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Comparing Two Authentic Assessments for Mechanical Engineering Students: Moderating Ill-Structuredness and Transferring Learning

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This study examined the efficacy of ill-structured and moderately structured authentic assessment strategies in facilitating the transfer of learning (ToL) among first-year year Mechanical Engineering students. Two student cohorts undertook separate authentic assessments, one ill-structured and the other moderately structured. High-fidelity computer modelling and simulation using Finite Element Analysis (FEA), a common tool widely adopted in engineering education, supported the solving of these complex problem tasks. Analysis of qualitative and quantitative data from junior engineering students revealed no significant effect on moderating the ill-structuredness of authentic assessments on the transfer of learning. Nonetheless, there were notable decreases in students' barriers to transfer associated with moderately structured assessment without compromising learning quality. The findings suggest that authentic learning experiences generally enhanced learning outcomes and were positively received by students. However, while increased ill-structuredness may foster greater integration of knowledge across modules, educators should exercise caution when reducing the structure of assessments intended to build foundational understanding.

Keywords: virtual simulation, web-based application, multimedia, teaching, learning

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INTRODUCTION

Implementing authentic assessments in addition to conventional assignments and coursework has become commonplace in educational institutions (Darling-Hammond & Snyder, 2000), particularly in higher education. Authentic assessments can be broadly considered as assessments which simulate and include elements of tasks and challenges faced by practitioners in real world scenarios outside of the classroom (Joy Cumming & Maxwell, 1999). These are placed in academic settings to enable a more holistic education and better prepare students to apply learnt theoretical knowledge and skills in their disciplines practically. By facing tasks not found in school, students will be better prepared to understand the issues and problems in their respective fields (Karunanayaka & Naidu, 2021; Sokhanvar et al, 2021). As solving realistic problem scenarios can be challenging, optimal implementation of such assessments for a university curriculum requires a better understanding of the pace of learning and required skills of students.

Ill-structuredness is frequently tied into the creation of authentic and realistic classroom assessments. Ill-structured problems, as opposed to well-structured ones, are tasks with not well-defined goals and constraints (*ambiguity*), and lend themselves to multiple solutions and perspectives (*open-endedness*). Everyday workplace problems tend to be messy, complex and less defined, making the implementation of ill-structuredness in assessments appropriate for pursuit of realism and authenticity (Gupta et al, 2018; Jonassen, 1997), and more effectively simulating actual challenges faced by practitioners. Instructors can also implement moderately structured assessments, containing problems with given context and defined solutions which regardless require outside-context information and multiple perspectives (Kirkley, 2003).

The implementation of ill-structured authentic assessment should be analysed alongside the transfer of learning (ToL). ToL is the successful utilisation and application of knowledge, skills and attitudes in training or lessons (Baldwin & Ford, 1988; Adnan et al, 2019), from one context to another, such as from school to work or across modules in school. What students learn in their studies, such as the skills to solve an ill-structured task, must be retained and applied after they graduate. The aim of this comparative study assesses the impact of authentic assessments on improving transfer of learning process and outcomes of first-year mechanical engineering students. This would increase their ability to make connections between and within modules and ultimately, support knowledge transfer from school to work. More specifically, this study tests if increasing the level of ill-structuredness in authentic assessments affect how students transfer their learning, through an analysis of learning attitudes, barriers and perceptions of transfer. Mechanical Engineering students in a Singaporean university are provided with authentic assessments as part of the curriculum starting from their freshman year. These students gain experience in progressively more authentic and ill-structured assessments over the course of the undergraduate programme. Typically, students are assigned more ill-structured and complex assessments in their second year, with the first year establishing foundational understanding to learn the basics of engineering. In this study, significant ill-structuredness is introduced in first-year assessments to test the viability of increasing the complexity and ambiguity of problem tasks.

Context and Literature

Authentic assessments have been implemented and studied in a variety of contexts, being considered a highly useful tool for a range of learning outcomes. In designing authentic assessments, educators intend to imitate real-life work problems and situations (Joy Cumming & Maxwell, 1999; Koh et al, 2019), bridging the gap between school and work through applying knowledge and skills in practical fashion. Such assessments have become the subject of much research and use in engineering disciplines (Ullah, 2020), where teaching of practical application and implementation of skills and concepts are key.

In the context of engineering education, these assessments tend to mimic workplace problems and situations. That said, defining what is authentic can be difficult for educators due to the term's vagueness and contestability. A study on vocational training observed that students and teachers had differing definitions of authenticity in their assessments which can impede the communication and development of these practices, with educators often mistaking their practices as more authentic than students (Gulikers et al, 2008). Arnold & Croxford further suggests the term "authentic assessment" can be unclear and unhelpful due to this subjectivity and disconnect in view of student, teacher and stakeholder, and recommends instead being more specific and focused in identifying aims of the assessment instead of 'authenticity' (Arnold & Croxford, 2024).

Following, there are several factors generally agreed upon to encompass authenticity, such as realism, collaborative elements, and transfer of learning (Ashford-Rowe et al, 2013). Ill-structuredness is often considered one such component, as real-life workplace problems, such as those in the field of engineering, tend to be ambiguous and lack complete information (Gupta et al, 2018; Jonassen, 1997). It is difficult to discern a boundary between well-structured and ill-structured problems, but ill-structured problems usually have unclear criteria for testing solutions, unclear initial, intermediate and objective states, and knowledge for solutions meaningfully represented in existing problem spaces (Simon, 1973). Comparatively, moderately structured problems, which have defined solutions and greater context but still require open-ended perspectives and incorporate external information (Kirkley, 2003), lie between well and ill-structured problems and are also found in real-life workplaces. Educators seeking to bridge academia and industry often incorporate ill-structuredness into assessments (Akinci-Ceylan et al, 2018).

Ill-structured and authentic assessments have been associated with a range of positive outcomes for college students, as such becoming an important and routine part of tertiary educational curriculum in numerous fields (Darling-Hammond & Snyder, 2000). Karunanayaka & Naidu (2021) report authentic assessment as having potential to develop core skills in students they refer to as 'graduate attributes' such as critical thinking, problem-solving and self-regulation, as well as strongly associating with improved employability and job readiness (Sokhanvar et al, 2021; Nau et al, 2024; Villarroel et al, 2021). Authentic assessment is also noted to be key in developing the essential competencies for engineering students (Garay-Rondero et al, 2024).

The application of authentic assessments and ill-structured problems in engineering

syllabus comes with a share of challenges for both educators implementing them and students solving them (Faber et al, 2017). Student reception to authentic assessments can be mixed; In certain cases, engineering students have reported enjoying the authenticity of the assessment and being motivated and engaged (Akinci-Ceylan et al, 2018; Pereira Pessoa, 2023). A review has found that students were generally receptive and welcoming to authentic assessments and found value in taking them (Sokhanvar et al, 2021). However, tackling ill-structured, complex assessments can also be a source of anxiety and stress to students, with strong emotional responses often enhanced by the tasks (Swenson et al, 2024).

Studies have observed students frequently struggle with embracing ambiguity, particularly students less experienced with authentic assessments (Dringenberg & Purzer, 2018), and this lack of clarity can increase student resistance to these assessments (Murphy et al, 2017). Significant variance can hence be observed with how students handle such challenges (regarding student approaches and learning outcomes). Appropriate implementation is noted by researchers as key to success in this respect; an Aalborg University study noted students were much more able to process their learning experiences and solve complex and ambiguous problems with proper guidance and reflection (Riis et al, 2017).

Substantial research has been made in supporting the task of designing and implementing authentic assessments for educators and faculty, who as discussed, may overestimate the authenticity of their assignment (Gulikers et al, 2008). For example, several students reported university authentic assessments did not in fact align with workplace practice which affected their ability to tackle both, in an Australian study (Ajjawi et al, 2020). Such challenges highlight the difficulties educators face in balancing authenticity with the limitations of academic assessment and grading. This is also supported by studies which indicate educators can have difficulty drafting and designing authentic assessments or assessing learning outcomes, which makes training educators in designing such assessments and to develop authentic assessment instruments crucial for academic institutions (Toy, 2007; Villarroel et al, 2024).

METHOD

This study observed two undergraduate freshmen cohorts (2023 & 2024) taking a Mechanics of Solids (MoS) module while undergoing a Singaporean university's Mechanical Engineering degree programme. Both cohorts are tasked with completing a different authentic assessment, with different level of structuredness, general learning outcomes, and challenges. The students will be evaluated before and after the module to determine their engagement and experiences with the two distinct authentic assessments, perception of ill-structuredness, and whether assessment type impacts their transfer of learning. By examining the two cohorts, this study can understand the effects of an ill-structured authentic assessment versus a more moderately structured one.

Authentic and Ill-structured Assessment Intervention

The 2023 cohort was given the task to redesign a crucial component of an electric motorcycle. This task involved the structural and fatigue analysis of a motor mounting

(Figure 1 – left), where the problem scenario and geometry were defined by the university's industry partner. The problem itself was presented in a way that required the students to navigate through ambiguity, make decisions on how to approach the problem, and explore different possible solutions. Characteristics of an authentic assessment were naturally present since students were dealing with a real-world industry problem, using input data such as motor weight, acceleration, and cornering forces, and applying finite elements to develop practical solutions. The ill-structured nature of the problem closely mirrors the complexities engineers face in real-world practice, where problems rarely have one right answer, and multiple factors need to be balanced, such as optimising the swingarm for weight and manufacturability while ensuring an acceptable safety factor.

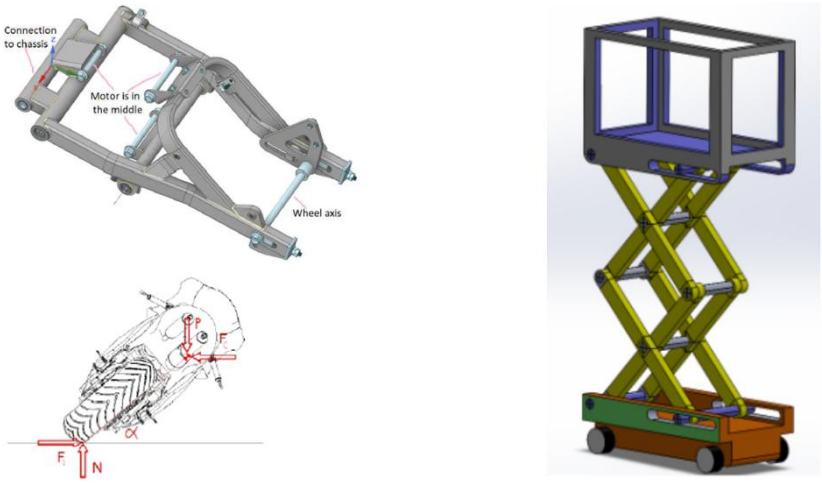

Figure 1
Left – 2023 Assessment to Redesign a Swingarm; Right – 2024 Assessment to Design a Scissor Lift

The 2024 cohort was given the task to create a new scissor lift design (Figure 1 - right). While this was still an authentic assessment, a more guided and defined approach was taken to provide a moderately structured problem. The problem was set by the MoS module lead, and students were given clearer guidance on the steps they need to follow, such as defining the geometry of the scissor lift and proceeding through a more standard finite element modelling process. This made it more of a guided task where students still apply practical skills and knowledge, but the level of ambiguity is reduced, compared to the ill-structured problem for the 2023 cohort. The authenticity lies in the fact that students were working on a realistic engineering challenge that simulated actual professional tasks, such as modelling and analysing a scissor lift structure. However, the structure of the task made it easier for students to navigate, as they were less likely to encounter the same degree of uncertainty as the previous cohort.

The ill-structured nature of the 2023 assessment encouraged more creativity, problem-

solving, and critical thinking by leaving many elements of the problem open to student interpretation. The 2024 assessment, while still authentic, provides more guidance and scaffolding, which may be better suited for learners who are still developing their problem-solving skills or need a more structured environment to work through complex analyses in their formative first year of study. The weightage of both assessments remained the same, at 50% of the module's overall grade. This 50% consists of a technical project report, verbal presentation, and reflection portion. All other aspects of the 2023 and 2024 modules were identical; both modules ran for 3 months, the same number of in-class lessons and lectures, the same module content and educational resources, and students were allowed a similar number of consultation sessions with faculty.

Survey Instruments

Both cohorts will be evaluated with two surveys, an adapted Transfer of Learning Questionnaire (Lightner et al, 2008), and the Ill-Structured Problem Validation Tool (Toy, 2007).

The Transfer of Learning Questionnaire (TLQ) measures three constructs; student's attitudes to transfer, barriers to transfer, and learning retention. These constructs assess student perceptions and sentiments towards the transfer of learning, ease of transfer of learning, and potential obstacles. The questionnaire consists of 12 closed-ended questions rated on a standard Likert scale from 1 (Disagree) to 5 (Agree), with 3 (Neither Agree nor Disagree) being a neutral option. Two open-ended questions are also included in the TLQ, allowing students to raise concerns and provide feedback about their educational needs. To pinpoint the effect of assessment type on their perception and experience in transferring learning, the students will be provided with the TLQ before and after the MoS module. The list of 12 questions can be found in Appendix A.

The Ill-Structured Problem Validation Tool (ISPVT) allows students to validate if a given task is ill-structured and raises their competency in transforming an ill-structured problem to a moderately structured problem for them to satisfactorily complete. Seven closed-ended questions are included, rated on a Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree), with 3 as a neutral option (Neither Agree nor Disagree). One open-ended question asks how the students modified, simplified, or structured the task to solve it. The ISPVT is only provided once following completion of the module and assessment.

Participants and Recruitment

All freshmen students taking part in the Year 1 2023 and 2024 MoS module were recruited for this study. No students in the 2023 cohort entered the 2024 cohort, as such, the 2023 and 2024 sample will be completely independent from each other. Each cohort consisted of over 120 students, with this figure being the maximum number of participants possible.

Students were invited to complete the pre-module TLQ via an email recruitment process. At this stage, informed consent was obtained via a consent form and Participant Information Sheet that detailed the duration and aim of the study, and the

student's responsibility in completing the questionnaires. Once the module is completed, the students would then again be invited to complete the post-module TLQ and ISPVT. Ethical approval was sought from the Singapore Institute of Technology's Institutional Review Board, project RECAS-0071.

Data Analysis

For each of the 2023 and 2024 cohorts, a paired *t*-test is conducted to identify significant differences between the students' pre- and post-intervention mean scores. In addition, an independent *t*-test will be conducted to compare the 2023 and 2024 cohort mean scores. This method gives a more balanced look of the impact of either assessment on the students' ability to learn and transfer learning, along with comparing the two assessments to each other more directly. In the case where unequal variances and/or sample sizes exist between the groups, Welch's *t*-tests will be used instead. To measure the impact of any changes from pre- to post-module, Cohen's *d* is then calculated to determine the effect size. The effect size will also be calculated for the differences between the post-module scores of the 2023 and 2024 cohorts as well.

Data from the open-ended segments of the TLQ and ISPVT will go through a simple thematic analysis to uncover repeatedly mentioned themes. These themes are then scrutinised to determine how they support or contrast the rest of the survey results.

As this study involves the collection and storage of potentially identifiable student data, some level of protection is needed. Student numbers and names are anonymized, with access to the decryption key only available to the lead researcher. The dataset is then aggregated to prevent further identification, before being stored in a secure password protected online platform.

FINDINGS

Transfer of Learning Questionnaire (TLQ): Pre- and Post-Module Comparison

Table 1 shows the mean scores for the pre- and post-module TLQ for both years. For 2023, 47 students completed the pre-module TLQ, and 26 students completed the post-module TLQ. For 2024, 11 students completed the pre-module TLQ, with 99 students completing the post-module TLQ. As the sample size of the pre-intervention group was considerably small, a paired *t*-test would not be recommended (De Winter, 2019). Instead, a Welch's *t*-test was applied to compare the mean change between the pre- and post-module ToL scores. The 2023 pre-module results were analysed against the 2023 post-module results, while the 2024 pre-module results were analysed against the 2024 post-module results. In the last column, the post-module results of both years were compared with each other. The *p*-values of the mean differences can be observed in brackets.

Table 1
2023 and 2024 TLQ Score Differences and Effect Size

Qn No.	2023			2024			2023 & 2024 Comparison
	Pre	Post	*d*	Pre	Post	*d*	*d*
Q1	4.15	4.19 *(.837)*	.053	4.00	4.42 *(.056)*	.658	.286 *(.244)*
Q2	3.98	4.23 *(.194)*	.318	4.18	4.27 *(.655)*	.128	.053 *(.807)*
Q3	4.36	4.23 *(.530)*	-.164	4.18	4.40 *(.365)*	.313	.211 *(.389)*
Q4	3.87	4.12 *(.189)*	.329	4.09	4.31 *(.339)*	.315	.268 *(.242)*
Q5	4.15	4.38 *(.203)*	.307	4.18	4.34 *(.269)*	.278	-.058 *(.791)*
Q6	4.06	4.38 *(.095)*	.400	4.18	4.38 *(.175)*	.335	-.001 *(.996)*
Q7	4.26	4.19 *(.725)*	-.091	4.18	4.49 *(.129)*	.515	.425 *(.082)*
Q8	4.11	4.38 *(.114)*	.390	4.27	4.45 *(.261)*	.318	.103 *(.648)*
Q9	3.28	3.38 *(.675)*	.102	3.45	3.09 *(.264)*	-.311	-.244 *(.232)*
Q10	3.51	3.96 *(.082)*	.420	3.64	3.57 *(.847)*	-.060	-.356 *(.086)*
Q11	3.28	3.73 *(.089)*	.425	3.64	3.56 *(.774)*	-.075	-.147 *(.484)*
Q12	3.26	3.65 *(.173)*	.345	3.55	2.99 *(.067)*	-4.80	-.500 *(.022)*

The Welch's *t*-test revealed that there were no statistically significant differences (<0.05 *p*-value) in pre- and post-module mean scores for both the 2023 and 2024 groups completing the TLQ survey, although many approached significance. Due to the nature and strength of non-parametric analysis, these results could still fall under the acceptable range (Delacre et al, 2017) and be considered when discussing the effects of authentic assessments on the transfer of learning.

After calculating Cohen's *d* for all 12 items, it can be observed that the effect sizes of both years differ from each other as well. For the attitudes to transfer questions (Q1-Q8), the largest changes were found in Q6 (*d*=.400) and Q8 (*d*=.390) in 2023, indicating a small effect. In 2024, the largest changes were found in Q1 (*d*=.658) and Q7 (*d*=.515), indicating a more medium effect. On the other hand, the pre- to post-module changes for the barriers to transfer questions (Q9-Q12) were in opposite directions across both years. All 4 of the barriers to transfer questions in 2023 increased post-module, with Q10 (*d*=.420), Q11 (*d*=.425), and Q12 (*d*=.345) displaying a small positive effect. In 2024, all 4 of the same items decreased post-module, with Q9 (*d*=-.311) showing a small negative effect and Q12 (*d*=-4.80) a large negative effect.

Despite the lack of statistical significance, in examining the direction and effect size of the changes, it can be inferred that students perceived the 2023 module to be more

difficult due to the increased barriers to transfer scores. For example, in Q10, students did not like to use more effort to transfer knowledge from other modules into the MoS module. They also thought that this transfer might potentially be confusing, in Q11. Combined, this could indicate that the industry provided assessment was academically taxing. The students perceived the 2024 version to be more approachable, with their self-reported obstacles in transferring learning decreasing by the end of the module. With the instructor defined moderately structured assessment, the students could have grasped the content easier and more readily integrated the information into and out of other modules.

In the open-ended section, the students were asked if there were any factors that kept the content of the MoS module separate from other modules. Both cohorts answered similarly, citing the overall difficulty of the MoS module compared to their other modules. They gave answers such as "the complexity of module content" (2023) or "workload for projects in MoS is significantly higher" (2024) to justify their experiences. Some students had a different perspective, mentioning that the MoS module could give them learning opportunities such as having a "large focus on learning how to use ANSYS" (2023) and that "without this module, I won't be able to understand Finite Element Analysis (FEA) in depth" (2024).

Transfer of Learning Questionnaire (TLQ): 2023 and 2024 Post-Module Comparison

The right most column of Table 1 displays the comparison between the 2023 and 2024 post-module mean scores and effect sizes. A Welch's *t*-test revealed a significant difference in the amount of free time students had in 2024 to refer to knowledge in other modules for the MoS module ($t(44)=2.37$, $p=.022$). The effect size, as measured by Cohen's *d*, was $d=-.500$, indicating a medium negative effect. No other items displayed a significant correlation.

These results echoed the findings from the previous section, where students felt having an easier time with the 2024 assessment; They had more free time to explore how they could learn from other modules and apply it within the MoS module (Q12). Overall, due to the ease in which students understood and completed the more defined moderately structured assessment in 2024, the barrier to transfer knowledge both in and out of the MoS module was lowered.

Ill-Structured Problem Validation Tool (ISPVT)

A Welch's *t*-test was conducted to compare the ISPVT results in 2023 (n=18) and 2024 (n=88), with the subsequent results shown in Table 2. A statistically significant difference was found in Q1 and Q2. Students believed that the problem scenario, or assessment, was more clearly stated in 2024 ($t(19)=-3.08$, $p=.006$), well as having enough relevant information to solve ($t(19)=-3.39$, $p=.003$), with large effects of $d=.950$ and $d=1.04$ respectively. Even Q3, although not significant, displayed a medium effect size ($d=.548$). These three ISPVT questions measures the ambiguity of a problem scenario, and based on the results, the 2023 assessment was more ambiguous than the 2024 version.

Table 2
2023 and 2024 ISPVT Mean Scores and *p*-Values

Question	2023	2024	*d*
Q1: The Problem Scenario is clearly stated.	3.17	4.28 *(.006)*	.950
Q2: There is enough relevant information provided for students to offer a valid solution.	2.94	4.18 *(.003)*	1.04
Q3: The tasks are appropriate for the contents of this module.	3.67	4.26 *(.089)*	.548
Q4: The tasks require the use of concepts and principles addressed in this module.	4.11	4.26 *(.559)*	.170
Q5: There are several ways to approach the Problem Scenario.	4.11	4.27 *(.415)*	.218
Q6: The solution involves multiple perspectives.	4.11	4.26 *(.482)*	.195
Q7: The problem, or any of the tasks, need to be modified to satisfactorily arrive at a solution.	4.11	4.14 *(.890)*	.034

In contrast to the TLQ, a higher score is not necessarily indicative of a better outcome when examining ISPVT results (Ajjawi et al, 2020). The 2023 assessment was more ill-structured by design, and this lack of guidance mirrored real world industry problems, where individuals would have to define the issue at hand and gather additional resources to offer a valid solution. Despite the differences in ill-structuredness between the two assessments, there were no significant implications on their attitudes or barriers towards ToL except the amount of free time. It is also notable that Q4 to Q7 of the ISPVT, measuring the open-endedness of problem scenarios, did not significantly contrast across the two cohorts.

The open-ended ISPVT question probed students on ways they had to modify the problem scenario to arrive at a solution. In both cohorts, students had to simplify the assessment into a proper simulated model in order to analyse them using certain computational tools. This could be done by streamlining the geometry of the structure to reduce the time needed for the analysis software to run, or by removing aspects of the structure that had no bearing on their intended solution. The 2024 cohort provided an additional perspective – they could also compare their simulated model with existing models found via the internet. Responses such as "cross-reference with … other modules or materials from online" or "acquired the CAD drawing from GRABCAD" highlighted their resourcefulness in adapting to authentic assessments.

DISCUSSION

Learning Outcomes

Both assessments were designed as engineering challenges to simulate actual professional tasks, with realistic input data and the application of finite elements to develop practical solutions. The key differential between both assessments was the degree of ill-structuredness. The 2023 assessment was ill-structured by design to facilitate ambiguous, messy workplace challenges in pursuit of maximizing authenticity. The problem scenario needed to be heavily modified to solve in the

absence of clear instructions and directives, encouraging creativity, problem-solving, and critical thinking by leaving many elements of the problem open to student interpretation. Comparatively, the 2024 assessment designed by faculty staff, was moderately structured with clarity in objectives and structure, retaining the overall design while removing complex parts and simplifying object geometry.

As the 2024 assessment was more structured and guided, the reduction in ill-structured could reduce authenticity and affect ToL. However, the assessment was still designed to be open-ended and introduce students to workplace-like problem scenarios, requiring students to make recommendations to improve and optimise the final design. It was found that student participants from both cohorts experienced high post-module scores in the ToL metrics, albeit in different areas. As such, both the 2023 and 2024 assessments were generally effective in obtaining the desired transfer of learning outcomes and that students were receptive and open to authentic assessments. An improved confidence and attitude towards understanding module material and inter-module transfer of content was observed in both cohorts. Although improvement in learning ability was not conventionally statistically significant in either group, it serves as a good starting point to analyse and compare the effects of ill-structured and moderately structured authentic assessments elsewhere.

There were minimal differences in the perception of ToL when examining the impact of the 2023 and 2024 assessments. As compared to 2023, the 2024 cohort reported marginally better confidence and attitude on average. However, differences in this area are slight prior to and after the authentic assessment, as the students entered the MoS module with fairly high pre-module scores (>4). Structure, or lack thereof, did not appear to have a significant effect on ToL across modules. It is therefore difficult to support that moderating the structuredness of an authentic assessment would impact a student's ability to transfer learning and is more so indicative of a baseline competence of students taking the MoS module.

A greater effect was found when comparing the barrier to transfer between the 2023 and 2024 assessments. Students taking the 2023 assessment experienced a greater difficulty in transferring their knowledge base to and from the module following the assessment. Students particularly had an increased aversion towards thinking about other modules in the context of MoS and had greater difficulty finding time to do so. Additionally, there was a greater sentiment that transferring knowledge from other modules to MoS was confusing, indicating the assessment had a detrimental effect on this learning objective. This outcome reinforces existing research that lack of clarity can increase student resistance to authentic assessment (Dringenberg & Purzer, 2018).

Conversely, such feelings and obstacles were lower among participants taking the moderately-structured 2024 intervention, suggesting the assessment had the effect of reducing learning obstacles and barriers, particularly across modules. This disparity in barriers showed the 2024 assessment design structure being more accessible to students, and more appropriate for learning material where accessibility is key. Comparatively, the ill-structured 2023 assessment more actively challenged student perceptions and pushes them to be more creative. It has been found that having a more moderately

structured assessment does not affect ToL and reduces student resistance to authentic assessments.

Perceptions of Ill-Structuredness and Authenticity

The findings from the ISPVT questionnaire suggested a persistent sentiment amongst the 2023 participant group that the ambiguity and lack of structure were a sign of poor question design. The 2023 cohort demonstrated belief that the problem scenario was not clearly stated, with unclear relevance to the module and insufficient information, the latter being the most significant. Confusion and frustration towards scenario design were comparatively absent among participants of the 2024 survey, suggesting greater ill-structuredness was responsible for such responses. These responses reaffirm the lessened ill-structuredness of the 2024 assessment, meant to guide students through the problem scenario, and had a noticeable result.

Questions 4 to 7 of the ISPVT recorded student perceptions on the open-endedness of the assessment – if the scenario required/enabled multiple perspectives and approaches, as well as if the problem scenario needed to be modified to solve. The 2023 and 2024 assessments recorded similar, positive results in these metrics, indicating both problem scenarios were perceived as open-ended despite differences in structure and information presented. As such, lowering ill-structuredness in 2024 did not compromise desired learning outcomes in this instance, and reinforced the goals of the authentic assessment.

In summary, the opacity and ambiguity of the ill-structured 2023 assessment appeared to be the primary differential in creating barriers in learning for first-year students, resulting in increased frustration. The increased difficulty of the 2023 ill-structured authentic assessment led to a decrease in perceived ToL. Students displayed awareness of learning objectives such as modifying the problem scenario and inter-module ToL but struggled to make such connections due to the difficulty of the problem scenario. Comparatively, structure meant information was more uniformly presented to students in the 2024 task, which led to better perceived ToL and a more positive learning experience for students.

Recommendations for Curriculum Design

Implementing ill-structured problems resulting in increased difficulty and challenge for students is unsurprising as researchers and lecturers have often reported that solving ill-structured problems are expected to present challenges for students (Faber et al, 2017; Shin & Song, 2015). As such, purposefully challenging assessments are usually intentionally provided to familiarise students with problems and frustrations that can come with real world engineering problems. However, the potentially detrimental effect on general learning outcomes of ill-structuring problems for inexperienced students means educators should be cautious in their implementation in entry-level and foundational modules. With a greater emphasis on integrating the engineering workplace into schools through industry collaborations or internship modules, educators should also assess how the ill-structured problems they pose fit into the classroom. Having students engage real world engineering issues for the sake of working experience at this stage of their learning programme should not compromise meaningful

academic benefit.

One recommendation for creating and implementing ill-structured authentic assessments in engineering would be identify a base level of competency for all students first. Foundational level skills such as numeracy and calculation, material science, a basic grasp of simulation software, and programming, amongst others, would be needed for students to progress to where they are able to solve open-ended and ambiguous problems. This is certainly why many educators leave higher-level authentic assessments for second-year or senior students. For junior students, a more moderately structured assessment might work better, while focusing on improving their baseline level of competency. A moderate level of structure, however, is still advised to introduce students to engineering content and scaffold students into applying their learnt knowledge into later modules, and eventually, a workplace setting.

Another recommendation would be for educators to communicate the intention of authentic assessments to students before starting out. The outcome of authentic assessments should be closely related to certain pedagogical learning objectives, like essential engineering competencies (Garay-Rondero et al, 2024) or in this study's case, the transfer of learning. Educators should not strictly aim to maximize authenticity in their assessments for the sake of matching industry problems. Following, this has to be communicated to those teaching the programme curriculum as well. In certain circumstances, such as if students are not foundationally competent, the ill-structuredness of assessments should even be toned down. Educators must have clarity in the goals of the authentic assessment and design the parameters of problem scenarios and tasks accordingly. Ultimately, authenticity is a feature of the assessment and not the goal. These learning objectives should be communicated to students beforehand to ensure that they share the same outlook, work towards the same goals, and reduce obstacles and frustrations in transferring learning.

Lastly, the engineering industry can prove to be a valuable resource for creating new authentic assessments. Educators can have difficulty drafting quality authentic assessments (Villarroel et al, 2024), and to create additional workload for them may not always be in the educational system's best interest. Having a direct source of information from the engineering field works best here to ensure that students receive the most authentic, open-ended, and ambiguous problems to solve to ensure that they are work ready. As in this study's case, a specific regional company partner was contacted to pose students a novel and complex engineering issue on electric motorcycles. Other universities and institutes of higher learning could leverage this form of industry collaboration to understand the modern challenges facing the engineering industry, while forming a pipeline between school and work.

Limitations

Firstly, this research study uses two separate student cohorts, introducing a potential cohort effect. It is understood these cohorts may have differences in learning ability and performance levels, potentially affecting their attitudes towards the transfer of learning and skill in solving ill-structured tasks. Their baseline learning perceptions and abilities were measured in the pre-intervention TLQ survey, which reflected generally

comparable learning abilities with marginal differences. However, there may be some other factors affecting the results in this study that could not be controlled such as the individual learning habits of student participants, or their realisation of computer model simplification techniques. This contextual imbalance amongst the two group of students may affect the analysis of the post-module scores and should acknowledged to be a limitation of the results discussed above.

Next, as not all students completed the surveys, the limited sample sizes within and across cohorts could lead to less significant and generalisable results, impacting the validity of the analysis. As the questionnaires were completely voluntary, this study saw uneven pre- to post-module response rates, such as with the n=11 sample size of the 2024 pre-module responses. Although open-ended qualitative feedback to gauge student responses and experiences with the assessments was supplemented, its implications on the quantitative portion of this study was minimal. The low sample sizes introduce concerns on the statistical power and overall generalisability of the results presented in the previous sections. As such, it is possible that the two types of authentic assessments may have had a statistically significant effect on students' ToL when this study did not find any. Thus, the results should be interpreted with this limitation in mind.

CONCLUSION

Based on the findings, varying the degree of ill-structuredness in authentic assessments does not have a statistically significant effect on the attitudes and barriers towards transferring engineering content among first-year students. Nevertheless, the observed trends from the data seem promising. The 2024 assessment, which was moderately structured yet retained open-endedness, reduced the time needed for students to consult knowledge from other modules. By moderating the ambiguity inherent in authentic assessments, students were better able to manage their studying time and focus on improving their transfer of learning. Such an approach may be more appropriate for foundational-level curriculum, especially for entry-level undergraduates before they progress towards more ill-structured authentic assessments in later years. Nonetheless, both forms of authentic assessments, ill-structured and moderately structured, demonstrated value to engineering education, with the implementation of work-related and realistic problem scenarios generally maintaining holistic learning outcomes.

Ill-structured problems remain invaluable for cultivating essential work knowledge of engineering students, including students' adaptability in real-world problem scenarios and challenging their creativity, problem-solving skills and initiative. Accordingly, it must be appreciated that authentic assessments serve as instruments toward achieving key learning objectives for engineering students, rather than as ends in themselves. The integration of such problems and tasks must be balanced with the fundamental learning process of engineering concepts and theories. Scaffolding mechanisms such as a gradual increase in the structure of the assessment, peer support, and industry collaborations should be considered to facilitate students to understand ambiguity and open-endedness in the workplace. Future research is warranted to develop effective scaffolding strategies that prepare students for ill-structured authentic assessments.

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APPENDIX A

TLQ QUESTION LIST

No.	Question
Q1	I can connect the material learnt in the Mechanics of Solids module with other modules.
Q2	I often think about how to relate the Mechanics of Solids module topics with other modules topics taught in this degree programme.
Q3	It is important to relate materials from the Mechanics of Solids module with materials from other modules in this degree programme.
Q4	It is easy to use or apply material from other modules into the Mechanics of Solids module.
Q5	I expect to make connections from one topic to another within the Mechanics of Solids module.
Q6	I expect to make connections between different modules in this degree programme.
Q7	The material from other modules is relevant for the Mechanics of Solids module.
Q8	I focus my efforts on what the Professor wants in the Mechanics of Solids module.
Q9	I don't know the materials from other modules well enough yet to apply in the Mechanics of Solids module.
Q10	I don't like to think that hard to transfer the knowledge from other modules to the Mechanics of Solids module.
Q11	Transferring knowledge from other modules to the Mechanics of Solids module might confuse students.
Q12	I don't have time to refer to knowledge in other modules for the Mechanics of Solids module.