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Student engagement and perception of study materials in an undergraduate subject that teaches core engineering concepts.

Stephan F. Oehler, Jonathan Eden, Raquel de Souza
The University of Melbourne, Faculty of Engineering and IT
Corresponding Author Email: Stephan.Oehler@unimelb.edu.au

ABSTRACT

CONTEXT

The level of student engagement with and the perceived usefulness of study materials have been explored for a subject that teaches systems modelling to undergraduate students in Mechanical and Mechatronics Engineering. Students now have access to a wide variety of learning materials and formats. While this can provide flexibility to different learners, the lack of standardisation could lead to confusion.

PURPOSE OR GOAL

The objective of this project is to analyse which kind of study materials students perceive as useful and engaging in their engineering studies. This is particularly important in subjects that teach groundwork concepts, as this can affect future subjects that make use of those concepts. The ultimate goal is to provide students with more efficient tools that will engage them in learning and understanding concepts deeply.

APPROACH OR METHODOLOGY/METHODS

Teaching materials, in particular tutorial solution sheets, were standardised to the same format using an AI-assisted conversion process. Additionally, tutorial teaching notes were introduced, which were more streamlined with the lecture material, while providing more scaffolding and guidance to get students to solve problems on their own. After these changes were made, a 2-page survey was administered to analyse students' engagement with all the accessible materials.

ACTUAL OR ANTICIPATED OUTCOMES

The survey results show that the changes in teaching material were well-received by students and mostly positively affected their experience. The results also indicate that lecture recordings, tutorial teaching notes and tutorials were perceived as most useful by the cohort. Moreover, in addition to the provided content, most students employed external resources, with online videos being most popular, but generative AI was already being used as a learning aid by a large portion of the surveyed cohort.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Classical learning using lecturers and tutorials is perceived as useful, though the responses to the survey suggest that students prefer flexibility and to study at their own pace. Going forward, it is important to study AI as an interactive learning material, as students are starting to use AI as a personal tutor.

KEYWORDS

Threshold Concepts, Learning Material, AI

Introduction

Biggs et al. (2022) suggest that teachers need to support students in constructing their own understanding of learning material, rather than expecting students to passively absorb information. Therefore, effective university teaching should use a student-centred approach. Students either chose a Surface Learning Approach, a Deep Learning Approach, or a combination of both; their choice is influenced by their learning environment, which should be designed to encourage deep learning and self-regulated learning approaches (Zimmerman, 2013). Modern learning environments now have a wider variety of learning materials and formats, ranging from online videos to interactive learning environments to the increasing adoption of GenAI. On the one hand, this is great for the students because there is more flexibility to suit different learning styles. However, it will make it more difficult for them to realise what learning materials work for them. Students have to be more selective with what to interact with, which is determined by their motivation to learn. This motivation to learn is influenced by the perceived usefulness, a term that comes from technology acceptance models (Huang, 2021; Mirriahi et al., 2025) and an important aspect to consider when designing and selecting learning materials for students.

In this research, we will look at the learning material in a subject that introduces groundwork material from many subsequent subjects. Therefore, it is important to understand threshold concepts. The theory of threshold concepts in Teaching and Learning was first introduced by Meyer and Land (2003) and made its way quickly into Engineering Education (Baillie et al., 2006). Threshold concepts are typically described as ‘core concepts’ that are often difficult to grasp but will ultimately change the way that students view, understand and process the materials they learn in their university courses. These concepts need to be mastered first for students to be able to understand and learn advanced materials. It is therefore paramount for students to develop a deep level of understanding. Although the field has never fully determined what defines a threshold concept (Quinlan et al., 2013), some studies have identified threshold concepts that are relevant to the subject about to be discussed (Beuchat et al., 2022; Hesterman et al., 2011; Male et al., 2021)

Background

In this study, we want to test what materials are best provided for a class to support students’ learning of groundwork material. Specifically, we are looking at the impact that learning materials have on the student and teacher experience in one of the undergraduate subjects at The University of Melbourne, which is a gateway to more advanced subjects in the fields of dynamics, control, system modelling, stability analysis, acoustics and fluids. The subject is System Modelling and Analysis (SMA), which is a third-year undergraduate-level subject taken by approximately 120 Mechatronics and Mechanical Engineering students every semester.

SMA is a fundamental applied mathematics feeder subject of core concepts that prepares students for a range of post-graduate subjects in Mechanical and Mechatronics Engineering. It teaches concepts such as Transfer functions, Fourier Transforms and Discretisation. The subject builds upon multiple applied maths concepts, and students who did not perform well in the prerequisite subjects often struggle, which is reflected by a relatively high failure rate and feedback from students. The subject has 36 lecture hours and 22 tutorial hours, which are delivered over a 12-week period by one Lecturer and two Tutors. Lectures are recorded, but tutorials are not.

SMA is taught by two different tutors (both semesters) and two different lecturers (one for each semester) throughout the year. The different teaching styles, while trying to share teaching resources, can sometimes lead to a certain misalignment between teaching notes. For example, one might add handwritten notes or solutions for some content and structured and typed content notes for another topic. And while teaching styles will always have variations, keeping a common structure for the content could support students' experience.

To address these problems, we introduced new tutorial teaching notes and solution sheets to standardise content and align the delivery style to that of the lectures. Specifically, we

- ensured that there is a consistent order of how the Lecture content is presented,

- converted all tutorial solution sheets to LaTeX with the help of AI, and
- created LaTeX-based Tutorial teaching notes that better align with the style and format of the Lecture notes and Tutorial sheets.

We conducted a survey on the students' perception of the provided learning materials, as well as what other external learning materials they access while studying. This is to (1) assess the impact of the changes, (2) see how well students engage with the teaching material, and (3) better understand the students' study behaviours.

For the remainder of this study, we will describe how the notes were converted using AI, discuss the new tutorial teaching notes, analyse the survey results and draw conclusions and recommendations.

Methods

Tutorial Solution Sheet Conversion using AI

The motivation was to standardise the tutorial sheets by converting all handwritten solutions to LaTeX with the help of Chat GPT (GPT-4o). We got permission from the University to use this external AI tool because no sensitive student data was involved in the process. The conversion process was as follows:

1. Manually split scanned handwritten solutions into smaller pieces (about 1/2 to 1 page each). This was to be within the constraints of the AI.
2. The scanned images of the solutions were uploaded to the AI, which was prompted to convert the image to a LaTeX script, i.e. "Please convert this image to LaTeX".
3. The resulting scripts were integrated into a single LaTeX document.
4. Finally, manual changes were made to fix the formatting and any mistakes made in the conversion process.

Here, it is noted that particular attention was required in the review to ensure that the AI did not skip steps and to ensure that any produced LaTeX code was compilable. While it was not possible for the AI solution to completely and correctly recognise all handwritten engineering solutions, the process allowed for an offloading of most content. This enabled a refocusing of tutor attention towards improving content and existing teaching material.

Tutorial Teaching Notes

A dedicated set of tutorial teaching notes was developed to better align the tutorials with the style and format of the lectures. Previously, each tutor had their own handwritten notes, and these were not provided to students. The dedicated tutorial teaching notes correspond to modifications from existing notes, which were changed to match the format of fill-in-the-gap style, where students are given incomplete notes that they fill out during the tutorial. Later, they are given a complete set of notes. The developed tutorial teaching notes follow the same principle as the lectures.

Other than aligning them with the lecture notes, there were other reasons for these notes:

1. Provide better scaffolding for students to help them get started on problems.
2. Smooth out the timing for each question.
3. Allow students to spend more time on important parts of the problem while skimming through simpler items.
4. Ensure homogenous teaching quality, especially to support future tutor changes.
5. Provide more revision material and help on how to set up problems.

There are usually two tutors in this subject. The new tutorial teaching notes (gaps and filled in) were made available to all students. However, both tutors taught in accordance with their own existing style. Here, it is noted that, as Tutor 1 developed the notes, the previous notes were consistent with their tutorial but also aligned with Tutor 2's teaching material. Tutor 1 opted to use the fill-in-the-gap style while Tutor 2 followed the more classical, fully handwritten whiteboard

delivery. It is noted that due to time constraints, these notes were only developed up to Week 7 of the course. For the remaining weeks, handwritten course notes were provided. However, this was rectified for the second semester, which provided a full set of notes.

Survey[1]

The survey consisted of 9 questions in total, including two demographic questions (Q1 and Q2) and three open-ended questions (Q6 to Q8). The survey was offered in Weeks 11 and 12, with 95% of students completing it in Week 11. By that point, results for two out of three assignments had been returned to the students. The survey was taken in class with a response rate of 100% among students who attended the tutorials in those weeks. We received a total of 63 responses, and therefore had an attendance rate of over 50% in the final two weeks of the semester.

Results and discussion

Teaching Notes

The notes were perceived positively. It was observed that stronger students who did not want to hear the revision and detailed explanations could work ahead, while students who had fallen behind could use the material as scaffolding to catch up. Explanations became more efficient, and extra time could be dedicated to explaining and letting students work through difficult parts of the problem sheets while skipping through the already-understood simple concepts.

Anecdotally, students conveyed that they enjoyed this format, as it meant they were more focused on the important content. Here, the old handwritten notes were perceived as less positive due to a perception of lower clarity. Overall, the changes did result in improved guidance and scaffolding for students, who seemed to have a better picture of what to do and how to get started. Meanwhile, the changes reduced the amount of preparation Tutor 1 had to do, while also allowing them to play to their strengths of explaining problems and responding to students' struggles with the subject content more.

We will now discuss the survey in three parts. First, demographics, then we will look into quantitative results and finally discuss the qualitative responses.

Demographics

The students studying SMA come from diverse backgrounds. The subject is attended by both Undergraduate and Postgraduate students, due to the model used at our University. Subject data shows that there were 93 Undergraduate and 27 Postgraduate students enrolled at the time that the study was conducted (Semester 1, 2025). SMA students have a diverse background with 75 domestic and 45 international students, one of whom is on exchange. It is important to note that students doing SMA in their postgraduate studies are lateral entries and may not have covered all prerequisites in the same way, or prerequisites might have been learned further in the past. To further understand our demographics and identify any potential biases in the survey cohort, we included two demographic questions in the survey.

Question 1: "Which degree are you currently studying?"

Out of the 63 participants, 53 were studying a Bachelor's and 10 students a Master's. Therefore, we had an attendance of 57% (53/93) undergraduate and 37% (10/27) postgraduate students. It is noted that this surveyed distribution of the cohort is 78% (93/120) are undergraduates and 22% (27/120) are postgraduate students. Only 11% (3/27) of the postgraduate students are domestic, while 77% (72/93) of the undergraduate students are domestic. Most domestic postgraduate students will have completed SMA already during their undergraduate studies.

[1] This survey was conducted under research ethics protocol 29248 secured by the Engineering Faculty's Teaching and Learning Laboratory of the University of Melbourne.

The difference in demographics is interesting. A possible explanation might be that undergraduate students need more support than postgraduate students in their studies. Though there could also be other barriers, such as language, or more master's students already working alongside their studies.

Question 2: "Before your current degree, what did you study?"

The majority of participants attended high schools (51/63) before commencing their degree, which almost matches the number of Bachelor students. The results also indicate a bias in the sample towards local students.

Quantitative results

Question 3: "What percentage of each of the following sessions have you attended this semester?"

The results in Figure 1 show a trend towards online lecture attendance. Most students selected either online, in-person or a mix of both. Only five students said they watched 100% of online lectures and attended some in-person lectures. The in-person attendance was roughly in line with what has been observed by the lecturer. While not captured within the survey, it is noted that tutorial attendance has been consistent at just over 50% throughout the semester, after a sharp drop at the start. Those who did come were mostly engaged and wanted to be in the class. When talking to students who stopped coming to classes, the main reasons given were that they were too busy with assignments and had fallen behind with the lecture content.

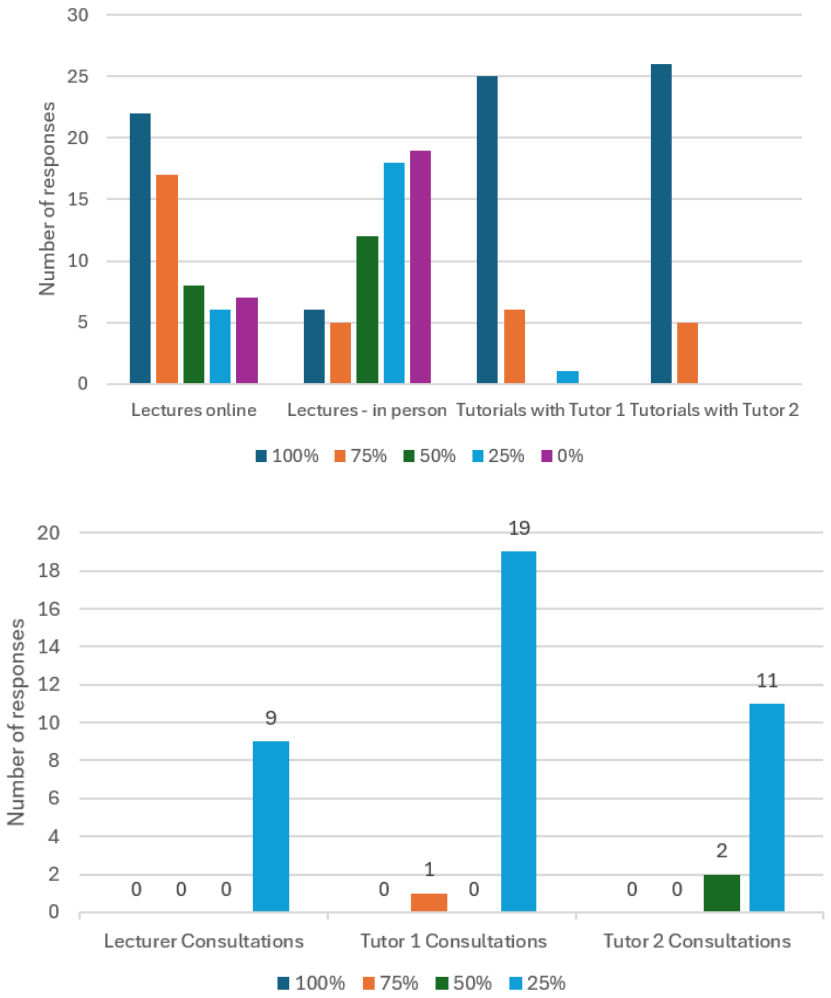

Figure 1: What percentage of each of the following sessions have you attended this semester?

The question also asked about attendance at consultations. Please note that Tutor 1 provided 2 - 1-hour consultations per week, while Tutor 2 and the Lecturer provided 1 hour of consultations per

week. Attendance is low, with only around 10-20 students saying they would go to 25% of the consults (or most likely less), which matches observations.

Question 4: "*How useful do you find the learning material that is provided?* "

The results are shown in Figure 2. It can be seen that the resources that were perceived as most useful were the Lecture recordings, given the flexible nature of the content, followed by the new Tutorial Teaching notes and Lecture Slides. Tutorial sheets and solutions were mostly rated useful, while LMS Quizzes, Course Notes, Reference Materials and LMS discussion boards received mixed reviews.

According to statistics from our Learning Management System (LMS), the average video view across all SMA lectures through the semester is 45.2%. Assuming an average in-person attendance of 25 students (and students not rewatching content online), it means that at most 2/3 of lectures get watched. Therefore, on average, 1/3 of delivered lecture content is not accessed by students. This is important to keep in mind as (i) those students with low lecture engagement might struggle in tutorials and (ii) might feel discouraged from going because they are unprepared.

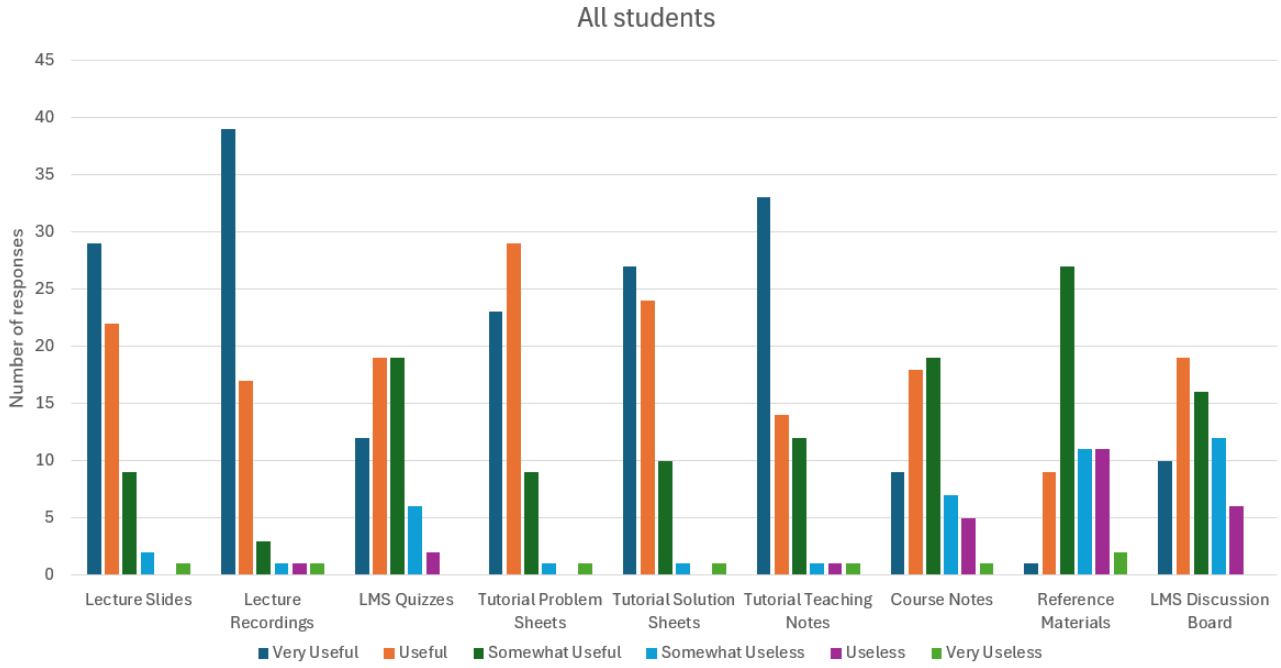

Figure 2: ***How useful do you find the learning material that is provided?***

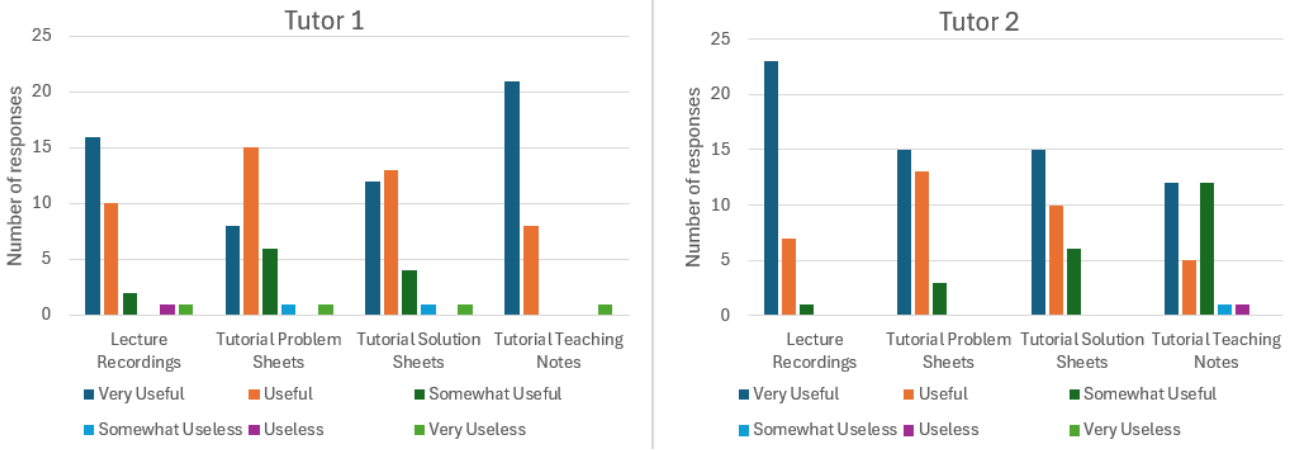

Figure 3: ***How useful do you find the learning material that is provided? Broken down between tutors.***

It is worth noting that there was a trend of differences when comparing the Lecture Recordings and Tutorial material evaluation across both tutors (Figure 3). Tutor 1, who used the new Tutorial

Teaching Notes with gaps, got an overwhelmingly positive rating for the tutorial materials. The other categories, such as Recordings, Tutorial and Solutions sheets, were not seen quite as useful compared to the results for Tutor 2. Their students rated the teaching notes at least somewhat useful, despite not being directly exposed to them. However, they did have access via the LMS, and it was an optional learning material for them.

Question 5: "*Do you use external resources to support your learning? If so, which ones?*"

There was no clear difference between tutor cohorts, as shown in Figure 4. Online videos scored the highest, which matches observation and experience. What's surprising is that over half of the respondents said they consult GenAI as an external resource.

Questions 6, 7 and 8 are open-ended and will be discussed in the next section. We asked them (i) if there is any learning material they found particularly useful, (ii) which material they would like us to improve and about their typical study habits.

Question 9: "*How confident do you feel about SMA?*"

The goal of this question was to compare open-ended comments from students with how they feel. The results are shown in Figure 5, with a mean of 6.04, a median of 7 and a standard deviation of 1.97. We did not see any significant correlations between the other survey questions.

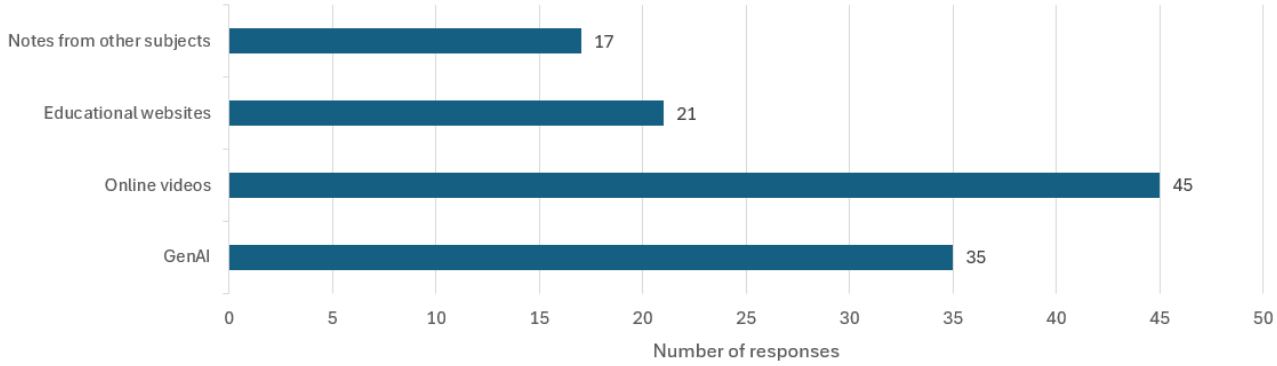

Figure 4: ***Do you use external resources to support your learning? If so, which ones?***

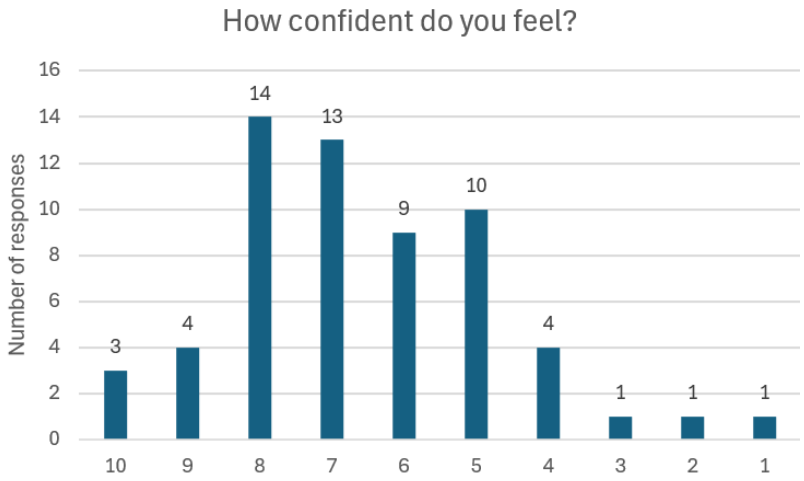

Figure 5: On a scale of 1 to 10, how confident do you feel about SMA?

Qualitative results

Question 6: "*Do you find any of the learning material we provide particularly useful? Why?* "

The most highlighted material was the lecture notes (in particular the step-by-step summaries) and the Tutorial Teaching notes. Students enjoyed the guidance and scaffolding to make complex problems more accessible to them. They also enjoy the overview from the lecture in combination

with the detailed step-by-step breakdowns of the tutorial teaching notes, one highlighting the different views that these materials provide. One student in particular mentioned the fact that other subjects would just go through a tutorial problem on the whiteboard without any kind of revision, which made it difficult for students to follow who did not get the entire lecture content.

Other highlighted materials were practice exams, the tutorial solutions themselves and the LMS Quiz. Based on interactions with students, the unassessed LMS quizzes seem to be well received as a way to check understanding, while others did not like them because they were set up as a Quiz. They would much rather prefer a booklet with these questions and a step-by-step breakdown of them.

Question 7: "*Are there any other learning materials that you would like us to provide in SMA to help you study?*"

The main response was asking us to provide the detailed solution to past exam papers and the LMS quizzes, which we do not provide to avoid rote memorisation. Students also asked for additional practice material through booklets and more detailed breakdowns of some of the problems, e.g. through a video. This makes sense, as students tend to focus on passing the exam. However, SMA provides many core concepts that students need to understand in order to do well in their Master's, so we do our best to encourage long-term learning and not just rote memorisation.

Other feedback was to provide a complete set of typed teaching notes, not just until week 7. This has already been addressed going forward. It shows that the typed notes were well-received. Other than that, students asked for more MATLAB resources, as the assignments rely heavily on MATLAB.

Question 8: "*Please describe your typical study habits in SMA. For example, did you encounter something that you found challenging, but then later overcame it? What helped you?* "

The majority of students, especially the ones with highly-rated feelings of confidence, describe a process of engaging strongly with the lectures, tutorials and quizzes. So, engaging with the material and attending workshops seems to have a positive impact on how students perceive themselves. The tutorial teaching notes were highlighted as useful when someone had fallen behind or didn't get a concept right away.

Five students mentioned the use of ChatGPT explicitly to help them understand difficult concepts, citing its patience and good understanding, though over half the class mentioned earlier that they use GenAI as an external resource. While the use of ChatGPT can be beneficial for students' learning, there is a risk that students will not learn the content deeply and struggle to answer questions in the exam.

Conclusion and Recommendations

In this study, we set out to better understand student engagement with learning material for a key undergraduate threshold concept subject in Mechanical and Mechatronics Engineering. In particular, we (i) looked at how recent changes to teaching material impacted students' learning experience and (ii) conducted a survey on students’ opinions and engagement with the learning materials they are exposed to.

We found that the changes were well-received, and anecdotal evidence showed an improvement in the students’ learning experience. Classical learning using Lecturers and Tutorials is perceived as useful, though the high response of usefulness for teaching notes and lecture recording suggests that students prefer flexibility and to study at their own pace. Going forward, we plan to repeat a similar survey, but with the complete set of teaching notes available to the students. There is currently not enough data to make a confident correlation between results. However, findings suggest that students value flexibility and variety of learning materials to enhance their learning experience and accommodate other commitments.

Future studies should focus more on the students' use of AI, as it can also be considered an interactive learning material. Half of the respondents said they consult GenAI as an external resource, which is only going to increase in the future. The main concern with the use of AI is that students will only learn on a surface level and be given a false sense of confidence. This is especially important for threshold concept subjects, as these are the gateways to higher knowledge. It is our job as educators to guide and support students as they engage with emerging new technology.

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