



Integrating Gen-AI in Authentic Scenario-Based Assessment for Sustainable Chemical Engineering Education

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Abstract. This paper explores the integration of generative AI-assisted authentic scenario-based assessment in chemical engineering education, emphasizing sustainability and future-proofing the learning process. Traditional assessment methods often fall short in preparing students for real-world engineering challenges due to their focus on theoretical knowledge and rote memorization. In contrast, this innovative assessment approach aims to enhance student engagement, learning outcomes, and skill development by aligning educational practices with industry standards and incorporating advanced technologies. The feedback from an innovation pitching project assessment was analyzed, revealing high levels of student engagement, improved understanding of practical applications, and significant skill enhancement through the use of AI tools and real-world scenarios. The findings indicate that such assessments can effectively prepare students for the dynamic demands of the modern engineering industry, fostering the development of adaptable, skilled, and ethically aware engineers.

Keywords: Generative AI, Authentic Scenario-Based Assessment, Chemical Engineering Education, Sustainability, Future-Proof Assessment.

1 Introduction

1.1 Background

The landscape of engineering education is undergoing significant transformation, driven by rapid technological advancements and evolving industry demands. Traditional educational practices, which often emphasize theoretical knowledge and rote memorization, are increasingly viewed as insufficient in preparing students for the complexities of real-world engineering challenges [1]. In chemical engineering, bridging the gap between academic learning and practical application is crucial. This necessitates innovative assessment strategies that not only measure student learning effectively but also fosters the development of skills relevant to the dynamic technological landscape. For instance, integrating artificial intelligence (AI) methods

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can offer efficient solutions for complex engineering problems and enhance decision-making and computational efficiency [2].

The integration of advanced technologies into educational frameworks presents an opportunity to overhaul traditional assessment methods. In particular, the use of generative AI in creating personalized and contextually relevant assessment tasks can significantly enhance the learning experience. These AI-driven assessments can adapt to individual student needs, providing immediate feedback and adjusting the level of difficulty based on the student's performance. This level of customization is nearly impossible to achieve through conventional assessment methods. Moreover, AI technologies such as natural language processing and machine learning can be leveraged to analyze large sets of educational data, identifying patterns and trends that can inform the development of more effective teaching and assessment strategies [3].

Furthermore, the current global emphasis on sustainability and ethical practices in engineering highlights the need for educational assessments that go beyond traditional metrics. It is essential to evaluate not only the technical competencies of students but also their understanding and application of sustainable practices. The ability to assess these competencies accurately and meaningfully requires the use of sophisticated tools and methodologies. Generative AI, with its capacity to simulate complex real-world scenarios and provide rich, interactive experiences, is particularly well-suited to this task. It can help educators design assessments that are both challenging and relevant, preparing students to meet the sustainability challenges of the modern engineering landscape.

In addition to the technical and sustainability aspects, there is a growing recognition of the importance of ethical considerations in engineering education. The ethical use of AI in educational settings, for example, is a topic of significant debate. While AI has the potential to enhance learning and assessment, it also raises concerns about data privacy, bias, and the potential for misuse. Educators must navigate these challenges carefully, ensuring that AI tools are used in ways that support equitable and inclusive learning environments. Discussions around the ethical implications of AI in education are critical to developing frameworks that can leverage the benefits of AI while mitigating its risks [4].

The purpose of this paper is to present the integration of generative AI in authentic scenario-based assessment in chemical engineering education and to enhance the relevance and effectiveness of assessments by aligning them with industry standards and incorporating emerging technologies.

1.2 Relevance of Generative AI in Education

Generative AI, which includes technologies such as natural language processing, machine learning, and data analytics, has emerged as a transformative tool in the field of education. The potential of AI to create personalized, interactive, and contextually relevant learning experiences is particularly significant in the realm of educational assessment. By leveraging generative AI, educators can design assessments that are more aligned with the diverse learning needs and abilities of students, thus enhancing the overall educational experience.

One of the primary benefits of generative AI in education is its ability to provide personalized learning experiences. Traditional assessment methods often adopt a one-size-fits-all approach, which can be limiting for students with different learning styles and paces. Generative AI can analyze individual student data to create customized assessments that adapt to the student's unique learning journey. For example, AI can generate questions that vary in difficulty based on the student's performance, ensuring that each student is challenged appropriately and can progress at their own pace [3]. Furthermore, generative AI can offer immediate and detailed feedback, which is crucial for effective learning. Unlike traditional assessments that often involve delayed feedback, AI-driven assessments can provide instant responses, helping students to understand their mistakes and learn from them in real-time. This immediate feedback loop enhances the learning process, making it more dynamic and responsive to the needs of the student. Generative AI also has the capability to create highly realistic and immersive assessment scenarios. In fields like chemical engineering, where practical application of knowledge is critical, AI can simulate real-world engineering problems and environments. These simulations allow students to apply theoretical knowledge in a practical context, enhancing their problem-solving and critical-thinking skills. For instance, AI can generate complex industrial scenarios that require students to design processes, troubleshoot issues, and make decisions based on real-time data, thus preparing them for the challenges they will face in their professional careers [5].

Additionally, generative AI facilitates the scalability and accessibility of educational assessments. Traditional methods of assessment, particularly those involving hands-on or practical components, can be resource-intensive and difficult to scale. AI, however, can generate a wide range of assessment tasks that can be delivered to large numbers of students simultaneously, regardless of their geographical location. This capability is particularly beneficial in the context of online and remote learning, which has become increasingly prevalent in recent years. Moreover, the integration of AI in educational assessments aligns with the broader trend towards data-driven decision-making in education. By collecting and analyzing vast amounts of data on student performance, AI can provide valuable insights into learning patterns and outcomes. Educators can use these insights to refine their teaching strategies and develop more effective assessment methods. For example, AI can identify common areas where students struggle and suggest targeted interventions to address these challenges, thereby improving overall educational outcomes [6].

1.3 Importance of Authentic Scenario-Based Assessment

Authentic scenario-based assessment has gained prominence as an effective educational strategy that bridges the gap between theoretical knowledge and practical application. This type of assessment involves evaluating students through tasks that closely mirror real-life challenges and industry practices, thereby providing a more holistic measure of their capabilities. In the context of chemical engineering education, authentic scenario-based assessments are particularly valuable for fostering the development of critical skills that are essential for professional success.

Authentic scenario-based assessment emphasizes the practical application of knowledge. Traditional assessment methods, such as multiple-choice tests or rote memorization, often fail to capture the complexities of real-world problem-solving. In contrast, scenario-based assessments require students to apply their theoretical understanding to practical situations, thereby enhancing their problem-solving and critical-thinking skills. For instance, students might be tasked with designing a chemical process or troubleshooting an industrial issue, which necessitates a deep understanding of the subject matter and the ability to think critically under pressure [7]. Additionally, authentic scenario-based assessments provide a more engaging and meaningful learning experience for students. By working on tasks that are relevant to their future careers, students are likely to be more motivated and invested in their learning. This engagement is further enhanced when assessments are designed to reflect real-world challenges that engineers face in the industry. For example, a scenario-based assessment might involve students collaborating on a project to develop a sustainable chemical process, thereby mirroring the collaborative and interdisciplinary nature of modern engineering work. Such experiences not only make learning more enjoyable but also help students develop important soft skills such as teamwork, communication, and project management.

Moreover, authentic scenario-based assessments offer valuable opportunities for formative assessment and feedback. Unlike traditional summative assessments, which often provide limited feedback at the end of a course, scenario-based assessments can be integrated throughout the learning process, allowing for continuous assessment and feedback. This ongoing feedback is crucial for helping students identify areas for improvement and refine their skills over time. For instance, instructors can provide real-time feedback as students work through a scenario, offering guidance and support to help them overcome challenges and improve their performance. Authentic scenario-based assessment can simulate complex and dynamic environments. In chemical engineering, professionals often work in settings where they must navigate multiple variables and make decisions based on incomplete information. Scenario-based assessments can replicate these conditions, providing students with a safe yet challenging environment to practice their decision-making skills. For example, a simulation might require students to respond to an emergency situation in a chemical plant, forcing them to apply their knowledge and skills quickly and effectively. These experiences are invaluable for preparing students for the realities of professional

practice [5]. Authentic scenario-based assessments can be designed to evaluate a wide range of competencies, including technical skills, critical thinking, creativity, and ethical decision-making. This comprehensive approach ensures that students are not only knowledgeable but also capable of applying their knowledge in diverse and complex situations. For instance, a scenario-based assessment might involve ethical dilemmas related to sustainability or safety, requiring students to consider the broader implications of their decisions and actions. By addressing these multifaceted aspects of engineering practice, scenario-based assessments help produce well-rounded and competent engineers.

The integration of generative AI into authentic scenario-based assessments further enhances their effectiveness. AI can be used to create more realistic and dynamic scenarios, providing students with richer and more immersive learning experiences. For example, AI-driven simulations can adapt in real-time to students' actions, creating a more interactive and engaging assessment environment. Additionally, AI can provide detailed and personalized feedback, helping students understand their strengths and areas for improvement more clearly.

1.4 Future-Proof Assessment

In the rapidly evolving landscape of technology and industry, the concept of future-proof assessment has become increasingly relevant in engineering education. Future-proof assessment refers to the design and implementation of evaluation methods that are adaptable to technological changes and evolving industry requirements. This type of assessment ensures that students are not only equipped with current knowledge and skills but are also prepared to adapt to future advancements and challenges.

For chemical engineering, new technologies and methodologies are constantly emerging. Thus, assessments must be flexible enough to incorporate these developments. This adaptability can be achieved through the integration of advanced technologies such as artificial intelligence (AI), virtual reality (VR), and augmented reality (AR). These technologies can create dynamic assessment environments that simulate real-world scenarios and allow students to engage with the latest tools and techniques. For example, VR simulations can provide immersive experiences where students can practice and refine their skills in a controlled yet realistic setting [6]. Future-proof assessment also prioritizes real-world applicability. Assessments designed with real-world relevance ensure that students are prepared for the practical challenges they will face in their professional careers. This can be achieved through scenario-based assessments that simulate industry-specific tasks and problems. For instance, students might be required to develop a chemical process that meets sustainability criteria, reflecting the increasing industry focus on environmentally friendly practices. By working on such practical tasks, students not only apply their theoretical knowledge but also develop critical skills such as problem-solving, decision-making, and project management [7].

Table 1. A comparative overview of conventional assessment, authentic scenario-based assessment, and future-proof assessment.

Aspect	Conventional Assessment	Authentic Scenario-based Assessment	Future-Proof Assessment
Focus	Theoretical knowledge and rote memorization	Practical application of knowledge	Adaptable skills and continuous learning
Approach	Standardized tests and exams	Realistic scenarios and industry practices	Dynamic, technology-enhanced tasks
Relevance to Real World	Low; often disconnected from practical applications	High; mirrors real-world challenges	Very High; directly applicable to current and future industry challenges
Technology Integration	Minimal	Moderate; can include simulations and case studies	High; includes AI, VR, AR
Feedback Mechanism	End-of-course feedback	Continuous formative feedback	Real-time, continuous feedback
Skill Development	Basic theoretical understanding	Critical thinking, problem-solving, decision-making	Advanced skills including adaptability, data analysis, and ethical decision-making
Adaptability to Changes	Low	Moderate; scenarios can be updated	High; designed to incorporate technological advancements
Ethical Considerations	Rarely addressed	Incorporated through realistic and ethical scenarios	Strong emphasis on data privacy and algorithmic bias

The integration of emerging technologies into assessment strategies also enhances the comprehensiveness and engagement of future-proof assessments. Technologies like AI can analyze vast amounts of data to identify learning patterns and predict student performance. This data-driven approach allows educators to tailor assessments to individual student needs and provide targeted support where necessary. Additionally, AI-driven assessments can create a more engaging and interactive learning environment, keeping students motivated and invested in their education.

Future-proof assessment also involves aligning assessments with industry standards and practices. Collaboration with industry partners can ensure that the skills and knowledge assessed are relevant and up-to-date. Industry partnerships can provide valuable insights into current trends and future directions, helping educators design assessments that prepare students for the demands of the workforce. For example,

incorporating industry-specific software and tools into assessments can give students hands-on experience with the technologies they will use in their careers [2].

2 Methods

The authentic scenario-based project assessment, titled "Innovative Minds, Sustainable Solutions: Redefining Food Preservation" is structured into three main parts: Project Proposal and Planning, Innovative Production Proposal, and Production Design. Students are required to document their work in an individual e-portfolio and present their findings in a group pitching.

Students begin by visiting a local supermarket to observe various food products, such as fruit juice, coffee/tea/chocolate drinks, and milk products. They identify gaps or opportunities for innovation and supplement their observations with AI-assisted research using tools like ChatGPT. Students brainstorm and propose an innovative production method for the chosen product. They justify the selection of specific preservation techniques based on their research and analysis. Students design the entire production process, including raw materials, processing steps, and packaging. They address health, safety, and environmental considerations in their design. AI tools are used throughout the process for research and idea refinement, and all AI-generated content is verified and ethically used. Each student compiles their work into an individual e-portfolio, documenting the project execution. Groups then present their project in a 5-minute pitch to the fictional client, GreenFood Innovations, summarizing their proposal, highlighting innovative aspects, and justifying their preservation techniques.

The project fosters critical thinking, problem-solving, and collaboration skills. Students learn to navigate and leverage AI tools, preparing them for future technological advancements in their field. At the end of the project, students are asked to provide feedback.

3 Results and Discussion

3.1 Engagement and Learning Experience

Table 2 shows the student feedback on various aspects of the innovation pitching project assessment. Students generally found the innovation pitching project highly engaging and interesting, with a mean rating of 4.5 ± 0.7 . The hands-on, real-world aspect of the project was particularly appreciated (4.6 ± 0.5). A significant number of students recommended this project format for other courses (4.5 ± 0.6) and would suggest it to other students (4.6 ± 0.5). The activity of visiting a supermarket to select products was rated very positively, adding substantial value to the learning experience (4.6 ± 0.5). The project helped students understand the importance of innovative

production methods in food preservation (4.4 ± 0.6) and gain a deeper understanding of food preservation techniques (4.4 ± 0.6). The high engagement ratings suggest that the project format, including real-world, hands-on activities, successfully captivated students and enriched their learning experience. The practical context provided by activities like supermarket visits helped students better understand theoretical concepts and apply them meaningfully. The strong recommendation for using this project format in other courses indicates its perceived value and effectiveness. The emphasis on sustainability and real-world application aligns well with industry trends, preparing students for future challenges.

Table 2. Student feedback on various aspects of the innovation pitching project assessment.

Criteria	Mean Rating
I found the innovation pitching project engaging and interesting.	4.5±0.7
Visiting a supermarket to select the product added value to my learning experience.	4.6±0.5
Using ChatGPT helped me in brainstorming and refining my ideas.	4.4±0.6
I felt that using AI tools like ChatGPT was beneficial for conducting research.	4.5±0.6
I used ChatGPT ethically and verified all AI-generated content.	4.3±0.8
The project was well-structured and easy to follow.	4.6±0.5
The objectives of the project were clear and achievable.	4.5±0.5
The project helped me understand the importance of innovative production methods in food preservation.	4.4±0.6
I gained a deeper understanding of food preservation techniques.	4.4±0.6
The project improved my ability to conduct research and analyze data.	4.5±0.6
I feel more confident in my ability to propose and justify innovative solutions.	4.5±0.6
Collaborating with my team members was a positive experience.	4.4±0.7
The group pitching session helped enhance my presentation skills.	4.5±0.6
Creating the e-portfolio was a valuable part of the project.	4.3±0.7
I enjoyed the hands-on, real-world aspect of this project.	4.6±0.5
This project format should be used in other courses.	4.5±0.6
I would recommend this type of project to other students.	4.6±0.5

3.2 Use of AI Tools

Students found the use of ChatGPT and other AI tools beneficial for brainstorming and refining ideas (4.4 ± 0.6) and for conducting research (4.5 ± 0.6). They also felt confident in their ethical use and verification of AI-generated content (4.3 ± 0.8), indicating an understanding of the importance of ethical considerations in AI usage. The integration of AI tools like ChatGPT was well-received, with students finding these tools helpful for brainstorming, refining ideas, and conducting research. This indicates that AI can be a powerful aid in educational settings, enhancing creativity and research capabilities.

The importance of ethical use and content verification was also acknowledged, demonstrating students' awareness of responsible AI usage.

3.3 Project Structure and Objectives

The feedback indicates that the project was well-structured and easy to follow (4.6, ± 0.5), with clear and achievable objectives (4.5 ± 0.5). This clarity likely contributed to the overall positive experience and successful learning outcomes, as students were able to understand and meet the project's expectations. A well-structured project with clear objectives is critical for student success. The positive feedback on the project's structure and clarity indicates that students were able to follow the project guidelines effectively and achieve the desired learning outcomes.

3.4 Skill Development

The project significantly improved students' research and data analysis skills (4.5 ± 0.6) and increased their confidence in proposing and justifying innovative solutions (4.5 ± 0.6). Collaborative activities and group pitching sessions were positively received, enhancing teamwork (4.4 ± 0.7) and presentation skills (4.5 ± 0.6). Creating an e-portfolio was also considered a valuable part of the project (4.3 ± 0.7), helping students document and reflect on their learning process. The project not only enhanced technical skills in research and data analysis but also developed soft skills such as teamwork, presentation, and ethical considerations. These skills are essential for future engineers, highlighting the value of comprehensive assessment methods that go beyond traditional exams.

4 Conclusions

The innovation pitching project assessment demonstrates the potential of authentic, scenario-based assessments to enhance engagement, learning outcomes, and skill development in chemical engineering education. The integration of AI tools and real-world activities provides a robust framework for future-proof assessments, ensuring that students are well-prepared for the dynamic demands of the engineering industry. Future implementations should continue to focus on clear structure, ethical use of AI, and the incorporation of practical, real-world contexts to maximize educational impact.

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