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Relationship between deep learning and authentic assessment in undergraduate engineering education

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Abstract

This study aims to explore the relationship between deep learning and authentic assessment in Australian undergraduate engineering education. The hypothesis posits that students will adopt deep learning approaches when engaging with authentic assessment tasks. Drawing from existing literature on student learning approaches, assessment influences, and disciplinary differences, this study aimed to identify the dimensions influencing deep learning, examine student perceptions of authentic assessment, and establish the relationship between assessment types and deep learning factors. After carefully designing the survey questionnaire, pilot testing was conducted, aimed to determine if the questionnaire effectively measures its intended constructs, assess its ease of completion, and identify any areas of confusion. The final online questionnaire was sent to the students of some selected civil and mechanical engineering subjects at QUT. Students received the questionnaire after completing all their assessments of the respective units. Total 72 students responded, among which 37 were found to be complete. The results indicate that authentic assessments, such as group research projects or project-based learning, are considerably more effective in fostering self-directed learning, critical thinking, and knowledge integration compared to traditional assessments like invigilated written exams.

1. INTRODUCTION

In recent years, engineering education has witnessed a shift towards more student-centered approaches that emphasise deeper learning and the development of critical thinking skills. One of the key drivers of this transformation has been the increasing focus on authentic assessment. Authentic assessment is a pedagogical approach that frames learning activities within contexts that mirror real-world applications. It is designed to reflect real-world challenges and require students to apply their theoretical knowledge in practical, problem-solving contexts, thus fostering deeper engagement with the subject matter (Schultz, et al., 2022). This shift is especially critical in undergraduate engineering programs, where students must not only acquire technical knowledge but also develop the ability to apply that knowledge to complex, multidisciplinary problems (Yildiz, R., 2020).

Traditional forms of assessment, such as timed written exams, often emphasize memorization and factual recall, which can limit students' ability to engage in critical thinking and integrate their knowledge across different contexts (Biggs et al., 2022). In contrast, authentic assessments allow for a more holistic learning experience, encouraging students to explore concepts in greater depth, collaborate with peers, and develop skills that are directly transferable to professional practice (Herrington & Oliver, 2000). Despite these advantages, the implementation of authentic assessment methods presents several challenges, including ensuring alignment with learning outcomes, designing meaningful tasks, and managing student perceptions of authentic assessments. Although there has been significant emphasis on authentic assessments, there has been no study to investigate the relationship between authentic assessments and deep learning for engineering students.

In order to address this gap, this paper explores the relationship between deep learning and authentic assessment in the context of Australian undergraduate engineering education. This study also compares students' engagement with their study based on authentic and non-authentic assessments. By examining students' perceptions of these assessment methods, we aim to identify the key factors that influence their learning approaches and evaluate the impact of different assessment types on student engagement and academic outcomes. The objectives of this study are to:

1. Assess the current practices and perceptions of students regarding deep learning and authentic assessment.
2. Identify potential challenges and opportunities associated with the implementation of authentic assessment in engineering programs.
3. Examine the effects of deep learning techniques on student learning outcomes and engagement.

2. LITERATURE REVIEW

2.1. Deep Learning in Engineering Education

Deep learning refers to an approach to learning in which students engage with the material at a conceptual level, seeking to understand underlying principles and ideas rather than merely memorizing facts (Wu, 2024). This approach is particularly relevant in engineering education, where students are required to apply complex theoretical knowledge to solve real-world problems (Masuku et al., 2021). According to Biggs et al. (2022), deep learning involves higher-order thinking, which is essential for students to become competent engineers capable of innovation and problem-solving in professional practice.

Studies have shown that traditional forms of assessment, such as exams and quizzes, tend to promote surface learning, where students primarily focus on memorization to pass exams (Yeen-Ju et al., 2014). In contrast, authentic assessments, which mimic real-life engineering tasks, encourage deep learning by requiring students to integrate and apply their knowledge in complex and meaningful ways (Boud & Falchikov, 2007). For example, project-based assessments, where students work on design projects, have been shown to improve critical thinking and problem-solving skills (Nachtigall et al., 2024). These forms of assessment align with constructivist learning theories, which posit that students learn best when they actively construct their own understanding through experience and reflections.

2.2. Authentic Assessment in Engineering Education

Research has demonstrated that authentic assessments promote deeper learning by encouraging students to engage with the material more meaningfully and critically (Nachtigall & Wirth, 2024). These assessments challenge students to think creatively, collaborate with peers, and apply theoretical knowledge to practical problems. For example, a study by Herrington and Oliver (2000) found that students who participated in authentic learning environments showed higher levels of motivation and engagement compared to those who were assessed through traditional exams. Similarly, Prince and Felder (2006) suggest that problem-based learning and project-based assessments can significantly enhance students' problem-solving abilities and preparedness for the workforce.

However, the implementation of authentic assessments is not without its challenges. One common issue is the perception of increased workload, as students may feel that these tasks require more time and effort compared to traditional assessments (Nachtigall & Wirth, 2024). Additionally, designing authentic assessments that align with learning outcomes and accurately measure student performance can be difficult for educators (Herrington and Oliver, 2000) . Despite these challenges, the benefits of authentic assessment in promoting deep learning and improving student outcomes are well-documented in the literature.

2.3. Impact of Assessment Type on Learning Approaches

The type of assessment used in a course plays a crucial role in shaping the learning approaches students adopt (Biggs et al., 2022). When assessments emphasize factual recall, students tend to use surface learning strategies, focusing on memorization to pass exams without fully grasping underlying concepts (Yeen-Ju et al., 2014). On the other hand, assessments that require students to apply knowledge to complex problems encourage the use of deep learning strategies (Zhou et al., 2024).

Research has consistently shown the positive effects of authentic assessments on student learning outcomes. For example, Herrington & Oliver (2000) found that students engaged in authentic assessments exhibited stronger conceptual understanding and higher levels of critical thinking. Similarly, (Yeen-Ju et al., 2014) reported that authentic assessments improved student engagement and enhanced long-term knowledge retention. These findings suggest that integrating authentic assessments into engineering education can foster deeper learning and better equip students to meet the challenges of professional practice.

3. RESEARCH METHOD

This study employs a questionnaire survey approach to achieve the objectives of this study outlined above. The initial phase involved distributing an online survey to students in various engineering disciplines at Queensland University of Technology (QUT). As mentioned above, the participants in this study were undergraduate students enrolled in civil and mechanical engineering programs at QUT. The survey was distributed to students from four engineering subjects: EGB273 (Principles of Construction), EGB387 (Project Value and Innovations), UXB212 (Design For Structures), EGB423 (Heating, Ventilation And Air Conditioning) and EGB435 (Advanced Manufacturing). A total of 72 students participated in the survey, representing a range of academic levels and backgrounds, including both domestic and international students.

Ethical Considerations

Ethical approval for the study was obtained from the university's Human Research Ethics Committee (HREC). All participants were informed of the study's purpose, procedures, and their right to withdraw at any time. Informed consent was obtained before the survey and focus group discussions, ensuring that participation was voluntary and confidential. Data collected from the participants were anonymized and stored securely to protect their privacy.

Data Analysis

The survey consisted of two sections:

1. The first section gathered demographic information, such as gender, study mode (full-time or part-time), residency status (domestic or international), and weekly work hours.
2. The second section comprised questions designed to assess student perceptions of different assessment types, learning approaches, and engagement. Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree) were used to capture the responses, along with an open-ended question to allow students to provide additional feedback.

The collected survey data were analysed using descriptive statistics in SPSS to summarize demographic information and key variables related to students' perceptions of assessments.

To ensure the validity and reliability of the findings, several strategies were employed. The survey instrument was piloted with a small group of students to assess its clarity and effectiveness in measuring the intended constructs. Statistical reliability of the data was tested using Cronbach's alpha test.

4. RESULTS

4.1 Demographic Analysis

The survey results provide valuable insights into the demographic characteristics of the 37 valid respondents, focusing on gender distribution, study mode, and the type of student. This analysis aims to explore these factors and understand their implications for the surveyed cohort. The gender composition of the survey participants reveals that majority of the respondents (81.1%) were male, while 18.9% identified as female. This ratio roughly represents the actual gender distribution among engineering students at Queensland University of Technology (QUT) as the proportion of female engineering students at QUT in 2023 was 22.72%. About 36 out of 37 respondents, representing 97.3% of the sample, indicated that they are pursuing full-time studies. In contrast, only 1 respondent (2.7%) reported studying part-time.

The survey also explored whether respondents were domestic or international students. The data shows that 67.6% of the respondents identified as domestic students while, 32.4% respondents were international students. While the majority of students are from the domestic student body, there is a considerable proportion of international students, constituting almost one-third of the group.

4.2 How long student spent on studying?

The data collected on the number of hours per week students spent studying reveals a wide variation in study habits. A majority of the students, 67.6%, reported spending less than 10 hours per week outside of class time. This indicates that most students allocate minimal additional study time for study. Another 21.6% of students reported spending between 11 and 20 hours per week on the course and 8.1%, dedicated between 21 and 30 hours per week. The data on the number of hours students spent per week in paid or voluntary employment indicates a significant level of engagement with work. About 32.4%, reported working between 21 and 25 hours per week and 16.2% worked between 16 and 20 hours per week, and 8.1% worked between 6 and 10. Interestingly, 8.1% of the students worked over 46 hours per week.

This high level of employment, may provide insight into how students manage their academic workloads alongside employment. These external commitments could influence the adoption learning approaches, as they may limit the time available for engagement with academic materials and assessment tasks. It is important to consider how work commitments interact with students' ability to engage in deep learning, particularly for assessments that require extensive self-directed study and critical thinking.

4.3 Descriptive Analysis on student perception on assessments:

This analysis compares, based on the proportion of respondents agreed to each statements on three types of assessments: Assessment Task 1 (A1-Problem-Solving Task/Mid-semester Exam), Assessment Task 2 (A2-Group Design/Research Project Report), and Assessment Task 3 (A3-Invigilated Written Exam). Each assessment is evaluated based on various learning aspects such as self-directed learning, critical thinking, conceptual understanding, and memorization. The analysis reveals distinct differences in how students engaged with each assessment and how each task fostered deep learning.

Encouragement of Self-Directed Learning

Self-directed learning was most prominent in A2, where 90.3% of students agreed that the task promoted independent learning. In contrast, A1 saw 86.4% of students perceiving it as encouraging self-learning, while A3 had the lowest score, with 75.9% agreeing to some extent. These findings suggest that group-based and problem-solving assessments were more effective in fostering self-

directed learning compared to traditional exams, which are typically more structured and less exploratory.

Perceived Study Load

Students reported the highest level of study load in A3, where more than half of the respondents (51.7%) felt burdened by the material they have to and review. In comparison, A1 was less overwhelming, with 32.4% of students expressing difficulty managing the material, while A2 had the lowest perceived workload, with only 29% of students feeling overwhelmed. This indicates that the final exam posed more challenges in terms of material volume and time constraints, whereas group projects and mid-semester exams offered more manageable workloads.

Independent Critical Thinking

A2 excelled in promoting independent critical thinking, with 61.3% of students agreeing that it required high level of critical thinking and brainstorming. A1 encouraged critical thinking in 45.9% of students but A3 only 37.9% of students agreeing that the exam fostered independent thinking. This highlights that group research tasks and problem-solving exercises are more conducive to developing critical thinking skills, while traditional exams tend to emphasize knowledge recall over analysis.

Reflective Engagement

Reflective engagement, or the extent to which students thought about the task outside of study hours, was highest in A2, where 54.8% of students reported reflecting on the project in their spare time with A1 showing mixed engagement, with 29.7% of students thought about the task outside of study. In contrast, A3 had the lowest reflective engagement. This suggests that more exploratory assessments like group projects encourage deeper cognitive engagement compared to time-limited exams.

Conceptual Challenges and Memorization

Memorization was most associated with A3, where 82.8% of students felt the exam required significant rote learning although formulas involved in the subjects are provided with their exam papers. A1 also involved a notable amount of memorization, with 54% agreeing that they needed to remember large amounts of material. In contrast, A2 was less focused on memorization, with only 35.5% of students agreeing that it required them to memorize facts.

Investigative Learning and Depth of Understanding

The strongest investigative learning experience was reported in A2, where 71% of students agreed that the task required them to explore topics independently. In A1, 54% of students also appreciated the task's investigative nature. Although A3 ranked lowest in terms of investigative learning, still about half of the students (48.3%) feeling the final exam did encourage exploration or deep inquiry. These suggest that authentic assessments like group projects are more effective in promoting deep, investigative learning than traditional exams. Similarly, most students felt most challenged to understand the course materials in depth in A2 (87.1%) and A1 (86.4%). Assessment Task 3, while still requiring some depth of understanding, was rated lower, with 69% of students agreeing that it tested their understanding beyond surface-level memorization.

Memorization and Repetitive Learning Strategies

While memorization was a significant component of all three assessments, A3 relied most heavily on rote learning, with 82.8% of students agreeing that the exam required substantial memorization. In contrast, A2 was viewed as less memorization-intensive, with only 35.5% of students reporting a focus

on memorization. A1 also involved memorization, but many students moved beyond it to a more holistic understanding of the material. Repetitive learning strategies, such as copying or repeating information to aid memory, were most common in A3, where 62% of students used these strategies. A1 also involved repetition for 48.6% of students. However, A2 relied less on repetitive learning, with only 35.5% of students using these strategies. This suggests that while all tasks involved some degree of memorization, the group project and problem-solving exam allowed for more conceptual integration.

Evidence-Based Thinking

Results show that A2 and A1 highly encouraged evidence-based thinking and drawing conclusions for 61.3% and 64.8% of students respectively, making these the most effective tasks in this regard. In contrast, A3 was less successful, with only 37.9% of students feeling the exam required critical evaluation of evidence. These findings suggest that authentic assessments like group projects are more conducive to developing higher-order thinking skills than traditional exams.

It can be seen that Assessment Task 2 (Group Research Project) was most effective in promoting self-directed learning, critical thinking, and investigative engagement, aligning closely with the principles of deep learning. Assessment Task 1 (Problem-Solving Task/Mid-semester Exam) also performed well, particularly in encouraging conceptual understanding and evidence-based reasoning. Assessment Task 3 (Invigilated Written Exam), while effective at testing factual recall and some depth of understanding, was perceived as more overwhelming and less conducive to independent thinking and deep learning approaches. These insights underscore the value of incorporating more authentic assessments like group projects and problem-solving tasks to support students in developing critical thinking and long-term comprehension skills.

5. CONCLUSION

The present study explored the impact of different assessment types on the learning approaches of Australian Engineering undergraduate students, specifically focusing on the relationships between authentic assessment tasks and deep learning. The findings suggest that authentic assessments, such as the group research project or project-based learning, are significantly more effective in promoting self-directed learning, critical thinking, and the integration of knowledge compared to traditional non-authentic assessments like the Invigilated Written Exam. Authentic assessments encouraged students to engage deeply with the study content, fostering a greater understanding of concepts and the ability to apply knowledge in practical scenarios. The data indicate that while traditional assessments can be beneficial for evaluating certain competencies, they often fail to support the deeper learning required for success in engineering disciplines.

Given these findings, it is imperative that engineering educators consider a balanced approach to assessment design, incorporating more authentic assessment practices that align with real-world applications of knowledge. This shift not only prepares students for professional challenges but also enhances their overall educational experience.

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