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A Self-Study of Faculty Methods, Attitudes, and Perceptions of Oral Engineering Exams

Dr. Darcie Christensen, Minnesota State University, Mankato

Dr. Darcie Christensen is a probationary Assistant Professor in the Department of Integrated Engineering at Minnesota State University Mankato. She teaches for Iron Range Engineering, which is located at the Minnesota North Campus in Virginia, MN. Dr. Christensen received her Ph.D. in Engineering Education from Utah State University in the Summer of 2021. The title of her Dissertation is ”A Mixed-Method Approach to Explore Student Needs for Peer Mentoring in a College of Engineering.” Darcie holds a Master of Engineering degree in Environmental Engineering (2019) and Bachelor of Science degree in Biological Engineering (2017), both from Utah State University. She is passionate about student success and support, both inside and outside of the classroom.

Dr. Lauren Singelmann, Minnesota State University, Mankato

Lauren Singelmann is an Assistant Professor at Minnesota State University, Mankato with the Iron Range Engineering program. She has a Ph.D. in Electrical and Computer Engineering and STEM Education through North Dakota State University. Her research interests include learning analytics and alternative assessment.

Mr. Rob Sleezer, Virginia Tech

Rob Sleezer earned his Ph.D. in Microelectronics-Photonics from the University of Arkansas. He attended Oklahoma State University where he graduated with a B.S. in Computer Science and an M.S. and B.S. in Electrical Engineering. He is currently a faculty

Dr. Emilie A. Siverling, Minnesota State University, Mankato

Emilie A. Siverling is an Assistant Professor of Integrated Engineering and the Iron Range Engineering Bell Program through Minnesota State University, Mankato. She has a Ph.D. in Engineering Education, an M.S.Ed. in Curriculum and Instruction - Science Education, and a B.S. in Materials Science and Engineering.

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Introduction

While it is commonly known that verbal communication and presentation skills are highly desirable by employers, many engineering students' technical learning is assessed primarily through written examination means. In the department of Integrated Engineering (IE) at Minnesota State University, Mankato, verbal exams are a fundamental formative and summative assessment method of checking students' understanding [1]. While the goals for verbal examination are common throughout the program, this paper aims to compile the individual philosophies, approaches, attitudes, and perceptions of faculty within the department who give verbal examinations on a regular basis. Each faculty member focuses their exam in some way on checking students' ability to orally discuss the fundamental principles and concepts that were covered in their flipped-classroom setting. These verbal engineering exams are employed across all engineering courses and in the students' professional and design learning. Because of this breadth, this paper is focused only on oral exams in students' technical engineering courses. Some methods included by faculty are more qualitative, such as discussing descriptions, sketches, applications, and connections of the principle or concept of interest, or are more quantitative, such as orally explaining the process of solving a problem in real-time.

The analytical framework used in this study to examine each faculty member's approach is the strength, weaknesses, opportunities, and threat (SWOT) analysis, commonly used in strategic planning and management [2]. The purpose of this analysis will be to provide recommendations for growth and best practices in administering verbal engineering exams, regardless of the specific engineering course.

Background

Do any general Google search on skills that an engineer needs in the workplace and communication will be on it, with a few examples cited here [3]–[5]. These communication skills are not just important for students to succeed during their engineering education, but also in their future careers, regardless of the industry [6]. Despite this importance, communication has been flagged by engineers' employers as a weakness in recent engineering graduates [7], [8].

Within the realm of communication, a variety of types of communication skills are applicable and important: written, oral, listening, visual, interdisciplinary, and intercultural [6]. Written communication is oftentimes the main emphasis in engineering education, but as a whole, engineering practice is a highly oral culture where daily work may include group work, meetings (in-person and virtual), presentations, etc. [9], [10]. While formal presentations about projects and stand-alone communication classes may be helpful in emphasizing oral communication skills specifically, integration throughout an engineering curriculum is key to helping students become the engineering communicators they need to be [6], [9], [10]. As emphasized by Riemer [6], "Knowledge and technical know-how are clearly important, but these must be presented with an excellent standard of communication skills, particularly oral" (p. 92). This is in alignment with ABET Student Outcome 3, which states that students should graduate with an "ability to communicate effectively with a range of audiences" [11]. For this purpose, we have focused this paper on sharing our experience with students orally showing their understanding through spoken exams in technical engineering courses. Oral communication is a learnable skill (Polack-Wahl, 2000) and through practice, such as continual oral examinations, students can be prepared for their future positions. Additionally, oral exams are much more learner-centered and focused on formative feedback rather than summative evaluation [1].

As the world of technology continues to advance, a shift and embracement of new assessment methods is appropriate and necessary. For example, as of early 2022, the New York Times reported that universities are now having to change the way they are teaching and assessing students because of the widespread availability of A.I. Chatbots such as ChatGPT [12]. Within IE at Minnesota State University, Mankato, differential methods of assessment have been employed for over a decade and we want to share our experiences with oral exams to support others in embracing the changing world, better preparing engineering students for their future positions.

Overview of Department of Integrated Engineering

There are two programs within IE, namely Iron Range Engineering (IRE) and Twin Cities Engineering (TCE), with IRE being formed first. These programs are catered to junior and senior students who have likely completed their freshman and sophomore years in other places, but there are potential opportunities to be tied to the program as they complete their freshman and sophomore years. Both IRE and TCE function under the same project-based learning model [1], [13], [14], though individual adaptations, interpretations, and changes have happened over time. The overall goal of the model is, "Student empowered development of technical and professional knowledge and competencies in context of industry/entrepreneur sponsored project-based learning, leading to regional economic development" [14, p. 4]. Within IE, there are three fundamental focus areas for student learning: design, technical, and professional [1]. While all three of these areas include oral exams, only technical learning is addressed in this self-study.

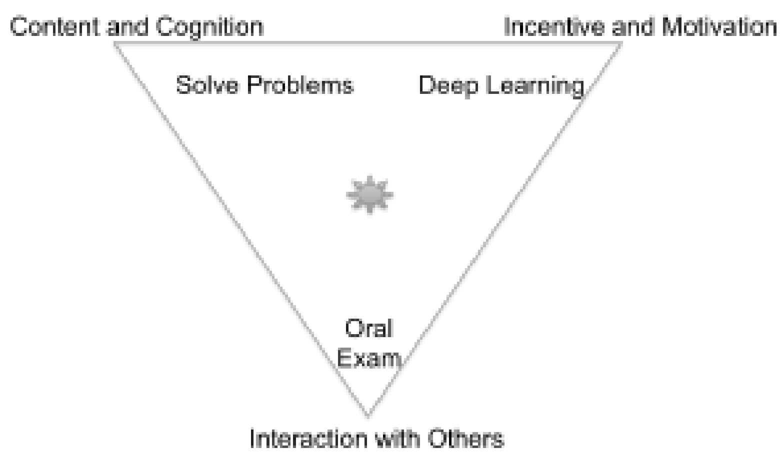
A full description of the theoretical and practical considerations surrounding the design of the programs within IE are available [1], [13], [14], but the portions relating to oral examination will be briefly presented. The model of oral examinations for IE originates from both the models employed by Aalborg University [15], [16] and the Military [17], [18], both of which regularly use oral means for examinations. Aalborg University primarily employs oral examinations within group project settings [19], not necessarily individually, while the Navy employs oral examinations for a variety of competency checks [17], [18].

Within IE specifically, the idea behind oral examination is to check if students have gained the quality of conceptual understanding needed and are able to clearly communicate that information, similar to a defense; written exams and project documentation are also included in technical competencies and are utilized separately as assessment means [1], [13]. This allows evaluators to really explore students' understanding and help them verbalize their technical understanding, so they are demonstrating competency [1]. To help students in embracing the many modes of communication that they may need to engage in for workplace practices, oral exams are administered in both virtual and face-to-face settings [6]. Traditionally, class sizes in

IE are between 4-20, so the population size is manageable to administer oral exams, though instructors may be teaching more than one class or section, which can make the load for administering exams quite daunting. For this reason, most oral exams take between 15-40 minutes.

In IE, each course is based upon fundamental principles (FPs) of engineering related to that topic [1]. Each course will have somewhere between 2-6 FPs that are the core learning topics for the course, thus the foundation of what is overall being assessed. There are projects in each technical course called Deep Learning Activities (DLA). The expectations for these projects look different depending on the course and may be explained in the context of the case studies included later in this paper. To prepare for the oral exam, students have many opportunities for low stakes practice with formative feedback [1] through course deliverables and discussions to prepare for the oral exam. All grading in IE is based upon a 5-point grading scale, developed from Bloom's Modified Taxonomy, ranging from poor/weak to exceptional [1], [13], [14], [20], [21]. The overall use of the scale is focused on helping students focus on growing and improving throughout the semester [21]. When looking at Illeris' triangle situated in the realm of IE (Figure 1), balance is obtained in assessment through these three aspects: solving problems (i.e., written assessment), deep learning (i.e., DLA documentation), and oral examination.

Figure 1. IE assessment situation on Illeris' triangle [1, p. 147].



Methods

For this self-study, four faculty perspectives (one from TCE, three from IRE) and approaches to verbal exams are presented. To encompass the entirety of the SWOT technique [2], faculty used the SW (i.e., strengths and weaknesses) to analyze their chosen course. The faculty perspectives chosen give a range of focus areas with a mixture of different student populations (juniors and seniors). While these perspectives are not comprehensive of every approach in IE, they give a foundational picture of the variety of approaches used in administering oral exams for technical learning competencies in engineering. After each individual case was developed and presented to the research team, a collaborative OT (i.e., opportunities and threats) analysis was performed in order to determine the overarching lessons learned from the different approaches to oral examination.

Case Study Results

The following cases present four different technical engineering courses that oral examinations have been employed in. As mentioned previously, all courses implement oral examinations for the same purpose, but may have differing approaches in their execution of course content and examination procedures. The cases are ordered from the most structured to least structured approach to oral exams.

Material Science

Material Science is a technical course that all students take in their first semester of their tenure with IRE during their junior year. The course incorporates five FPs, which include Materials Paradigm, Crystal Structures, Stress-Strain Curves (and Associated Properties), Dislocation Mobility-Strengthening Mechanisms (DMSM) Principle, and Phase Diagrams. Because the course is one credit, it primarily focuses on metals with a brief introduction to ceramics and polymers. The course is structured using the flipped classroom approach, with students watching videos introducing them to the main content before class, and then class time is used to address students' questions and for students to work in small group and whole class activities.

At the beginning of the course, students are given a "Verbal Exam Expectations" document that lists all the learning outcomes of the course (e.g., Describe the Materials Paradigm and its importance; Draw reduced-sphere unit cell models of SC, BCC, FCC crystal structures; Calculate engineering stress and strain from an applied force and initial and final dimensions). Throughout the course, students practice these learning outcomes and receive feedback from the instructor through formative assessments such as homework problems, quizzes, conceptual describe and define sheets, reflective learning journals, and a DLA. During the last class session, students review the Verbal Exam Expectations document as preparation for the oral exam. The learning outcomes that are directly related to the five FPs and a few other important supporting concepts are starred. Students are told that although any of the learning outcomes could be asked during the verbal exam, 70-80% of the questions asked will be the starred learning outcomes. In this way, students know what to review before the oral exam and what outcomes to focus on.

The verbal exam is fairly structured in that students are all asked the same base questions, primarily focusing on the five FPs and important supporting concepts. However, there is some flexibility. First, for two FPs - Crystal Structures and DMSM - students choose which crystal structure and materials process they want to answer questions about, so they can tailor that section of the verbal exam to what they understand best. Second, the questions change depending on how students perform during the exam. For those students who are struggling or are stuck on answering a question, the instructor has some pre-determined follow-up questions to help guide the students in better learning the concepts while taking the exam. There are also questions the instructor has created that may be used for those students who are doing well in the exam and may be served well by having a more challenging question as a follow-up. The verbal exams typically take 20-35 minutes; students who need several clarifying follow-up questions tend to need more time, as do students who struggle with oral communication. Students receive a range of points for each question depending on how they do. They then get a score for each FP, which contributes to their overall weighted score for the entire exam. The instructor emails each student their feedback sheet, including scores for each FP and overall score, by the end of the day of the verbal exam. The summary of the SW analysis for the Materials Science approach is shown in Table 1.

Table 1. SW analysis for Materials Science oral exam approach.

Strengths
• Allows for grading consistency since students receive the same base questions. • Students get to choose which crystal structure and material process they want to explain, allowing them to focus on one they understand better and/or find more interesting. • Evaluator has the ability to ask follow-up questions and give small hints to determine what students really know when they struggle with a question (e.g., maybe they understand the concept but don't remember all the exact vocabulary, maybe they need a hint for the first part but can figure out the rest from there). • Evaluator can ask questions that challenge students who are otherwise acing the exam. • Students know the full list of questions that could be asked with the most important ones noted, so studying is straightforward AND no one is upset by a "surprise" question. • Verbal Exam Expectations document is based on things they have already done (Describe sheet, HW Problem, quiz problem, DLA, etc.). • Students get Verbal Exam grade immediately (at end of exam) and feedback sheet that day via email. • Feedback sheet color coding gives students a visual understanding of how they did: blue = good, purple = incorrect or needed hints, coral = exceeded expectations. • Evaluator obtains a good idea of what FPs and concepts need improvement for teaching of the next semester.
Weaknesses
• Each exam takes ~30 minutes, which is a lot of time for one evaluator over a short period of time. • Oral exams can be challenging and take longer for students whose first language isn't English, and/or students who struggle with spoken communication. • Students late or missing for an exam throws off all scheduling and demands more time resources from the evaluator. • Administration of the same questions can get boring for the evaluator. • Technical issues can arise when doing verbal exams on Zoom (e.g., Wi-Fi issues, difficulty for students new to sharing screen on tablet, or new to annotating on someone else's shared screen, etc.). • Handwritten feedback sheets take a lot of effort and may be difficult to read since the evaluator has to write quickly. • Difficulty in determining what was a reasonable amount of questions to ask in a 30 minute verbal exam, especially during first few iterations of teaching the course. • Difficulty in figuring out what were good follow-up questions for struggling students. • Lower in analysis and application questions. • Students may share what was actually asked during a verbal exam. • Students may just memorize answers to prompts on the Verbal Exam Expectations document.

Thermodynamics

Within the one-credit thermodynamics course in the IE department, there are five FPs: First Law of Thermodynamics, Second Law of Thermodynamics, Conservation of Mass, Cycle Analysis, and Property Relationships. Throughout the course, students learn in a flipped classroom format, watching videos to learn the content about each of the fundamental principles. As their DLA, students are able to re-vamp a traditional cycle (e.g., Rankine or AC) by altering at least two things (e.g., working fluid, number of components, order of components, etc.) to determine the thermodynamic favorability [22]. In-class activities are primarily focused on answering questions about the videos, homework problems, quizzes, DLA, etc. followed by structured problem solving exercises to further their computational understanding and analysis skills in thermodynamics. For each of the FPs, the students must fill out what is called a describe sheet, which includes a word description, sketch, equation with units, engineering application, real-world significance, and connection to other learning. For a variety of concepts in the course (e.g., entropy, enthalpy, temperature, pressure, Carnot engine, efficiency, etc.), students fill out a define sheet, which includes a word description, sketch, and equation with units. Throughout the semester, students have many opportunities for formative feedback through homework problems, describe sheets, define sheets, quizzes, learning journals, etc. in preparation for their final exams. The format for the oral exam will be presented next, but it should be noted that they do also complete a written examination, which is performing a thorough cycle analysis on a designated system.

For the oral exam, students complete one or more describe sheet questions, which are given at random, for each of the five fundamental principles of thermodynamics (e.g., provide a sketch of the first law of thermodynamics, what is an engineering application of cycle analysis, etc.). This allows for the evaluator, which is the professor of the course, to probe the student further to gauge their understanding of the principle. Follow-up questions may include addressing gaps that appeared in the students' understanding. Additional describe sheet questions may also be asked to allow for continuing discussion on understanding. After completion of the five fundamental principle questions, students will give at least six word descriptions of the course concepts as asked by the evaluator (e.g., provide a word description of temperature, provide a word description of enthalpy, etc.). At this point, students are given immediate oral feedback on their performance with a score on the five-point scale. The FP portion of the exam is worth 67% of the grade while the conceptual portion is worth 33% of the grade. All grading and notes were recorded throughout the exam on a pre-created template in a spreadsheet that calculates the grade based on the weighting in the five-point scale. This is provided to students as well via email. The verbal exam takes anywhere from 10 to 30 minutes with an average of 20 minutes. The summary of the SW analysis for the Thermodynamics approach is shown in Table 2.

Table 2. SW analysis for Thermodynamics oral exam approach.

Strengths
• Students know up front the content on the exam since it is based on worksheets they already completed. • Limited scope of the exam emphasizes what is important. • Relatively easy to administer since the evaluator can use a pre-developed spreadsheet. • Can probe/follow-up students with further questions. • Immediate feedback, both spoken and written. • Reliability in grading since all students are receiving the same number of questions. • Automation of grade calculation through pre-created template spreadsheet
Weaknesses
• Reliability of assessment since there is likely only one evaluator. • Students can memorize answers, especially for word descriptions. • Students can give direct examples and answers that were already given in class, not allowing them to extend. • Very focused on timing - if there's any disruption it can throw off everything. • Lacks a focus on applications and analysis. • Students can just repeat what was discussed in class instead of extending their understanding. • Limited scope of structured exam emphasizes only certain principles, so other things in the course may fall off. • Focus is on getting through all the questions versus going into depth.

Electronics

Electronics is a one-credit electrical engineering competency required for all IE students. The FPs of the course include diodes, transistors, and operational amplifiers. Each FP is framed within the context of form, function, application, and analysis. *Form* focuses on semiconductor physics, names of the inputs and outputs of a component, and appearances of the physical and schematic component. *Function* focuses on the relationships between inputs and outputs as well as the various ways a component can behave. *Application* is the explanation of why a component would be used in an engineering context. *Analysis* is solving quantitative problems to find missing voltages and currents within a circuit.

For example, for a transistor, *Form* focuses on p-type and n-type material and its layout within a transistor; the location of the collector, base, and emitter ports; and what a transistor looks like in both physical circuits and schematics. *Function* focuses on how inputs and outputs are related in both the active and saturated modes. An *Application* could be turning on an ultrabright LED with a high current requirement using a microcontroller that outputs a small current. An *Analysis* problem could show a simple circuit with some voltage measurements and the student must identify what mode the transistor is behaving in and why.

The *Form/Function/Application/Analysis* framework is used throughout the course when introducing topics, practicing course material, and during the final verbal exam. During the final verbal exam, students go through each of the fundamental principles. For each principle, the evaluator asks them to explain what they know about *Form* and *Function* of the component. The evaluator may then ask follow-up questions to further probe understanding. Next, the evaluator asks the student if they would like to give an example of an *Application* or complete an *Analysis* problem. The student is able to choose either option. If they choose an *Application*, they explain an example of an application of that component, and the evaluator asks appropriate follow-up questions. If they choose an *Analysis* problem, the evaluator shows a problem and asks the student to go about solving the problem. These problems are designed to be short and mostly straightforward. Rather than asking a student to solve for a certain value and do the required calculations and algebra, the student is asked to explain how they would go about solving the problem.

The student is scored on a 5-point scale. A '4' represents a complete and correct answer to the question, a '3' represents an incomplete or partially incorrect answer to the question, a '2' represents a mostly incorrect answer to the question, and a '1' represents no attempt made. To earn greater than a '4', the student must share something beyond what was covered explicitly in the course (e.g. describing an application that was not covered in class, framing a concept in a new way, or elaborating on a topic beyond what was covered in class).

The final part of the exam is asking the student what score they think they earned. The evaluator determines the grade before the student answers this question, but their response can help the evaluator determine appropriate framing for the feedback. For example, if the evaluator scored the student a 4.3 and the student scored themselves a 3.3, the evaluator can use the feedback as an opportunity to remind the student that the content may feel challenging but emphasizing that they are doing a good job framing and articulating the most important concepts in their own words. On the other hand, if the evaluator scored the student a 3.3 and the student scored themselves a 4.3, the feedback time can be used to discuss the misalignment between the student's performance and instructor expectations. Although this part of the oral exam is not necessary for implementation, it can be useful in supporting open communication between student and evaluator. Those trying verbal exams for the first time may also benefit from this strategy to get a sense of how students are gauging their performance. The SWOT analysis for the Electronics approach is summarized in Table 3.

Table 3. SW analysis for Electronics oral exam approach.

Strengths
• Gives students opportunities to focus on things that are important and/or interesting to them, which can also strengthen the relationship between student and instructor. • Encourages students to go beyond the course material and make new connections or frame things in new ways. • Encourages potential risk-taking and creativity rather than mimicry of the instructor. • Adaptable to meet students where they are at.

Weaknesses
• Little to no evaluation of engineering problem-solving or design. • Evaluator’s expertise may be limited to whatever topic they choose to talk about. • Giving students more flexibility in their responses can lead to challenges in validity. • Requires scaffolding throughout the course to ensure students understand the “language” of the exam. • Students could misinterpret or be unprepared for the open-ended questions if framing isn’t used throughout the course. • Students who are naturally good at “playing the game” of exam taking may be advantaged because they can prepare ahead of time. • Assessment varies from student to student (e.g., a student doing only Application questions and no Analysis questions).

Programming/Modeling

All IE student engineers complete a one-credit technical competency in Programming/Modeling. The course focuses on either programming or modeling depending on the objective of the facilitator as well as the desires of participating student engineers. When focused on programming, course topics include content on both the tools and practices of programming. Throughout the class, student engineers create algorithms, develop pseudocode, navigate a programming environment, and generate code while engaging in guided discovery learning [23]. The basis for the majority of content in this course is that student engineers are asked to implement the unfamiliar but common algorithm of computing the square root as one would do if calculating it by hand [24]. While implementing the square root, students are exposed to key elements of algorithmic thinking, generating code, and debugging in a space where they are immediately able to check their results.

The final oral exam, which is scheduled for either 30 minutes or 60 minutes, replicates the overall course experience. Student engineers are asked to generate a script or program to complete a real objective not discussed during the competency. For example, the evaluator may ask a student engineer to develop code to sort a list of numbers, compute a logarithm with a particular process, or implement Newton’s method for numerically solving a differential equation. During the exam, the evaluator observes the development of the algorithm, the ability to write code, and the skill at debugging code using the programming environment. Importantly, like in the real world, the student engineer may use any resources they wish. When the student engineer struggles, appropriate hints and scaffolding ensure they do not get stuck in a particular space too long. The assessment of the exam is based on the amount of success (or progress towards success), the support needed for the student engineer to achieve the success they achieve, and the ability of the student engineer to articulate how they solved the challenge. The SWOT analysis for the Programming/Modeling approach is summarized in Table 4.

Table 4. SW analysis for Programming/Modeling oral exam approach.

Strengths
• Exam emulates an authentic application of the course material. • Process uncovers small errors in understanding that could propagate into major perceived deficiencies. • Small errors resulting from fundamental misunderstanding are discovered through observation, correction, and conversation. • Exam format often helps student engineers reframe and connect their knowledge in a way that makes more sense to them because of evaluator guidance. • Instances of academic dishonesty are reduced. • Evaluator is able to get more nuanced response to questions. • Student engineers tend to better know where their strengths and weaknesses in an area are at the end of the assessment.
Weaknesses
• Lack of formality in the exam situation may cause difficulty in determining if the student engineers have a different cultural context influencing their communication or have a lack of understanding. • Analogies can cause difficulty in knowing if students truly understand the concept or understand the limits of the model. • Time investment per student is relatively high. • Reliability of assessment may be low. • Risk student engineers focus on communicating with a particular examiner, which may not translate to success with another examiner. • Some student engineers are very effective at written communication and not oral communication.

Discussion

Throughout the case studies, the strength in variability of approaches was shown, which allowed for different strengths and weaknesses to emerge. Table 5 provides an overall collaborative summary of the SW analysis developed from the separate analyses for each course approach described in the results.

Table 5. SW summary for IE oral exam approach.

Strengths
• Entire IE department implements oral exams. • Evaluator has the opportunity to talk to each student in a one-on-one situation, which may be one of the first times based on class size and mode of class delivery. • Evaluator has the ability to probe in real time. • Evaluator may be able to find misunderstandings that only come through direct communication and can be corrected in real-time. • Immediate feedback as well as a variety of feedback is provided. • Targets higher levels of Bloom's Taxonomy by asking follow-up questions. • Adaptable to where students are currently at. • Applications and meaning-making can be the focus instead of simply performing calculations. • Less opportunities for cheating since students must defend individually
Weaknesses
• Approaches may tend to be less focused on engineering application and design, leading to memorization of answers and applications. • Time commitment may be demanding with large course numbers and multiple courses happening at the same time. • Challenging for students who may not be as naturally adept at oral communication or may not have English as their primary language. • Difficulty in determining what the appropriate amount of content or concepts for exam length of time is. • Hard to remember who said what for evaluation if not completed in real time.

After discussing and reviewing one another's strengths and weaknesses for each individual case, the research team collaboratively discovered some unique opportunities that oral exams provide for IE as well as some potential threats to the IE approach. The summary is provided in Table 6.

Overall, it was agreed that it is much easier to implement oral examinations when the entire department is administering exams in this format so that instructors have support and advice as needed. This also allows students to continually grow and adapt to the oral examination environment since they are consistently taking oral exams in their technical, design, and professional learning. It is also a strength that evaluators can have a one-on-one opportunity to target misunderstandings, probe and push students in their understanding, and provide feedback in both quantitative and qualitative ways. Students are also less likely to cheat in the sense they still must come in and provide their own oral answer to the exam questions, even if helpful information about the exam has been shared with them. The researchers all agreed that many times, the students are able to finally have information "click" or more fully make sense of FPs and concepts when explaining things in an oral exam.

All the approaches did have their downfalls, many of which focused on the time and cognitive demands or limitations for instructors. There is also the potential for the assessment to be catered toward those who are naturally more adept at oral communication and having English as their primary language. While some approaches were more structured, others were more flexible and adaptable, both were able to assess students in a non-traditional yet effective manner. Ultimately, none of these methods are perfect and have room for improvement, but that's where personal analysis using SWOT comes in to determine an individual's approach for what works and what doesn't based on circumstances.

Table 6. OT analysis for IE oral exam approach.

Opportunities
• Evaluator has flexibility in trying new approaches with practice and time to adapt. • Administration of the exam is aligned with more realistic situations that a student engineer may face in their future career. • Students are better able to retain information, especially theoretical information, for future conversations. • Differential and adaptive assessment method allows retaining students versus weeding them out. • Students are drawn to a differential approach of assessment, leading to strong recruitment of students. • Department can give workshops to other institutions on approach. • Shifts to remote learning are more easily adjusted to with a more flexible and adaptive environment for assessment than written examinations would. • Adaptable to workforce demands and needs. • Assessment at higher levels of Bloom's taxonomy than is typically accessible in other exam formats. • Use of oral exams across the department allows students to become more comfortable with the approach and improve over time.
Threats
• Growth of the program with the same faculty resources may overburden instructors with too many students or sections of courses. • University budget allocation to maintain appropriate student to instructor ratio may not always stay the same. • Evaluation may be inconsistent when giving too many exams. • Reliability can be decreased because people are people, which makes things more complex. • Inadequate amount of course content may be assessed because of limited time, which may leave students with gaps in their understanding. • Inadequate scaffolding and preparation for the oral exam during classroom activities may cause students who are naturally better at oral communication and/or have English as their first language to excel easier than others. • Accreditation issues if not well executed or explained

Limitations & Future Work

This self-study only included the approaches of four faculty members whereas the IE department has 12+ instructors that are involved in doing oral examinations in technical competencies. That also opens the limitation that only oral assessment approaches in technical learning were covered here. In the future, we would like to include additional faculty perspectives of the assessment method, both with technical learning as well as design and professional learning. Student perspectives on oral assessment would also be valuable in the engineering context. The grading scale for these assessments were not discussed in depth here, but can be found with interpretations in other publications [1], [21].

Conclusion

From this self-study, the research team acknowledges that any form of assessment, whether written or spoken, is attempting to evaluate what is in the student's brain and what they truly understand. As any instructor or evaluator knows, this is very difficult, regardless of the assessment form. Based on the SWOT analysis performed on individual cases and the approach of IE overall, spoken form creates a better approximation of student learning and understanding, but it is still not perfect as evidenced by the variety of approaches presented in this paper. Ultimately, some students may deeply understand some content but may not be able to orally communicate it, whereas some students may be better at communicating orally but may not fully understand the content as they need to as an engineer. The approaches and SWOT analysis provide potential ideas and a framework for practitioners to determine their own best implementation of the oral exam. That may be in conjunction with traditional written assessment methods or stand-alone as the sole method of assessment. It may be used as both a summative and formative assessment method and should be properly scaffolded in a course to support all students to be successful. While it is acknowledged that depending on the course size and number of sections taught, this may seem to be an unapproachable assessment method for many, but the research team emphasizes the real-world value of students being assessed in a way that is representative of their future roles as working engineers.

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