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Integrating Oral Assessment in Engineering – A Program-Based Approach Focused on Student Competency Development

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ABSTRACT

The pandemic and the evolution of generative artificial intelligence (GenAI) systems have disrupted traditional learning assessment methods. These changes have necessitated the experimentation of alternative forms of assessment, some of which have been permanently adopted. This is the case with oral assessment in the Chemical Engineering program at Polytechnique Montréal, where this assessment method has been in use for over 15 years. Recent developments have helped to solidify the role of oral assessment in the program and extend the approach to other courses. This paper describes the principles of oral assessment, the general structure of the Bachelor's program in Chemical Engineering, the implementation of this form of assessment over the four years of the program, and the success conditions of such a system. The originality of this contribution lies in identifying and operationalizing the elements necessary to make it an inclusive, non-anxiety-inducing, and respectful system for students.

KEYWORDS

Oral assessment, program-based approach, capstone projects, evaluation, competencies development

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Introduction

The traditional learning assessment landscape in engineering education (EE) has faced significant disruptions due to the COVID-19 pandemic and the rise of generative artificial intelligence (GenAI) technologies. These changes have sparked a reflection across institutions on how to evaluate students in a way that ensures integrity, fairness, and the development of professional competencies. In engineering education, where professional communication and problem-solving skills are essential, oral assessment presents an especially relevant modality. This paper focuses on the long-term implementation of oral assessment in the Chemical Engineering program at Polytechnique Montréal. It highlights the program's competency-based approach and explores how oral evaluation supports the development of essential engineering skills across the curriculum. This paper contributes originally by

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identifying the key conditions and mechanisms that foster an inclusive, respectful, and psychologically safe oral assessment environment, especially suited to the realities of engineering education.

Oral Assessment

Oral assessment, where a student answers questions in front of one or more instructors, has a long tradition in Europe (Stray, 2001), but its use is rare in North American universities, except in graduate studies where oral defenses mark key milestones. Generally, students are evaluated through written assessments in university settings (Alexander, 2004). The almost complete absence of oral assessments in some programs is surprising, as graduates are often expected to interact orally in professional settings. This is particularly true for future engineers who will soon face job interviews and may eventually have to defend their ideas orally as highly qualified professionals (Huxham, et al, 2012).

An assessment can be considered oral as soon as it involves verbal interaction (Joughin 1998). Our definition goes further. Oral assessment encompasses six dimensions, each involving decisions regarding the assessment format (Joughin, 1998; Theobold, 2021). First, the knowledge and skills to be demonstrated must be identified. These may target the memorization of knowledge, the understanding of concepts, and/or the ability to solve problems or respond to a given situation. Second, oral assessment differs from the traditional oral presentation by the presence of a viva voce dialogue between the student and the instructor. Third, the assessment is authentic if it includes unscripted, natural interactions typical of professional settings or if it simulates an expected oral competency in the future profession. Fourth, the format can be open or closed, depending on the level of freedom granted to the student in interactions. Here, open refers to the possibility of many different correct responses or methodologies, whereas closed refers to a single correct answer. Fifth, the student may lead the oral assessment to demonstrate their mastery of a subject or competency, or the assessment may be led by the instructor, who asks questions. Sixth, the examination can be exclusively oral or partially oral if it complements a written assessment. These parameters vary the format of the assessment. While these six dimensions apply broadly to oral assessment, their application in engineering education requires particular attention. For instance, authentic interactions often involve technical problem-solving, design justifications, or safety-critical decisions — all central to engineering practice. Similarly, the open or closed nature of the assessment must reflect not only student autonomy but also the discipline's emphasis on precision and standards. The format thus evolves to simulate real-world engineering dialogues, such as design reviews or client briefings, and this alignment enhances both the credibility and relevance of the evaluation.

The inclusiveness of an assessment method is rarely debated in academic settings. Although institutions are required to offer accommodations to students with disabilities, these are usually managed by a third-party service, and the instructor is often unaware of them. The constant increase in the number of students with special needs puts pressure on these services. In this context, it is appropriate to create more inclusive assessments to avoid the need for adaptive measures (Tai et al. 2021). Students consider authentic assessments to be inclusive in that they resemble typical contexts of the future profession and their constraints (Pereira, Flores, and Niklasson 2016; Tai et al. 2023). For example, when future professionals are required to explain and defend their solutions or demonstrate a high level of critical judgment, oral assessment is a justified choice. Nevertheless, to make it an inclusive and less anxiety-inducing assessment, the instructor must provide opportunities to practice the format during the term, specify the time allocated to the assessment, indicate what students will need to demonstrate and how they can prepare, and communicate the evaluation criteria and the nature of the feedback they will receive (Theobold 2021). On the day of the assessment, the instructor must also ensure that every student, regardless of their background or perception of authority, feels comfortable expressing their thoughts (Theobold 2021).

Moreover, as a method, oral assessment is considered more inclusive for students with disabilities, particularly dyslexic students (Waterfield and West 2006). It allows for a more accurate assessment of understanding and analysis compared to written assessments (Tan et al. 2022; Theobold 2021). This method also provides evaluators with a more comprehensive view of student understanding, as this format allows for quick clarification of ambiguities and provides immediate feedback (Theobold 2021). Finally, coherence is enhanced when such a method is used throughout the program (Tan et al. 2022).

Despite all the advantages it offers, the method is perceived by instructors as time-consuming (Theobold 2021), subjective, prone to various biases (Huxham, Campbell, and Westwood 2012), anxiety-inducing, and favoring extroverted and confident students (Wisker 2004). Conversely, this added stress may encourage students to prepare more thoroughly than for a standard written exam (Huxham, et al., 2010). In contexts involving problem-solving with mathematical reasoning, an oral examination where students are asked to defend their choice of method or suggest alternative approaches requires different preparation. In such contexts, students do not limit themselves to memorizing previous problems. They prepare as a team, ask each other questions, and engage in deep learning (Ofade 2006; Farand & Tavares 2017).

With the advent of GenAI technologies, oral assessment offers the added opportunity of directly and authentically measuring student understanding. This is in stark contrast to the current reality where many take-home written evaluations risk being written by various chatbots. Authentic measurements of understanding, possible through oral assessments, ensures that the engineers trained have validated key elements of their curriculum, and most importantly have shown the ability to think critically, avoiding the illusion of competence (Barba, 2025).

In this context, the Chemical Engineering program at Polytechnique Montreal has chosen to experiment with and maintain oral assessment because of its multiple advantages and contributions to learning. The next section describes the general elements that structure the Chemical Engineering Bachelor's program at Polytechnique Montréal and how oral assessment gradually establishes its coherence within the program.

The Chemical Engineering Bachelor's Program at Polytechnique Montréal

The undergraduate program in Chemical Engineering at Polytechnique Montréal is a 120-credit, four-year curriculum built according to a program-based approach (Prégent et al., 2009). This concerted way of constructing the program has allowed for a high level of synergy between the different core courses. Since 2005, this high degree of coordination has enabled the creation of several courses evaluated based on a competency framework. It is thus possible to track the evolution of a future engineer's competencies throughout a series of courses, particularly through a combination of criterion-referenced evaluation grids (Stevens &Levi 2005; Huba & Freed 2000) rather than simply assigning a grade compared to, for example, a class average (Harvey, et al., 2015).

A distinctive element of this training program is the progression of student autonomy and the gradual reduction of supervision over the four years. The program is structured to promote student autonomy and develop certain competencies specific to chemical engineers. At the beginning, considerable support is offered, which gradually shifts from support to mentoring as the student progresses through the program. This evolution is linked not only to the progression of course content but also to the frequency and structure of the evaluations used, moving from a normative approach (comparing students to each other in an evaluation structure with many assessments) to a criterion-referenced approach (judging a student's ability to meet a predetermined criterion in an evaluation structure with fewer assessments). The progression in the number of assessments and the reduction in student

supervision also greatly impact the format of the oral assessment offered to students between the first and fourth years of the program. Before addressing their format, another important context is the notion of capstone projects within the program.

Each year of the program, students complete a capstone project. These major projects synthesize the main concepts learned during the year and offer an opportunity to solve a complex, open, and authentic engineering problem (Prégent, et al., 2009). Increasingly complex, the capstone projects are mainly activities focused on the design of a chemical process, requiring both technical and transversal competencies such as teamwork, literature research, and written and oral communication. These projects act as checkpoints in the training, allowing students to mobilize and showcase their competencies with help and under the constant supervision of an expert (or team of experts). This sets the foundation for professionalization in engineering. The following section describes how oral evaluations have been implemented as part of this program-based approach, both in the context of capstone projects and in various courses in the curriculum; core characteristics for successful and inclusive oral evaluations are part of this process (Joughin, 1998, Theobold, 2021).

Oral Assessment... A Program-Based Approach

Figure 1 illustrates how oral assessment has been implemented in a program-based approach since 2007 in the Bachelor's program in Chemical Engineering at Polytechnique Montréal, as part of the capstone projects.

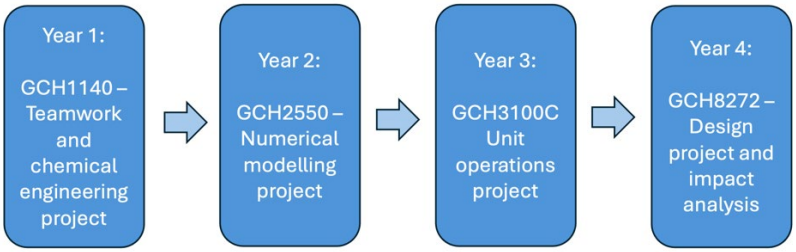

Figure 1: Chronology of Oral Assessment Over 4 Years in the Chemical Engineering Bachelor's Program

Oral evaluation is first introduced within the first-year capstone project (*GCH1140 – Teamwork and Chemical Engineering Project*). It is then more formally utilized in the second-year capstone project (*GCH2550 – Numerical Modeling Project*), which marks the end of the first half of the 4-year training program. In the third year, the capstone project (*GCH3100C – Unit Operations Projects*) also includes an oral assessment. Finally, each student undergoes a fourth oral assessment as part of their final capstone project in the fourth year (*GCH8272 – Project Design and Impact Analysis*). Other courses also use this method, such as the mandatory course *GCH8271 – Process Design and Synthesis* and the elective course *GCH8729 – Solid Waste and Waste Heat*.

These oral assessments, also referred to as oral defenses in a project context, evaluate the student's ability to individually answer questions about the work done individually or in a team, and to demonstrate their competencies. The fact that this sequence is spread over four years allows students to become familiar with the oral assessment method. The ability to orally defend one's competencies and the rationale behind the steps taken in a completed project are crucial elements in the engineering profession.

Year 1 – An Informal Introduction to Oral Assessment

Upon entering the Chemical Engineering Bachelor's program, students have completed their college education or a similar level of schooling. The transition from college to university is an important step that requires many adjustments. To facilitate this transition, early-program courses offer a traditional

framework largely similar to what they already know. Many courses include several assessments that represent a small weighting of the final course grade. This strategy encourages students to work regularly, thus making it easier to prepare for exams and associated projects. Autonomy is therefore limited at the beginning of the curriculum to foster their integration into the academic culture and contribute to the development of good study habits.

The first capstone project, completed in the first year (course GCH1140), allows the integration of concepts learned during the first year of training and introduces students to teamwork. Students are grouped into teams of six and must complete a project over the semester. Each team selects a process of their choice (e.g., cheese production, aluminum production) and models it using a three-dimensional simulation.

At the end of this project, a presentation day is organized. Each team prepares a poster summarizing the completed project and presents the model of the studied process. Few guidelines are provided for the poster's composition. Besides a maximum size, students have the freedom to highlight the content they deem appropriate to present their project. Before the poster is printed and presented, written feedback is provided by the instructor to allow some improvement of the proposed poster. This aims to raise student awareness of the possibility to continuously improve their work. These presentations are open to the entire university community, who can question students about the overall project.

This event represents the first oral assessment within the students' training and allows them to be introduced to this form of assessment "gently." Questions posed are not directed; in other words, students can help their teammates respond to questions asked. For this first oral assessment, the preparation of both instructors and students is similar to what one might know of a traditional oral presentation. Table 1 summarizes its parameters.

Table 1: Relevance of the oral assessment dimensions to the 1st year project course (GCH1140)

Oral Assessment Dimensions	**Relevance to GCH1140**
1) Nature of the competencies to be demonstrated	Knowledge in chemical engineering, problem-solving, creativity
2) Presence of a viva voce dialogue between the student and the instructor	Yes
3) Unscripted, natural interactions typical of professional settings	Free, unscripted interactions
4) Open or closed format depending on the level of freedom given to the student	Open format
5) Led by the student or by the evaluator	Hybrid – the student team prepares a poster presentation speech, and the evaluator openly dialogues
6) Exclusively oral or partially with written support	The poster and its oral presentation are accompanied by a written report

Time commitment for the evaluation team

- Logistics and scheduling: 1 h total
- Drafting questions: not applicable, questions determined during the presentations

- Oral examination time: 3 h per evaluator, 1 instructor, 1 teaching assistant, 6 h total

The total time commitment for the evaluator team is normally 7 h.

This first experience with oral assessment will be followed by a second experience in the subsequent year, during which the level of student autonomy will increase.

Year 2 – First Short Individual Oral Assessment

In the second year, instructors give students more autonomy. Courses include fewer assessments with less weighting and more "recommended" problems to be explored independently. Assessments integrate concepts learned in the first year.

The second oral assessment occurs in *GCH2550 – Numerical Modeling Project*, which includes about 80 students who must complete a project in teams of four. This project-based course aims to achieve several objectives, including integrating the knowledge acquired during the first two years of training into a project closer to industrial reality, consolidating communication and teamwork skills, and developing professional aptitudes. These elements are of great importance at this stage of the students' training program as they will be undertaking their first industrial internship the summer following this course. The mandate assigned to all student teams is identical, focusing on the same process and units (which vary from year to year however).

To ensure that each student masters the evaluated competencies, two individual evaluation mechanisms are provided: a final written exam (20% of the course grade) and an oral defense (5% of the course grade); the remaining 75% are assigned to project deliverables. A minimum grade of 50% on the two former evaluations is required to pass the course. This defense also aims to prepare students for the much larger-scale oral defense that will take place in the third year.

Preparation of the Teaching Team for the Oral Assessment

To maximize fairness during the oral assessment, the teaching team, consisting of three members (an instructor and two teaching assistants), prepares a collection of several questions based on the three main themes of the capstone project (understanding the process and design of a plant, design of a material and energy balance simulator, and design of a dynamic simulator for a unit operation). These questions can revisit themes explored during the project's execution, assess the understanding of the work done, or require partial developments to be reproduced on the board. For each of the three themes, the teaching team prepares about 50 questions. However, during the oral assessment, additional minor variants of these questions may be improvised.

Once the three sets of 50 questions are produced, they are reviewed by the three members of the teaching team. This ensures alignment between the questions asked and the work done in class by the students with the expected level of difficulty. As an indication, here are two examples of questions asked:

- During furnace operation, what would be the impact of increasing the amount of excess air?
- What would be the main greenhouse gas emissions in the process studied this semester?

It is important that the questions asked are open-ended, allowing the student to express themselves more fully.

Student Preparation for the Oral Assessment

To prepare students for this assessment, a simulated oral defense is conducted in class two weeks ahead of time. The course instructor asks questions to one of the teaching assistants present in all sessions, explicitly mentioning to the group whether they have answered correctly or not, identifying various

alternate ways to respond in different contexts, and providing an overview of the grade they would have received. Strategies such as asking to rephrase the question, or circumventing obstacles are exemplified in this simulated defense. About 20 minutes are allocated during one of the last class sessions for this simulation. This approach reassures students regarding the assessment process and the types of questions they are likely to be asked (Nash, Crimmins, and Oprescu 2016). Feedback from students over the years has shown that this approach greatly contributes to reducing the stress associated with the course's oral assessment.

In particular, this classroom preparation addresses common student concerns, such as the fear of not knowing how to react to an unclear question or how to respond when they do not know the answer. We therefore take the time to equip students thoroughly so that they know how to respond if such situations arise.

Oral Assessment

On the day of the assessment, each project team presents in class for about 30 minutes in front of the teaching team. During the oral exam, each student is questioned for approximately 7 min 30 s. Questions related to the project are asked to each student for about 2 min 30 s before returning to the first student, and so on, to cover all three themes. This allows each student to answer questions and have a break before answering additional questions. Each student will speak three times. Depending on the question, the student may need to use the board to draw diagrams or perform specific mathematical developments. Since this is an individual exam, students are not allowed to help each other answer the questions. Additionally, no documentation is permitted. This oral assessment is recorded for review purposes in case a grade revision is requested.

For a group of 80 students (20 teams), approximately 10 hours of oral assessment are required. As mentioned earlier, the perception that oral assessment is time-consuming is strong among the teaching population (Theobold 2021), but experience gained over the years has shown that the time invested by the teaching team is either equivalent to or less than the time required for designing, supervising, and grading a traditional assessment on the same content. For a comparable written exam, 8 hours would typically be allocated for its design and writing, 3 hours for supervision, and nearly 40 hours for grading (totaling over 50 hours).

During a student's oral assessment, the instructor adopts a supportive attitude, regardless of the situation. This helps reduce stress when the student perceives that the examiner is there to help and genuinely assess what they know rather than to "trap" or belittle the student. Students are informed that instructors will adopt a neutral attitude, both in verbal interventions and body language.

If a student does not know the answer to a question, the instructor provides a first hint or clarifies the question. If this intervention is unsuccessful, the question may be divided into sub-questions. This approach allows the student to at least partially answer the question, thus avoiding a stressful situation in which no response is given. However, to ensure fairness, it is important not to offer additional or repeated hints to the same student.

Grading

The student's answers to the questions posed by one of the three members of the teaching team are graded using a letter scale based on a holistic evaluation rubric. The student can easily ask for the question to be rephrased if they feel it is unclear. At the end of the oral assessment, each member of the teaching team assigns a grade for each student (Table 2). The average of the three assigned letter grades is calculated and converted to a percentage.

Table 2: Rubric used to evaluate student performance in 2nd year oral evaluations (GCH2550)

Observed Performance	**Assigned Grade**
The student answers the questions very well and without hesitation. There is excellent understanding of all the concepts.	A
The student answers the questions well, despite a few minor errors or inaccuracies. There are some hesitations. A minor hint had to be given. There is good understanding of most concepts.	B
The student answers some of the questions, but significant errors were made. There are several hesitations. Several major hints had to be given. There is nonetheless an understanding of important concepts.	C
The student answers some of the questions with difficulty and several significant errors were made. There is a significant lack of confidence. Several major hints had to be given. There is a weak understanding of important concepts.	D
The student answers all the questions incorrectly. There is a lack of understanding of important concepts.	F (failure)

Feedback and Advice

After the oral assessment period, as the semester is over, each student receives an email with a file compiling the grades assigned by the three evaluators. In this course, it is unfortunately not possible to provide detailed feedback to all students. However, if a student has doubts about an assigned grade, they can meet with the course instructor to review their oral assessment. It is then possible to re-explain certain concepts and clarify how the responses were evaluated using the grading rubric. This situation is quite rare. Out of 80 students, usually only one or two will contact the instructor. Table 3 summarizes the alignment of oral assessment dimension with the GCH2550 course.

This second-year oral assessment has a low weighting and does not last very long, but it aims to ensure that all team members master the concepts involved in the project. In engineering professional practice, a global understanding of the phenomena underlying a given problem is important for the engineering solution to be relevant and safe.

Time commitment for the evaluation team

- Logistics and scheduling: 1 h total
- Drafting questions:
    - Initial drafting of questions (non-recurring): 4 h per evaluator, 1 instructor, 2 teaching assistants, 12 h total
    - Updating the question bank (recurring): 1 h per evaluator, 1 instructor, 2 teaching assistants, 3 h total
- Oral examination time: 10 h per evaluator, 1 instructor, 2 teaching assistants, 30 h total

The total time commitment for the evaluation team is normally 34 h. For the first time the oral exam is prepared, this estimate climbs to 43 h, split across 1 instructor and 2 teaching assistants.

Table 3: Relevance of the oral assessment dimensions to the 2nd year project course (GCH2550)

Oral Assessment Dimensions	**Relevance to GCH2550**
1) Nature of the competencies to be demonstrated	Knowledge in chemical engineering, problem-solving, justification of hypotheses
2) Presence of a viva voce dialogue between the student and the instructor	Yes
3) Unscripted, natural interactions typical of professional settings	Scripted initial questions, unscripted clarifications or hints
4) Open or closed format depending on the level of freedom given to the student	Closed format limited to predefined questions
5) Led by the student or by the evaluator	Led by the evaluating team
6) Exclusively oral or partially with written support	Hybrid – the board can be used as support. The oral exam is the culmination of three written reports submitted during the semester

Year 3 – Long Individual Oral Assessment

In the third year, professors encourage students to further develop their autonomy by providing minimal formal support in situations they have already encountered. When students have questions about a course, they are encouraged to find the answer themselves or with the help of their classmates. As a last resort, they consult their professors, according to their thematic expertise. Most assessments evaluate competencies using defined rubrics, and some more traditional exams are also used.

The third oral assessment occurs in the project-based course *GCH3100C – Unit Operations Projects*. The course comprises approximately 60 students who must complete a project in teams of eight. This six-credit course is part of a thirteen-credit overall course (GCH3100) that occupies the students' entire schedule for a full semester, and in which twelve evaluation members are involved. All projects focus on the same process, but each team is assigned a different unit (product purification for one team, reagent preparation for another, etc.).

To ensure that each student masters the competencies on four main themes of the project (fluid mechanics, heat transfer, separation processes, process control), an individual oral defense worth 20% of the GCH3100C course grade is provided. The result obtained in this evaluation is a passing criterion for the course; this means that if a student fails this evaluation, they will fail the GCH3100C course.

The various steps for the teaching team and students, including oral assessment preparation, execution, and grading, are conducted similarly to what was described earlier for the second-year capstone project. However, the following distinctions can be noted:

- A particularity of this oral assessment is that it is conducted by eight members of the course's teaching team (versus three in the second year). The members are grouped into teams of two (one senior instructor and one junior instructor or teaching assistant), and each pair of evaluators occupies a different classroom.
- The students of each eight-member team also divide into four pairs. Each pair spends 15 minutes per classroom and then moves to the next room.

- During their time in a classroom, each student is questioned for 7 min 30 s on one of the four themes of the capstone project.
- This means that each student is questioned for a total of 30 minutes on all the elements worked on during their capstone project.

This way of organizing the oral assessment saves a lot of time. For eight teams of eight students, a total of 8 hours is required. The assessment process is also formative for the evaluators – the evaluation pairs typically consist of one senior, more experienced member and one junior member. This course is an opportunity to train our instructors on the oral assessment methodology. Table 4 summarizes how GCH3100C aligns with the various dimensions of an oral assessment.

Table 4: Relevance of the oral assessment dimensions to the 3rd year project course (GCH3100C)

Oral Assessment Dimensions	**Relevance to GCH3100C**
1) Nature of the competencies to be demonstrated	Knowledge in chemical engineering, problem-solving, justification of hypotheses and design choices by theme
2) Presence of a viva voce dialogue between the student and the instructor	Yes
3) Unscripted, natural interactions typical of professional settings	Scripted initial questions, unscripted clarifications or hints
4) Open or closed format depending on the level of freedom given to the student	Closed format limited to predefined questions
5) Led by the student or by the evaluator	Led by the evaluation pairs
6) Exclusively oral or partially with written support	Hybrid – the board can be used as support. The oral exam is accompanied by a significant design report

Time commitment for the evaluation team

- Logistics and scheduling: 1 h total
- Drafting questions:
  - Initial drafting of questions (non-recurring): 4 h per instructor, 4 instructors, 16 h total
  - Updating the question bank (recurring): 1 h per instructor, 4 instructors, 4 h total
- Oral examination time: 8 h per evaluator, 4 instructors, 4 teaching assistants, 64 h total

The total time commitment for the evaluator team is normally 69 h. For the first time the oral exam is prepared, this estimate climbs to 81 h, split across 4 instructors and 4 teaching assistants.

Year 4 – Oral Assessment as a Design Dialogue

For fourth-year students, we offer courses where the degree of autonomy in decision-making is high. The support provided by instructors is intentionally minimal and primarily aims to guide students toward useful resources, as the required expertise may be outside the instructor's competence, given the diversity of the various industrial projects tackled. The project-based course *GCH8272 – Project Design and Impact Analysis* comprises 7 credits. One credit is assigned to the initiation of the capstone project in the previous semester's course (*GCH8271 – Process Design and Synthesis*), in which students prepare a service proposal in response to a real industrial mandate presented by industrial partners. Most of the work (6 credits) is then carried out in GCH8272. The group typically consists of

50 to 60 students, and all projects assigned to teams of 4 to 6 students are different, completely open, and conducted in close collaboration with industry. Students from the Mechanical Engineering or Electrical Engineering departments are sometimes integrated into the teams to bring authentic multidisciplinary expertise to the projects. Each team is mentored by an instructor, and an instructor typically supervises three teams. The teaching load for this capstone project is reserved for professors and lecturers with industrial experience. Students must mobilize not only strong technical skills but also project management and written and oral communication skills. The service proposal oral exam carries a 10% weighting for the GCH8271 course, whereas the progress report and final report oral exams carry 20% and 30%, respectively, of the GCH8272 course grade.

For all deliverables of this capstone project, the evaluation criteria are clearly defined from the outset by the instructors and industrial partners, and are directly linked to industrial standards. In this final project of the undergraduate program, a particular feature is highlighted for the evaluation of oral presentations: no evaluation rubric is provided in advance. This approach allows consideration of the diversity of different projects and aims to sensitize students to the importance of calibrating their message according to the precise expectations of their client for their project. This evaluation approach aims to replicate the authentic industrial framework, where fixed criteria and rubrics are not available when preparing an oral presentation for a superior or an external client.

This particularity modifies the oral assessment process compared to previous years, converging on increased professionalization of students:

- For the three oral presentations associated with the project (the service proposal, the progress report and the final presentation), a practice period led by a team of teaching assistants is offered a week before each exam. This preparation period, lasting at least half a day, brings together all students in a room where they take turns presenting their work. The teaching assistants provide constructive feedback, not on the technical aspects but rather on the clarity and structure of the presentation and the choice of key elements to present (each project has its particularities, so students must choose which elements to highlight). Students attend their colleagues' presentations, allowing for amplified general feedback (Van Ginkel, et al., 2017).
- During presentations, 10 to 25 minutes (depending on the exam) are reserved for a question period led by the assigned instructors (typically at least three instructors are present). When the industrial partner of the project is present, they also contribute to the question period. Instructors who have not closely followed the team's progress are invited to ask questions first, so that students can benefit from external feedback.
- The format of the question period remains open: students decide and designate among themselves who will answer questions on particular themes (instructors can, if necessary, target an individual for clarification, for example, in a context of detected inequities within the team). The assigned grade will generally be a team grade.
- The evaluation of these oral presentations is the result of a consensus among the entire teaching team, including contributions from the teaching assistants. This allows for jointly obtaining external and internal opinions on the project to assign a grade proportional to the actual and perceived efforts.
- Student teams are met after the service proposal presentation and the progress report to receive constructive feedback from the supervising instructor, compiling comments collected from the entire teaching team.
- For 12 teams, these three evaluations (the service proposal, the progress report, and the final presentation) last approximately 6 hours per exam, plus a few breaks spread throughout the day.

Ultimately, this assessment method is perfectly aligned with the professional world, as engineering projects are typically carried out and presented in teams and defended as a team. Its alignment with oral assessment dimensions is highlighted in Table 5.

Table 5: Relevance of the oral assessment dimensions to the 4th year capstone design project (GCH8272)

Oral Assessment Dimensions	**Relevance to GCH8272**
1) Nature of the competencies to be demonstrated	Problem-solving, justification of hypotheses and design choices, selection of key elements to present, and communication skills
2) Presence of a viva voce dialogue between the student and the instructor	Yes
3) Unscripted, natural interactions typical of professional settings	Unscripted questions focused on validating design choices and techno-economic contextualization
4) Open or closed format depending on the level of freedom given to the student	Open format – students decide among themselves who answers questions on particular themes (instructors can, if necessary, target an individual for clarification)
5) Led by the student or by the evaluator	Led by the instructors
6) Exclusively oral or partially with written support	Hybrid – the board and additional slides can be used as support. Each oral exam is accompanied by a comprehensive written report.

Time commitment for the evaluation team

- Logistics and scheduling: 1 h per exam, 3 exams
- Drafting questions: not applicable, questions determined during the presentations
- Practice sessions: 4 h per evaluator, per exam, 4 teaching assistants, 3 exams, 48 h
- Oral examination time: 6 h per evaluator, per exam, 4 instructors, 4 teaching assistants, 3 exams, 144 h total

The total time commitment for the evaluator team is normally 195 h (for 12 project teams).

Oral Assessment as an Alternative to Written Exams

In a similar vein, oral assessment is gradually being implemented in traditional courses (i.e., not linked to a capstone project) in our university. This is particularly the case for a mandatory fourth-year course, *GCH8271 – Process Design and Synthesis*, and an elective course, *GCH8729 – Solid Waste and Waste Heat* (the latter will not be discussed here as it differs very little).

The GCH8271 course is a three-credit course offered in the fourth year of the Chemical Engineering program. This course aims to integrate the various concepts taught during the first three years of the bachelor's program in a plant design context. To this end, technical notions and the design process are presented in the context of economic evaluation, environmental impact assessment, and process safety. Students also learn to confront the inherent uncertainty of design mandates and how to use heuristics, deploy troubleshooting methods, and make coherent assumptions to advance the design and operation of a chemical process. The theoretical aspect of the course is carried out in parallel with the fourth-year capstone project described earlier.

To accustom students to explaining the key concepts of the course in a targeted and concise manner, the oral exam is chosen as the evaluation mechanism for two individual exams: the mid-term exam (20% of the final grade) and the final exam (30% weighting). Like the second- and third-year course-projects, a double threshold is applied for this course – students must maintain an individual weighted average of 60% to pass the course. This double threshold is particularly important for this last mandatory course in the Chemical Engineering curriculum, as it validates individual competencies before entering the professional world.

Preparation of Instructors and Students for the Oral Assessment

As in the previously described project-based courses, each oral exam requires preparation in advance by the teaching team (typically 2 instructors and 2 teaching assistants). A collection of (at least) 20 conceptual questions divided into 4 or 5 categories related to the course themes is prepared in advance. Each student must answer at least one question per category. Between 5 and 7 questions will be asked to each student (the same number for each student in the same exam, with the number being dictated by the teaching team's estimation of the time required to answer adequately). Expected answers are defined for each question, with some cases including weighting per answer element.

Before each exam, a simulation of the oral exam (a shortened version comprising 2 or 3 questions) is presented in the form of an online video. This simulation between the instructor and two teaching assistants aims to show students the exam structure, the type of questions chosen, and the grade assigned, all with the goal of reducing anxiety related to the oral exam.

Each student is met individually during an assigned 15-min time slot. To limit the total duration of the exam period, the group of about 50 to 60 students is divided into two subgroups evaluated by two different teaching teams (one instructor and one teaching assistant per room). Thus, the evaluation takes place over a period of 5 to 7.5 h, plus a few break periods totaling 45 to 60 min spread throughout the day (in other words, the exam can be held in a single day). Each subgroup is met by one of the two instructors and a teaching assistant during the mid-term exam, and the instructors are switched for the final exam. The teaching assistants remain the same to ensure continuity and consistency between the grades assigned. Since the exam schedule exceeds the time allocated for the course, it is important to survey students well in advance to determine their availability.

Oral Assessment

On the day of the exam, this assessment is conducted in three phases:

1. **Welcome:** The student arrives at the exam room at least 5 minutes in advance and waits outside until their turn. When the time comes, the instructor and the teaching assistant invite the student in, offer a brief welcome, and start the timer. They proceed with a systematic explanation of the process (which had already been sent in advance by email):
    - The number of questions that will be asked;
    - The student can return to any question if time permits. At that time, they can change their initial answer if it was incorrect. Only the last provided answer will be considered for evaluation;
    - If the response takes more than 2 minutes, the student will be asked to move on to the next question to ensure that as many themes as possible are covered;
    - Before moving on to the next question, the student will always be asked, "Is there anything else to clarify?" (specifying that this is simply to ensure completeness before moving on and has nothing to do with the quality of the response).
2. **The Exam:** The instructor and the assistant take turns asking questions.

- The questions are randomly assigned in advance in an Excel spreadsheet, ensuring that each theme is covered equivalently for each student. Some questions are variants of others.
- For certain themes, an illustration or table is displayed on a screen, for example, to invite the student to analyze a flow diagram.
- Over the years, a request from students has been to systematically display the questions (whether accompanied by a graphic or not) on the screen so they can reread the question if necessary.
- The instructor or teaching assistant are free to ask for clarification if needed to fully understand the response provided by the student. Similarly, a request for clarification may involve rephrasing the question if the instructor believes it was misinterpreted or if the student is heading in an irrelevant direction. As with the previously described assessments, controlling oral tone and non-verbal behavior is important to avoid contributing to the student's anxiety.
- The student may also ask for clarification on the question, and the teaching team must judge the appropriate response to provide for these queries.
- If time permits, the instructor or teaching assistant provides a quick summary of the questions asked and asks the student if they wish to revisit certain questions.

3. **Conclusion:** When the exam is over, the student is thanked and told that the results will be posted in the coming days on the course's web platform. Before welcoming the next student, the two evaluators share their assigned grades, and the average of the two evaluations is used as the final grade.
   - If significant discrepancies are noted on certain questions between the two evaluators, a discussion takes place to determine if elements were overlooked or misinterpreted.
   - At the end of the day, both evaluator teams meet to determine if there are any significant differences between the grades offered between room, or between the morning and the afternoon, and calibrate accordingly.
   - Feedback is provided in class after the mid-term exam, particularly for questions and themes that posed more general difficulty. After the final exam, or for more problematic situations, individual feedback is available by appointment with one of the instructors.

This method of orally evaluating students can be applied to any course that does not require complex calculations, and it is particularly well-suited to the evaluation of open-ended questions without prescribed answers. The oral assessment described in this section allows for the easy evaluation of higher taxonomic levels of cognitive processes (Anderson & Krathwohl, 2001). Alignment with the dimensions of an oral assessment is presented in Table 6.

Table 6: Relevance of the oral assessment dimensions to the 4th year course (GCH8271)

Oral Assessment Dimensions	**Relevance to GCH8271**
1) Nature of the competencies to be demonstrated	Knowledge and understanding in design, problem-solving, justification of hypotheses and design choices
2) Presence of a viva voce dialogue between the student and the instructor	Yes

3) Unscripted, natural interactions typical of professional settings	Scripted questions determined in advance with the possibility of clarifications offered
4) Open or closed format depending on the level of freedom given to the student	Closed format limited to predetermined questions
5) Led by the student or by the evaluator	Led by the evaluation team
6) Exclusively oral or partially with written support	Oral, with the possibility of using the board to clarify answers if needed

Time commitment for the evaluation team

- Logistics and scheduling: 1 h per exam, 2 exams, 2 h total
- Drafting questions:
    - Initial drafting of questions (non-recurring): 6 h per instructor, per exam, 2 instructors, 2 exams, 24 h total
    - Updating the question bank (recurring): 1 h per instructor, per exam, 2 instructors, 2 exams, 2 h total
- Oral examination time: 8 h per evaluator, per exam, 2 instructors, 2 teaching assistants, 2 exams 64 h total

The total time commitment for the evaluator team is normally 68 h, combined for the midterm and final exams. For the first time the oral exams are prepared, this estimate climbs to 90 hours, split across 2 instructors and 2 teaching assistants.

Summary of Acquired Experience and Conclusions

A Few Observations

Oral assessment in the Chemical Engineering Bachelor's program has been in place for several years now and has allowed for the evaluation of thousands of students. This practice has greatly contributed to consolidating our students' oral communication skills. Indeed, we notice greater confidence in responding orally to questions as students progress through the training program. Several interesting observations have been made by both internal and external individuals to our program.

- Instructors participating in oral assessments highlight their ability to quickly identify whether a concept is mastered or not by openly discussing it with the student, unlike a written assessment where iteration or requests for clarification are not possible. Moreover, posture and non-verbal cues may help gauge the student's level of understanding.

- The instructors responsible for the fourth-year capstone project note a greater ability to dialogue with students, as the discussions are now more focused on the important components of the project rather than simple alignment with a general evaluation rubric.

- Every year, a team from the fourth-year capstone project presents and defends their project in the Hatch/Zeton Design Competition during the Canadian Chemical Engineering Conference. In 2016, 2018, 2019, 2021 and 2023, the design teams nominated for the competition qualified as finalists (3rd or 4th place at the Canadian level), and the 2017 and 2020 teams won the national competition.

- Industrial partners who supervise the fourth-year capstone project teams often comment on the students' excellence in communication. For example:

"Professional and very diligent team. It was a pleasure to collaborate with them! [...] They were able to clearly justify each of their choices orally."

Comments from Students and Faculty Members

Over the years, we have established a continuous improvement process for our oral assessment practices based on feedback received from students, faculty members, and our graduates. This practice is part of an ongoing effort to improve the development of student competencies already in place in the Chemical Engineering program (Farand & Tavares, 2017).

Among the noteworthy elements, the preparation of students for the oral defense is highly appreciated. Whether through a classroom simulation or a video tutorial on the subject, many highlight during end-of-term teaching evaluations that preparation is important and appreciated:

> *"Very good explanation of the oral defense. The task at hand is very clear."*

Students do note however that oral examinations are more useful when they lead to discussion and exchanges; questions that rely on memorization are not appreciated:

> *"Interesting oral exams, but avoid focusing on questions that are too specific (they're not meant to be about going into details, but about thinking through arguments)."*

Students also note, especially at the beginning of their journey, that this assessment mechanism is anxiety-inducing.

> *"The oral exam does not allow us to know exactly what points we will be evaluated on, and this adds a source of stress. Maybe that's intentional since it can also have a positive effect."*

We are constantly striving to explain how the assessment will be conducted to reduce the associated stress in response to such comments. For the specific case of students who normally benefit from additional time for exams, the stress imposed by an oral examination can be compounded:

> *"The oral exam modality does not allow students who normally receive additional time to receive it. I normally have 50% extra time due to anxiety issues, and I felt disadvantaged, and this actually increased my stress levels."*

Indeed, the student is correct here: the academic policies in place at Polytechnique Montréal do not award additional time for oral evaluations, or more generally for evaluations lasting less than 60 min. However, what the student does not mention in their comment is that the instructors will strategically schedule students who normally receive accommodations right before the break periods, informing them that they can safely take a bit of extra time without penalty.

Faculty members also contribute to the evolution of this assessment practice. Some instructors were initially reluctant to use oral assessment, mainly due to the perceived time this mechanism requires and the difficulty of accurately assessing students. However, integrating these instructors into the capstone projects (namely in third- and fourth-year courses) has allowed them to grasp the full potential of this mechanism, and all now support oral assessment.

Further, instructors responsible for evaluating oral communication skills at Polytechnique Montréal frequently point out that students in the Chemical Engineering program are among the best

communicators across all engineering programs. Finally, discussions with graduates during annual alumni and networking events (alumni night, internships and job fair, etc.) highlight the importance of our emphasis on oral assessment and the communication skills that result from it. The typical comment emphasizes how "horrible" the activity was at the time but how the benefits are widely felt in professional practice.

Points of Caution

As highlighted in some student comments, oral assessment can be quite anxiety-inducing. This stress can be linked to several factors. First, students are less accustomed to oral assessment when they arrive at university. Even in the context of the program where students regularly experience oral exams as part of capstone projects, this stress reappears when this assessment modality is used in courses where written exams were traditionally used. As the adoption of oral exams progresses in training programs, this element may diminish over time.

Second, a highly negative experience can strongly influence students' perception of this assessment mode. When a new faculty member is integrated into an oral assessment process, increased awareness is required to convey the importance of words, tone, posture, and non-verbal behavior in building students' confidence.

There are also occasional perceptions of inequities in student treatment. For example, some students have noted that their colleagues can communicate the questions (or at least the general themes addressed) as they leave their exam, resulting in better performance for students later in the day. The faculty team is vigilant on this point, and corrections can be made if significant differences are identified between the beginning and end of the day. An alternative solution would be to ensure a different set of questions for the morning and afternoon. Finally, as previously stated, Polytechnique Montréal's policies do not provide for specific accommodations for written assessments lasting less than 60 min, including oral assessments. Accordingly, students with disabilities do not necessarily receive extra time or special considerations. This element is a point of vigilance that remains to be addressed in the coming years.

Success factors

Considering the dimensions of oral assessment (Joughin, 1998; Theobold, 2021) and the experience gained in the Chemical Engineering program at Polytechnique Montréal, Table 7 summarizes the main success factors for implementing oral assessment.

Table 7: Success factors for implementing oral assessment

Actions to Increase the Potential Success	**Impact**
Implement oral assessment in multiple courses within a program (program-based approach)	Continuum of student autonomy and confidence development, promoting professionalization
Adequately prepare students: explanation of the process, classroom simulation, video tutorial	Reassure students and reduce their stress, while gradually reducing the level of guidance moving forward in the curriculum, to align students the expectations of autonomy in professional practice.
Adequately prepare the faculty: question bank and expected responses	Ensure pedagogical alignment between course objectives and assessment and promote consistency in evaluation among different evaluators

Plan a well-defined process: systematic scripted process, time management	Ensure schedule adherence and equity among students
Use an appropriate room: board or projector if required for evaluation elements	Allow for a diversity of response modalities
Adopt a supportive attitude: posture, verbal and non-verbal reactions	Reassure and respect students, thereby contributing to reducing their stress
Encourage dialogue: open evaluation, exchange of ideas, constructive feedback	Allow the evaluator to accurately assess whether a concept is mastered
Use a simple grading system: criteria-based evaluation grid	Quickly assess and ensure reliability of assigned grades
Provide feedback after the assessment: in classroom, by email, or individual meetings	Allow students to continuously improve their learning
Work as a team: pairing novice and experienced instructors, including teaching assistants	Ensure the sharing of best practices and reduce stress experienced by novice evaluators

Oral assessment offers a way to circumvent most plagiarisms strategies, but it is also an opportunity for instructors to spend quality time with students, ensuring mastery of essential course elements and project-related skills. At the end of the program, this method allows for greater certainty that successful students have the competencies to practice engineering. Contrary to beliefs, it is also possible to conduct oral evaluations in much less time than required to grade corresponding written papers. By giving students the opportunity to clarify their understanding of expectations, it allows for a more accurate assessment of their real abilities and skills. In short, oral assessment, in our view, has a very promising future. As highlighted, over the past decade, student teams from the Chemical Engineering program have frequently reached the finals or won the Hatch/Zeton National Design Competitions. Feedback from industry mentors highlights our students' strong oral communication skills and professional behavior, and internal evaluations at Polytechnique Montréal also show that students from this program perform above average in oral communication compared to peers in other engineering disciplines.

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Declaration of Interest

The authors declare no conflicts of interest for the present work.

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References

Alexander, B. K., Anderson, G. L., & Gallegos, B. (2004). *Performance theories in education: Power, pedagogy, and the politics of identity*. Routledge

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition. Addison Wesley Longman.

Barba, L. A. (2025). Experience embracing genAI in an engineering computations course: What went wrong and what next. figshare. Journal contribution. 10.6084/m9.figshare.28926647.v1

Farand, P., & Tavares, J. R. (2017). A concept inventory for knowledge base evaluation and continuous curriculum improvement. Education for Chemical Engineers, 21, 3339. https://doi.org/10.1016/j.ece.2017.07.001

Harvey, V. C., Farand, P., Legros, R., & Tavares, J. R. (2015). On the average perception of perceived averages. Education for Chemical Engineers, 12, 1219. https://doi.org/10.1016/j.ece.2015.06.002

Huba, M. E. et Freed, J. E. (2000). Learner-centered Assessment on College Campuses: Shifting the Focus from Teaching to Learning. Allyn & Bacon.

Huxham, M., Campbell, F., & Westwood, J. (2012). Oral Versus Written Assessments: A Test of Student Performance and Attitudes. Assessment & Evaluation in Higher Education, 37(1), 125136. https://doi.org/10.1080/02602938.2010.515012

Joughin, G. (1998). Dimensions of Oral Assessment. Assessment & Evaluation in Higher Education, 23(4), 367378. https://doi.org/10.1080/0260293980230404

Nash, G., Crimmins, G., & Oprescu, F. (2016). If first-year students are afraid of public speaking assessments what can teachers do to alleviate such anxiety? Assessment & Evaluation in Higher Education, 41(4), 586600. https://doi.org/10.1080/02602938.2015.1032212

Odafe, V. U. (2006). Oral Examination In College Mathematics: An Alternative Assessment Technique. Primus, 16(3), 243-256. https://doi.org/10.1080/10511970608984149

Pereira, D., Flores, M. A., & Niklasson, L. (2016). Assessment revisited: a review of research in Assessment and Evaluation in Higher Education. Assessment & Evaluation in Higher Education, 41(7), 1008-1032. https://doi.org/10.1080/02602938.2015.1055233

Prégent, R., Bernard, H., & Kozanitis, A. (2009). Enseigner à l'université dans une approche-programme: guide à l'intention des nouveaux professeurs et chargés de cours. Presses inter Polytechnique

Stevens, D. D., & Levi, A. J. (2005). Introduction to Rubrics: An Assessment Tool to Save Grading Time, Convey Effective Feedback, and Promote Student Learning. Stylus Publishing, LLC.

Stray, C. (2001). The Shift from Oral to Written Examination: Cambridge and Oxford 1700–1900. Assessment in Education: Principles, Policy & Practice, 8(1), 3350. https://doi.org/10.1080/09695940120033243

Tai, J., Mahoney, P., Ajjawi, R., Bearman, M., Dargusch, J., Dracup, M., & Harris, L. (2023). How are examinations inclusive for students with disabilities in higher education? A sociomaterial analysis. Assessment & Evaluation in Higher Education, 48(3), 390402. https://doi.org/10.1080/02602938.2022.2077910

Tan, C. P., Howes, D., Tan, R. K. W., & Dancza, K. M. (2022). Developing interactive oral assessments to foster graduate attributes in higher education. Assessment & Evaluation in Higher Education, 47(8), 11831199. https://doi.org/10.1080/02602938.2021.2020722

Theobold, A. S. (2021). Oral Exams: A More Meaningful Assessment of Students' Understanding. Journal of Statistics and Data Science Education, 29(2), 156159. https://doi.org/10.1080/26939169.2021.1914527

Van Ginkel, S., Gulikers, J., Biemans, H., & Mulder, M. (2017). The impact of the feedback source on developing oral presentation competence. Studies in Higher Education, 42(9), 1671-1685. https://doi.org/10.1080/03075079.2015.1117064

Waterfield, J., West, B., & Parker, M. (2006). Supporting inclusive practice: Developing an assessment toolkit. In *Towards inclusive learning in higher education* (pp. 97-112). Routledge.

Wisker, G. (2004). *Developing and assessing students' oral skills*. Staff and Educational Development Association.