such situations with other classmates, either manually or using automated features of learning management systems that enable students to re-pair on their own, as needed.

Based on our experience, more frequent than unresolvable scheduling conflicts are failures of one of the two peers in a pair to show up for the exam out of forgetfulness, and the frustration experienced by the other peer as a result. In such cases, we have observed students typically

reschedule the exam for another time (before the final submission deadline), if possible. The problem of no-show is not specific to peer oral exams, as it affects peer assessment more broadly, as well as other educational peer activities. While missing to meet for peer assessment and having to reschedule is certainly a nuisance to all parties, to the offending party the experience may serve as a much-needed lesson in responsibility, time management, and respect toward fellow peers. At any rate, occurrences of no-show are easily addressable and not expected to significantly impact scalability.

Threats to Validity

Four surveys were administered as part of this study. The response rate dropped gradually from 80.9% on the beginning-of-quarter survey to 35.5% on the end-of-quarter survey. This could have been the result of survey fatigue or growing obligations that students were faced with as the academic term progressed which may have averted many of them from completing the later surveys. It also could be that a portion of the students became disinterested in completing the surveys due to the lack of continuous encouragement to complete them. Regardless of the cause of lower response rates, such rates undermine the validity of conclusions drawn from the survey results because the sample population of respondents may not be sufficiently representative of the overall class population. For example, students who were most susceptible to survey fatigue might have answered survey questions differently on average (had they completed the survey) than their peers who actually participated in it. Other attributes or traits of students influencing their willingness to partake in the survey may have similarly contributed to selection bias. Since the surveys were anonymous, we were unable to run a post-hoc analysis to comprehensively compare the sample population to the overall class population to assess the randomness of the sample, and therefore our interpretations of survey results must be taken with caution.

An additional bias in the results could be due to the response options used for the five-point Likert-scale of the survey, viz.: *Not at all*, *Slightly*, *Moderately*, *Significantly*, *To a great extent*. While such response options allow students to express the degree to which they experienced certain benefits related to oral assessment with reasonable resolution, the scale does not have a distinct neutral point, such as a scale based on the responses of *Strongly disagree*, *Disagree*, *Neither agree nor disagree*, *Disagree*, *Strongly disagree*. Both the former [120]–[123] and latter class of response options [124]–[127] are commonly used in Likert-scales of surveys administered in educational research, including validated survey instruments (*ibid*.). The class of response options should be borne in mind when interpreting the survey data, as summarized in Tables II-V, and discussed throughout the paper.

Finally, we note that the study of the potential benefits of oral and peer oral assessments relied on students' self-reported perceptions, which has its limitations. More direct measures of benefits would therefore be desired, such as measuring learning gains in a control-group setting, which, although outside of the scope of the present study, is a possible direction for future research.

Conclusion

We have explored some of the potential educational benefits and dimensions of peer oral exams as implemented and piloted in our high-enrollment undergraduate computer programming course

for engineers. The peer oral exams were introduced as an innovative blend of two evidence-based pedagogical practices: oral assessment and peer review. The idea was to conveniently combine the merits of each of the two latter pedagogical approaches into a new all-inclusive approach. The quality of dialogic examination to probe deeper levels of knowledge interactively and motivate students toward concept mastery was thus merged with the benefits of peer learning, reduced stress, and superior scalability associated with peer assessment.

To investigate students' perceptions and attitudes about peer oral exams, surveys by questionnaire were conducted four times during the course. Students' survey responses were very encouraging, with participants indicating they felt more comfortable being examined by a peer, and that peer oral exams provided a more challenging and beneficial learning experience due to a richer and more intense exchange of knowledge occurring between classmates. Some students also noted that their preparation of questions for their role as examiner benefited their learning as well, for it gave them an opportunity to reflect on their knowledge and understanding of key concepts of the subject. Based on student responses to Likert-scale and open-ended survey questions, class performance, and observations of the peer oral exam process, we have argued that peer oral exams are a promising tool to foster deep learning, improve students' communication skills, encourage self-reflection, enhance students' evaluative skills, build self-efficacy, create a sense of community, and promote professional identity development and academic success.

While our initial study offers an encouraging glimpse into the dimensions of peer oral exams and their potential role in educational practice, dedicated future research will be required to deepen our understanding of the theoretical and practical aspects of peer oral assessment, primarily the ways in which the highly personal, dialogic, evaluative, peer interaction may impact educational equity, assessment authenticity, and cognitive, affective, and behavioral outcomes in learners.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 2044472. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. Discussions with Sheri Sheppard, Elizabeth Holcombe, Adrianna Kezar, and Christine Alvarado are gratefully acknowledged.

References

[1] N. W. Gleason, Ed., *Higher Education in the Era of the Fourth Industrial Revolution*. Springer Nature, 2018. doi: 10.1007/978-981-13-0194-0.

[2] K. G. Fomunyam, "Education and the Fourth Industrial Revolution: Challenges and possibilities for engineering education," *Int. J. Mech. Eng. Technol.*, vol. 10, no. 08, pp. 271–284, 2019.

[3] J. A. Bellanca, *21st Century Skills: Rethinking How Students Learn*. Solution Tree Press, 2010.

[4] R. S. Grabinger and J. C. Dunlap, "Rich environments for active learning: a definition," *ALT-J*, vol. 3, no. 2, pp. 5–34, Jan. 1995, doi: 10.1080/0968776950030202.

[5] R. J. Sternberg and L. Zhang, Eds., *Perspectives on Thinking, Learning, and Cognitive Styles*, 1st ed. 2001.

[6] M. Prince, "Does Active Learning Work? A Review of the Research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223–231, 2004, doi: 10.1002/j.2168-9830.2004.tb00809.x.

[7] C. A. Estes, "Promoting Student-Centered Learning in Experiential Education," *J. Exp. Educ.*, vol. 27, no. 2, pp. 141–160, Sep. 2004, doi: 10.1177/105382590402700203.

[8] S. M. Land, M. J. Hannafin, and K. Oliver, "Foundations, Assumptions and Design," in *Theoretical Foundations of Learning Environments*, 2nd ed. Routledge, 2012.

[9] E. Lee and M. J. Hannafin, "A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it," *Educ. Technol. Res. Dev.*, vol. 64, no. 4, pp. 707–734, Aug. 2016, doi: 10.1007/s11423-015-9422-5.

[10] K. H. Cattaneo, "Telling Active Learning Pedagogies Apart: from theory to practice," *J. New Approaches Educ. Res. NAER J.*, vol. 6, no. 2, pp. 144–152, Jul. 2017.

[11] S. Hartikainen, H. Rintala, L. Pylväs, and P. Nokelainen, "The Concept of Active Learning and the Measurement of Learning Outcomes: A Review of Research in Engineering Higher Education," *Educ. Sci.*, vol. 9, no. 4, Art. no. 4, Dec. 2019, doi: 10.3390/educsci9040276.

[12] T. H. Morris, "Experiential learning – a systematic review and revision of Kolb's model," *Interact. Learn. Environ.*, vol. 28, no. 8, pp. 1064–1077, Nov. 2020, doi: 10.1080/10494820.2019.1570279.

[13] T. J. Crooks, "The Impact of Classroom Evaluation Practices on Students," *Rev. Educ. Res.*, vol. 58, no. 4, pp. 438–481, Dec. 1988, doi: 10.3102/00346543058004438.

[14] F. J. R. C. Dochy and L. McDowell, "Introduction: Assessment as a Tool for Learning," *Stud. Educ. Eval.*, vol. 23, no. 4, pp. 279–298, 1997.

[15] J. Biggs, "Assessment and Classroom Learning: a role for summative assessment?," *Assess. Educ. Princ. Policy Pract.*, vol. 5, no. 1, pp. 103–110, Mar. 1998, doi: 10.1080/0969595980050106.

[16] E. Panadero, J. Broadbent, D. Boud, and J. M. Lodge, "Using formative assessment to influence self- and co-regulated learning: the role of evaluative judgement," *Eur. J. Psychol. Educ.*, vol. 34, no. 3, pp. 535–557, Jul. 2019, doi: 10.1007/s10212-018-0407-8.

[17] K. Sambel, L. McDowell, and C. Montgomery, *Assessment for Learning in Higher Education*. Routledge, 2012. doi: 10.4324/9780203818268.

[18] D. Pereira, M. A. Flores, and L. Niklasson, "Assessment revisited: a review of research in Assessment and Evaluation in Higher Education," *Assess. Eval. High. Educ.*, vol. 41, no. 7, pp. 1008–1032, Oct. 2016, doi: 10.1080/02602938.2015.1055233.

[19] K. J. Topping, "Peer Assessment," *Theory Pract.*, vol. 48, no. 1, pp. 20–27, Jan. 2009, doi: 10.1080/00405840802577569.

[20] K. S. Double, J. A. McGrane, and T. N. Hopfenbeck, "The Impact of Peer Assessment on Academic Performance: A Meta-analysis of Control Group Studies," *Educ. Psychol. Rev.*, vol. 32, no. 2, pp. 481–509, Jun. 2020, doi: 10.1007/s10648-019-09510-3.

[21] H. L. Andrade, "A Critical Review of Research on Student Self-Assessment," *Front. Educ.*, vol. 4, 2019.

[22] S. Baghdadchi, L. Klement, R. Bristol, and P. A. Hadjipieris, "Student-designed Assessments in Electrical and Computer Engineering: From Student Perceptions to Their Mastery of Materials," in *2021 ASEE Annual Conference & Exposition*, 2021.

[23] G. Joughin, "Dimensions of Oral Assessment," *Assess. Eval. High. Educ.*, vol. 23, no. 4, pp. 367–378, Dec. 1998, doi: 10.1080/0260293980230404.

[24] K. E. Guest and D. S. Murphy, "In Support of Memory Retention: A Cooperative Oral Final Exam," *Education*, vol. 121, no. 2, pp. 350–353, 2000.

[25] K. P. Rouser, "Oral Assessments of Student Learning in Undergraduate Aerospace Propulsion and Power Courses," *J. Eng. Gas Turbines Power*, vol. 139, no. 12, Sep. 2017, doi: 10.1115/1.4037577.

[26] D. Rodić, "Best Practices of Assessment as a Way to Promote Effective Learning," *J. Balt. Sci. Educ.*, vol. 17, no. 5, p. Continuous, 2018, doi: https://doi.org/10.33225/jbse/18.17.748.

[27] P. Iannone, C. Czichowsky, and J. Ruf, "The impact of high stakes oral performance assessment on students' approaches to learning: a case study," *Educ. Stud. Math.*, vol. 103, no. 3, pp. 313–337, Mar. 2020, doi: 10.1007/s10649-020-09937-4.

[28] M. H. Davis and I. Karunathilake, "The place of the oral examination in today's assessment systems," *Med. Teach.*, vol. 27, no. 4, pp. 294–297, Jun. 2005, doi: 10.1080/01421590500126437.

[29] J. P. East and J. B. Schafer, "In-person grading: an evaluative experiment," *ACM SIGCSE Bull.*, vol. 37, no. 1, pp. 378–382, Feb. 2005, doi: 10.1145/1047124.1047472.

[30] A. P. Dicks, M. Lautens, K. J. Koroluk, and S. Skonieczny, "Undergraduate Oral Examinations in a University Organic Chemistry Curriculum," *J. Chem. Educ.*, vol. 89, no. 12, pp. 1506–1510, Nov. 2012, doi: 10.1021/ed200782c.

[31] D. Grunwald, E. Boese, R. Hoenigman, A. Sayler, and J. Stafford, "Personalized Attention @ Scale: Talk Isn't Cheap, But It's Effective," in *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, Kansas City Missouri USA: ACM, Feb. 2015, pp. 610–615. doi: 10.1145/2676723.2677283.

[32] Y. Zhao, "Impact of Oral Exams on a Thermodynamics Course Performance," presented at the 2018 ASEE Zone IV Conference, Mar. 2018.

[33] M. Sabin, K. H. Jin, and A. Smith, "Oral Exams in Shift to Remote Learning," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, in SIGCSE '21. New York, NY, USA: Association for Computing Machinery, Mar. 2021, pp. 666–672. doi: 10.1145/3408877.3432511.

[34] M. Lubarda *et al.*, "Oral exams for large-enrollment engineering courses to promote academic integrity and student engagement during remote instruction," in *2021 IEEE Frontiers in Education Conference (FIE)*, Oct. 2021, pp. 1–5. doi: 10.1109/FIE49875.2021.9637124.

[35] J. A. Muldoon, “The value of oral examinations. Journal of Chemical Education, 1926. 3(7): p. 773.,” vol. 3, no. 7, pp. 773–776, 1926.

[36] V. U. Odafe, “Oral Examination in College Mathematics: An Alternative Assessment Technique,” *PRIMUS*, vol. 16, no. 3, pp. 243–256, Jan. 2006, doi: 10.1080/10511970608984149.

[37] M. Huxham, F. Campbell, and J. Westwood, “Oral versus written assessments: a test of student performance and attitudes,” *Assess. Eval. High. Educ.*, vol. 37, no. 1, pp. 125–136, Feb. 2012, doi: 10.1080/02602938.2010.515012.

[38] D. Kang *et al.*, “Providing an Oral Examination as an Authentic Assessment in a Large Section, Undergraduate Diversity Class,” *Int. J. Scholarsh. Teach. Learn.*, vol. 13, no. 2, May 2019, doi: 10.20429/ijsotl.2019.130210.

[39] P. Iannone and A. Simpson, “Students’ views of oral performance assessment in mathematics: straddling the ‘assessment of’ and ‘assessment for’ learning divide,” *Assess. Eval. High. Educ.*, vol. 40, no. 7, pp. 971–987, Oct. 2015, doi: 10.1080/02602938.2014.961124.

[40] N. Bassler, “Introducing Oral Summative Assessment in the Medical Radiation Physics Program at Stockholm University - Concepts, Challenges and Concerns,” Oct. 2019, doi: 10.17045/sthlmuni.10012547.v1.

[41] D. Ramella, “Oral Exams: A Deeply Neglected Tool for Formative Assessment in Chemistry,” in *Active Learning in General Chemistry: Specific Interventions*, in ACS Symposium Series, no. 1340, vol. 1340. American Chemical Society, 2019, pp. 79–89. doi: 10.1021/bk-2019-1340.ch006.

[42] A. L. Goodman, “Can Group Oral Exams and Team Assignments Help Create a Supportive Student Community in a Biochemistry Course for Nonmajors?,” *J. Chem. Educ.*, vol. 97, no. 9, pp. 3441–3445, Sep. 2020, doi: 10.1021/acs.jchemed.0c00815.

[43] R. Harper, T. Bretag, and K. Rundle, “Detecting contract cheating: examining the role of assessment type,” *High. Educ. Res. Dev.*, vol. 40, no. 2, pp. 263–278, Feb. 2021, doi: 10.1080/07294360.2020.1724899.

[44] S. J. Reckinger and S. M. Reckinger, “Oral Proficiency Exams in High-Enrollment Computer Science Courses,” in *2021 ASEE Annual Conference*, in Paper ID #34799. 2021.

[45] P. Ohmann, “An Assessment of Oral Exams in Introductory CS,” in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, in SIGCSE ’19. New York, NY, USA: Association for Computing Machinery, Feb. 2019, pp. 613–619. doi: 10.1145/3287324.3287489.

[46] A. Akimov and M. Malin, “When old becomes new: a case study of oral examination as an online assessment tool,” *Assess. Eval. High. Educ.*, vol. 45, no. 8, pp. 1205–1221, Nov. 2020, doi: 10.1080/02602938.2020.1730301.

[47] H. Qi *et al.*, “Insights from the First Year of Project # 2044472 “Improving the Conceptual Mastery of Engineering Students in High Enrollment Engineering Courses through Oral Exams,” in *2022 ASEE Annual Conference & Exposition*, 2022.

[48] S. J. Hanrahan and G. Isaacs, “Assessing Self- and Peer-assessment: The students’ views,” *High. Educ. Res. Dev.*, vol. 20, no. 1, pp. 53–70, May 2001, doi: 10.1080/07294360123776.

[49] K. J. Topping, “Trends in Peer Learning,” *Educ. Psychol.*, vol. 25, no. 6, pp. 631–645, Dec. 2005, doi: 10.1080/01443410500345172.

[50] H. Li, Y. Xiong, C. V. Hunter, X. Guo, and R. Tywoniw, “Does peer assessment promote student learning? A meta-analysis,” *Assess. Eval. High. Educ.*, vol. 45, no. 2, pp. 193–211, Feb. 2020, doi: 10.1080/02602938.2019.1620679.

[51] J. H. Sandholtz, C. Ringstaff, and D. C. Dwyer, *Teaching With Technology: Creating Student-Centered Classrooms*, 1st Paper edition. New York: Teachers College Press, 1997.

[52] G. B. Wright, “Student-Centered Learning in Higher Education,” *Int. J. Teach. Learn. High. Educ.*, vol. 23, no. 3, pp. 92–97, 2011.

[53] A. Karabulut-Ilgu, N. Jaramillo Cherrez, and C. T. Jahren, “A systematic review of research on the flipped learning method in engineering education,” *Br. J. Educ. Technol.*, vol. 49, no. 3, pp. 398–411, 2018, doi: 10.1111/bjet.12548.

[54] G. Akçayır and M. Akçayır, “The flipped classroom: A review of its advantages and challenges,” *Comput. Educ.*, vol. 126, pp. 334–345, Nov. 2018, doi: 10.1016/j.compedu.2018.07.021.

[55] C. H. Crouch and E. Mazur, “Peer Instruction: Ten years of experience and results,” *Am. J. Phys.*, vol. 69, no. 9, pp. 970–977, Sep. 2001, doi: 10.1119/1.1374249.

[56] S. Bell, “Project-Based Learning for the 21st Century: Skills for the Future,” *Clear. House J. Educ. Strateg. Issues Ideas*, vol. 83, no. 2, pp. 39–43, Jan. 2010, doi: 10.1080/00098650903505415.

[57] D. Kokotsaki, V. Menzies, and A. Wiggins, “Project-based learning: A review of the literature,” *Improv. Sch.*, vol. 19, no. 3, pp. 267–277, Nov. 2016, doi: 10.1177/1365480216659733.

[58] D. Dicheva, C. Dichev, G. Agre, and G. Angelova, “Gamification in Education: A Systematic Mapping Study,” *J. Educ. Technol. Soc.*, vol. 18, no. 3, pp. 75–88, 2015.

[59] I. Medica Ružić and M. Dumančić, “Gamification in Education,” *Informatologia*, vol. 48, no. 3–4, pp. 198–204, Dec. 2015.

[60] S. Baghdadchi, “Student-designed assessments in electronic systems and signal processing courses,” in *2022 ASEE Annual Conference & Exposition*, 2022.

[61] S. P. Bates, R. K. Galloway, and K. L. McBride, “Student-generated content: Using PeerWise to enhance engagement and outcomes in introductory physics courses,” *AIP Conf. Proc.*, vol. 1413, no. 1, pp. 123–126, Feb. 2012, doi: 10.1063/1.3680009.

[62] T. Palm, “Performance Assessment and Authentic Assessment: A Conceptual Analysis of the Literature,” *Pract. Assess. Res. Eval.*, vol. 13, no. 1, Nov. 2019, doi: https://doi.org/10.7275/0qpc-ws45.

[63] P. Sotiriadou, D. Logan, A. Daly, and R. Guest, “The role of authentic assessment to preserve academic integrity and promote skill development and employability,” *Stud. High. Educ.*, vol. 45, no. 11, pp. 2132–2148, Nov. 2020, doi: 10.1080/03075079.2019.1582015.

[64] V. Villarroel, D. Boud, S. Bloxham, D. Bruna, and C. Bruna, “Using principles of authentic assessment to redesign written examinations and tests,” *Innov. Educ. Teach. Int.*, vol. 57, no. 1, pp. 38–49, Jan. 2020, doi: 10.1080/14703297.2018.1564882.

[65] A. Irons and S. Elkington, *Enhancing Learning through Formative Assessment and Feedback*. Routledge, 2021. doi: 10.4324/9781138610514.

[66] P. Black and D. Wiliam, “Assessment and Classroom Learning,” *Assess. Educ.*, vol. 5, no. 1, pp. 7–74, 1998.

[67] V. Villarroel, S. Bloxham, D. Bruna, C. Bruna, and C. Herrera-Seda, “Authentic assessment: creating a blueprint for course design,” *Assess. Eval. High. Educ.*, vol. 43, no. 5, pp. 840–854, Jul. 2018, doi: 10.1080/02602938.2017.1412396.

[68] S. Baghdadchi, H. Qi, M. Lubarda, A. Phan, N. Delson, and C. Sandoval, “Student perceptions of oral exams in undergraduate engineering classes and implications for effective oral exam design,” in *2022 ASEE Annual Conference & Exposition*, 2022.

[69] D. B. Luckie, A. M. Rivkin, J. R. Aubry, B. J. Marengo, L. R. Creech, and R. D. Sweeder, “Verbal Final Exam in Introductory Biology Yields Gains in Student Content Knowledge and Longitudinal Performance,” *CBE—Life Sci. Educ.*, vol. 12, no. 3, pp. 515–529, Sep. 2013, doi: 10.1187/cbe.12-04-0050.

[70] A. S. Theobold, “Oral Exams: A More Meaningful Assessment of Students’ Understanding,” *J. Stat. Data Sci. Educ.*, vol. 29, no. 2, pp. 156–159, May 2021, doi: 10.1080/26939169.2021.1914527.

[71] B. B. Jensen, “Oral Assessment in Engineering Education,” *Int. J. Electr. Eng. Educ.*, vol. 47, no. 4, pp. 375–379, Oct. 2010, doi: 10.7227/IJEEE.47.4.2.

[72] N. Delson *et al.*, “Can Oral Exams Increase Student Performance and Motivation?” in *2022 ASEE Annual Conference & Exposition*, 2022.

[73] M. Dick, “Student interviews as a tool for assessment and learning in a systems analysis and design course,” in *Proceedings of the 10th annual SIGCSE conference on Innovation and technology in computer science education*, in ITiCSE ’05. New York, NY, USA: Association for Computing Machinery, Jun. 2005, pp. 24–28. doi: 10.1145/1067445.1067456.

[74] M. J. Buehler and L. U. Schneider, “Speak Up! Oral Examinations and Political Science,” *J. Polit. Sci. Educ.*, vol. 5, no. 4, pp. 315–331, Oct. 2009, doi: 10.1080/15512160903253277.

[75] I. Morrissett, “An experiment with oral examinations,” *J. High. Educ.*, vol. 29, no. 4, pp. 185-190., 1958.

[76] K. Nørmark, L. L. Thomsen, and K. Torp, “Mini Project Programming Exams,” in *Reflections on the Teaching of Programming: Methods and Implementations*, Berlin,

Heidelberg: Springer-Verlag, 2008, pp. 228–242. Accessed: Sep. 12, 2022. [Online]. Available: https://doi.org/10.1007/978-3-540-77934-6_18

[77] M. van Zundert, D. Sluijsmans, and J. van Merriënboer, "Effective peer assessment processes: Research findings and future directions," *Learn. Instr.*, vol. 20, no. 4, pp. 270–279, Aug. 2010, doi: 10.1016/j.learninstruc.2009.08.004.

[78] N.-F. Liu and D. Carless, "Peer feedback: the learning element of peer assessment," *Teach. High. Educ.*, vol. 11, no. 3, pp. 279–290, Jul. 2006, doi: 10.1080/13562510600680582.

[79] G. Pearce and G. Lee, "Viva Voce (Oral Examination) as an Assessment Method: Insights From Marketing Students," *J. Mark. Educ.*, vol. 31, no. 2, pp. 120–130, Aug. 2009, doi: 10.1177/0273475309334050.

[80] R. Boedigheimer, M. Ghrist, D. Peterson, and B. Kallemyn, "Individual Oral Exams in Mathematics Courses: 10 Years of Experience at the Air Force Academy," *PRIMUS*, vol. 25, no. 2, pp. 99–120, Feb. 2015, doi: 10.1080/10511970.2014.906008.

[81] P. Lundgren, "Effects of Elective Oral Examinations in a Semiconductor Devices Course for Computer Engineering Students," *Int. J. Eng. Educ.*, vol. 14, no. 4, pp. 294–299, 1998.

[82] D. Boud, R. Cohen, and J. Sampson, Eds., *Peer learning in higher education: Learning from and with each other*, 1st ed. London: Routledge, 2013. doi: 10.4324/9781315042565.

[83] M. Segers and F. Dochy, "New Assessment Forms in Problem-based Learning: The value-added of the students' perspective," *Stud. High. Educ.*, vol. 26, no. 3, pp. 327–343, Oct. 2001, doi: 10.1080/03075070120076291.

[84] K. Turner, L. Roberts, C. Heal, and L. Wright, "Oral presentation as a form of summative assessment in a master's level PGCE module: the student perspective," *Assess. Eval. High. Educ.*, vol. 38, no. 6, pp. 662–673, Sep. 2013, doi: 10.1080/02602938.2012.680016.

[85] L. S. Vygotsky and A. Kozulin, *Thought and Language*, Second. Cambridge, MA: The MIT Press, 1986.

[86] L. Gleitman and A. Papafragou, "Language and Thought," in *The Cambridge handbook of thinking and reasoning*, New York, NY, US: Cambridge University Press, 2005, pp. 633–661.

[87] N. Chomsky and I. P. & P. of L. (Emeritus) N. Chomsky, *Language and Mind*. Cambridge University Press, 2006.

[88] N. Chomsky, "Language and Other Cognitive Systems. What Is Special About Language?," *Lang. Learn. Dev.*, vol. 7, no. 4, pp. 263–278, Oct. 2011, doi: 10.1080/15475441.2011.584041.

[89] M. D. Hauser, N. Chomsky, and W. T. Fitch, "The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?," *Science*, vol. 298, no. 5598, pp. 1569–1579, Nov. 2002, doi: 10.1126/science.298.5598.1569.

[90] M. a. K. Halliday, *Explorations in the Functions of Language*. Edward Arnold (Publishers) Ltd, 1973.

[91] J. Potter and M. Wetherell, *Discourse and Social Psychology: Beyond Attitudes and Behaviour*. London, U.K.: Sage Publications Ltd, 1987.

[92] M. Augoustinos, I. Walker, and N. Donaghue, *Social Cognition: An Integrated Introduction*. SAGE, 2014.

[93] S. T. Fiske and S. E. Taylor, *Social Cognition*, 2nd ed. McGraw-Hill Ryerson, Limited, 1991.

[94] L. S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, Revised. Cambridge, MA: Harvard University Press, 1978.

[95] L. S. Vygotsky, *The Collected Works of L. S. Vygotsky: Problems of General Psychology, Including the Volume Thinking and Speech*. Springer, 2016.

[96] T. L. Rosenthal and B. J. Zimmerman, *Social Learning and Cognition*. Academic Press, 2014.

[97] S. W. H. Lee and P. S. Saw, "The Use of Building Blocks to Teach Communication and Social Skills to First-year Pharmacy Students," *Am. J. Pharm. Educ.*, vol. 85, no. 8, p. 8464, Sep. 2021, doi: 10.5688/ajpe8464.

[98] M. L. Pedler, R. Willis, and J. E. Nieuwoudt, "A sense of belonging at university: student retention, motivation and enjoyment," *J. Furth. High. Educ.*, vol. 46, no. 3, pp. 397–408, Mar. 2022, doi: 10.1080/0309877X.2021.1955844.

[99] P. Kinnunen, "Dealing with emotions – Engineering teachers' observations of students' emotional reactions to receiving feedback on their work," in *2020 IEEE Frontiers in Education Conference (FIE)*, Oct. 2020, pp. 1–5. doi: 10.1109/FIE44824.2020.9274107.

[100] "ASEE 2021 Editon: Engineering & Engineering Technology by the Numbers," Profiles of Engineering and Engineering Technology, Wahington, DC, 2021.

[101] E. Bilen and A. Matros, "Online cheating amid COVID-19," *J. Econ. Behav. Organ.*, vol. 182, pp. 196–211, Feb. 2021, doi: 10.1016/j.jebo.2020.12.004.

[102] T. Lancaster and C. Cotarlan, "Contract cheating by STEM students through a file sharing website: a Covid-19 pandemic perspective," *Int. J. Educ. Integr.*, vol. 17, no. 1, Art. no. 1, Dec. 2021, doi: 10.1007/s40979-021-00070-0.

[103] T. B. Gallant and P. Drinan, "Organizational Theory and Student Cheating: Explanation, Responses, and Strategies," *J. High. Educ.*, vol. 77, no. 5, pp. 839–860, Sep. 2006, doi: 10.1080/00221546.2006.11778946.

[104] D. L. McCabe, K. D. Butterfield, and L. K. Treviño, *Cheating in College: Why Students Do It and What Educators Can Do about It*. JHU Press, 2012.

[105] S. A. Stearns, "The Student-Instructor Relationship's Effect on Academic Integrity," *Ethics Behav.*, vol. 11, no. 3, pp. 275–285, Jul. 2001, doi: 10.1207/S15327019EB1103_6.

[106] R. L. Genereux and B. A. McLeod, "Circumstances surrounding cheating: A questionnaire study of college students," *Res. High. Educ.*, vol. 36, no. 6, pp. 687–704, Dec. 1995, doi: 10.1007/BF02208251.

[107] P. A. Hutton, "Understanding Student Cheating and What Educators can do About it," *Coll. Teach.*, vol. 54, no. 1, pp. 171–176, Jan. 2006, doi: 10.3200/CTCH.54.1.171-176.

[108] S. A. Bluestein, “Connecting Student-Faculty Interaction to Academic Dishonesty,” *Community Coll. J. Res. Pract.*, vol. 39, no. 2, pp. 179–191, Feb. 2015, doi: 10.1080/10668926.2013.848176.

[109] G. D. Kuh and S. Hu, “The effects of student-faculty interaction in the 1990s,” *Rev. High. Educ. J. Assoc. Study High. Educ.*, vol. 24, pp. 309–332, 2001, doi: 10.1353/rhe.2001.0005.

[110] M. P. Tippitt, N. Ard, J. R. Kline, J. Tilghman, B. Chamberlain, and G. P. Meagher, “Creating Environments that Foster Academic Integrity,” *Nurs. Educ. Perspect.*, vol. 30, no. 4, pp. 239–244, Aug. 2009.

[111] S. A. Bluestein, “Preventing Plagiarism (and Other Forms of Cheating): Advice From Students and Faculty,” *New Dir. Community Coll.*, vol. 2018, no. 183, pp. 7–14, 2018, doi: 10.1002/cc.20312.

[112] T. Bertram Gallant, “Academic Integrity as a Teaching & Learning Issue: From Theory to Practice,” *Theory Pract.*, vol. 56, no. 2, pp. 88–94, Apr. 2017, doi: 10.1080/00405841.2017.1308173.

[113] D. L. McCabe, “The Influence of Situational Ethics on Cheating Among College Students*,” *Sociol. Inq.*, vol. 62, no. 3, pp. 365–374, 1992, doi: 10.1111/j.1475-682X.1992.tb00287.x.

[114] C. Finelli, T. Harding, D. Carpenter, and M. Mayhew, “Academic integrity among engineering undergraduates: Seven years of research by the E^ 3 Team,” in *2007 ASEE Annual Conference & Exposition*, 2007.

[115] R. L. Young, G. N. S. Miller, and C. L. Barnhardt, “From Policies to Principles: The Effects of Campus Climate on Academic Integrity, a Mixed Methods Study,” *J. Acad. Ethics*, vol. 16, no. 1, pp. 1–17, Mar. 2018, doi: 10.1007/s10805-017-9297-7.

[116] L. Li, X. Liu, and A. L. Steckelberg, “Assessor or assessee: How student learning improves by giving and receiving peer feedback,” *Br. J. Educ. Technol.*, vol. 41, no. 3, pp. 525–536, 2010, doi: 10.1111/j.1467-8535.2009.00968.x.

[117] G. Turner and G. Gibbs, “Are assessment environments gendered? An analysis of the learning responses of male and female students to different assessment environments,” *Assess. Eval. High. Educ.*, vol. 35, no. 6, pp. 687–698, Oct. 2010, doi: 10.1080/02602930902977723.

[118] C. V. Gipps and P. Murphy, *A fair test? Assessment, achievement and equity*. in A fair test? Assessment, achievement and equity. Maidenhead, BRK, England: Open University Press, 1994, pp. ix, 308.

[119] M. A. Flores, A. M. Veiga Simão, A. Barros, and D. Pereira, “Perceptions of effectiveness, fairness and feedback of assessment methods: a study in higher education,” *Stud. High. Educ.*, vol. 40, no. 9, pp. 1523–1534, Oct. 2015, doi: 10.1080/03075079.2014.881348.

[120] F. Guay, R. J. Vallerand, and C. Blanchard, “On the Assessment of Situational Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS),” *Motiv. Emot.*, vol. 24, no. 3, pp. 175–213, Sep. 2000, doi: 10.1023/A:1005614228250.

[121] C. A. Myers and J. M. Hatchel, “Personality and Cognitive Factors Related to Completing Extra Credit Assignments,” *Int. J. Scholarsh. Teach. Learn.*, vol. 13, no. 2, 2019.

[122] R. Campbell, B. Soenens, W. Beyers, and M. Vansteenkiste, “University students’ sleep during an exam period: the role of basic psychological needs and stress,” *Motiv. Emot.*, vol. 42, no. 5, pp. 671–681, Oct. 2018, doi: 10.1007/s11031-018-9699-x.

[123] R. Trigueros, A. M. Padilla, J. M. Aguilar-Parra, P. Rocamora, M. J. Morales-Gázquez, and R. López-Liria, “The Influence of Emotional Intelligence on Resilience, Test Anxiety, Academic Stress and the Mediterranean Diet. A Study with University Students,” *Int. J. Environ. Res. Public. Health*, vol. 17, no. 6, Art. no. 6, Jan. 2020, doi: 10.3390/ijerph17062071.

[124] J. C. De Gagne, S. S. Kim, E. R. Schoen, and H. K. Park, “Assessing the Impact of Video-Based Assignments on Health Professions Students’ Social Presence on Web: Case Study,” *JMIR Med. Educ.*, vol. 4, no. 2, p. e11390, Nov. 2018, doi: 10.2196/11390.

[125] J. Reyna, J. Hanham, P. Vlachopoulos, and P. Meier, “A Systematic Approach to Designing, Implementing, and Evaluating Learner-Generated Digital Media (LGDM) Assignments and Its Effect on Self-regulation in Tertiary Science Education,” *Res. Sci. Educ.*, vol. 51, no. 6, pp. 1501–1527, Dec. 2021, doi: 10.1007/s11165-019-09885-x.

[126] K. M. Whitcomb, A. Maries, and C. Singh, “Progression in Self-Efficacy, Interest, Identity, Sense of Belonging, Perceived Recognition and Effectiveness of Peer Interaction of Physics Majors and Comparison with Non-Majors and Ph.D. Students,” *Res. Sci. Educ.*, Sep. 2022, doi: 10.1007/s11165-022-10068-4.

[127] S. J. Reckinger and S. M. Reckinger, “A Study of the Effects of Oral Proficiency Exams in Introductory Programming Courses on Underrepresented Groups,” in *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education - Volume 1*, in SIGCSE 2022, vol. 1. New York, NY, USA: Association for Computing Machinery, Feb. 2022, pp. 633–639. doi: 10.1145/3478431.3499382.