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Enhancing students' learning in engineering subjects through repetitive learning and self-reflection

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Repetitive learning and self-reflection have been introduced to an engineering foundation year to encourage students to actively engage and control their learning. Repetitive learning can help students to train their cognitive skills and develop deeper understanding of the subject matter. Through self-reflection, students can identify their knowledge gain and their weaknesses, and plan improvement to their learning. This paper will focus on how integrating both repetitive learning and self-reflection might help to encourage deep and active learning, thus enhancing students' performance and engagement in learning. The effectiveness of the method is evaluated based on the student feedback and teacher observation. From the feedback most students agree that repetitive learning and self-reflection has had a positive impact on their learning and has helped to improve their skills as independent and active learners. Teacher observations suggest that incorporating repetitive learning and self-reflection has improved students' confidence and engagement in learning.

Introduction

This article considers the implementation of repetitive learning and self-reflection in the Mechanical Science module of the Engineering Foundation Year at the University of Southampton. Repetitive learning is a learning technique whereby students review information or practise skills several times to deepen and improve their understanding or proficiency (Chen and Yang, 2020). Many researchers have shown that repetitive learning can secure a long-term memory of the subject matter (Toppino and Gerbier, 2014; Gilbert et al., 2023). As the topic is practised repeatedly, the students become familiar with new ideas and will naturally retain the knowledge or skill learned (Musfeld, Souza and Oberauer, 2023). As their knowledge and skills improve, students become familiar with the subject matter and are able to link it to other learning without realising it (Durrani et al., 2024). There are many methods that can be used to

implement repetitive learning such as using quizzes, engineering simulation, discussion and questioning strategies (Sevim-Cirak and Islim, 2023).

In addition to repetitive learning, self-reflection is needed to support a student's study and encourage them to think about their learning progress (Fastre et al., 2010). It is used to help students to assess and monitor their academic performance by grading their own achievement. Through self-reflection, the students can identify the knowledge gained and control the learning process by planning strategies to improve their performance. When students manage their own learning, it develops their ability to learn actively and independently, which is an essential skill for foundation students when they progress to the next level of their degree (Biggs and Tang, 2011). In addition, self-reflection is beneficial to educators for evaluating their students' learning and adapting their teaching activity to suit the students' needs (Race, 2020).

Literature review

The advantages of using repetitive processes in learning have been widely discussed and presented by many educational researchers. Toppino and Gerbier (2014) have shown that frequent repetition of skills and learning can help to embed them in the student's practice and to deepen students' understanding of the subject matter. In medical schools, spaced repetition has been used to develop students' skills and optimise their long-term retention in medical practice (Augustin, 2014). The study conducted by Augustin (2014) demonstrates that the amount of repetition is directly proportional to student achievement. The research shows that when a task is repeated once, students gain basic knowledge. However, repeating the task multiple times allows students to deepen their understanding and retain both knowledge and skills more effectively.

Furthermore, repetitive learning has been shown to improve memorisation and long term retention of information (Toppino and Gerbier, 2014; Kang, 2016). This has been evidenced through teaching practice in learning language (Clark, 2006) and music (Saville, 2011) where students are able to recall and improve their memorisation of words or musical notes. The data presented by Brooks and Brooks (1993) suggested that repetitive learning is able to lead to deeper understanding. They suggested that when learners acquire new knowledge, they tend to relate it to prior knowledge, thereby enhancing their cognitive structures. The research conducted by Bruner (1964) showed that repetitive learning can develop and improve students' problem-solving skills. The study suggested that when students repetitively engage in solving a problem, they develop a natural ability to apply these skills to other problems, as they have developed a recognition of the types and structures of those problems.

For self-reflection, many educators have included self-learning evaluations in their teaching to help students monitor, plan and control their learning. Self-reflection has also been shown to help students to develop into active and independent learners

(Martincova et al., 2021; Ng et al., 2022). Research conducted by Logan (2009) showed that integrating self-reflection in students' learning helps them to improve their engagement and confidence as learners by developing their critical thinking and supporting them to make judgements on how they learn. Some educators include statements such as: 'Have I understood the material thoroughly? What strategies did I use to learn and were they effective?' as a prompt for students to self-check their achievement and improve their metacognition (Mosston and Ashworth, 2002; Papaioannou et al., 2012). Metacognition refers to the high level thinking that is involved in the learning process and is essential in students' learning (Chatzipanteli et al., 2014). Ndoye (2017) claimed that self-reflection has a positive impact on students' learning and helps them to develop as life-long learners.

Motivation for implementing repetitive learning and self-reflection

The Engineering Foundation Year (EFY) at the University of Southampton is an intensive additional year that students attend because they do not have the traditional entry qualifications required to join the first year of an engineering or computer science degree programme. This might be because they did not take one or more required A Level subjects, typically Mathematics or Physics, because they took a more vocational qualification at Level 3, or because they are mature and returning to study with few, or few recent, formal qualifications. Because of this, the teaching techniques used with the foundation students must be inclusive and able to cater to students with different academic backgrounds and motivations for learning. In addition, students who enter the EFY will progress to a wide variety of degree programmes, including Mechanical or Electronic Engineering, Computer Science, Physics, and Mathematics, following their foundation year. The modules they study during EFY might not be directly related to their chosen degree, which could lead to surface rather than deep learning whereby students aim to pass the exam, not to master the module (Biggs and Tang, 2011; Lindblom-Ylanne et al., 2019).

In the Mechanical Science module, the syllabus involves many derivations of equations requiring mathematical skill. Topics within the module are linked, and each builds upon the previous topic. Therefore, it is essential for students to memorise and recall the engineering equations, symbols and scientific terms for each topic. They also need to know how to apply their memorisation to solving engineering problems and link their knowledge with other topics. However, during my teaching I found that students struggled to recall and remember formulas, symbols or important definitions of engineering terms in each topic. I also noticed that students had difficulty grasping new information and connecting those concepts to other topics. This can result in frustration and feeling overwhelmed, as students struggle to study the subject but feel that they have made no progress in their learning (Chitrakar & Nisanth, 2023).

To support and enhance students' learning, repetitive learning was implemented to help them master and retain the essential knowledge, concepts and skills in the

module. By repeatedly engaging with the material, students develop a deeper understanding and stronger connection to the subject matter (Dunlosky et al., 2013). This approach minimises the tendency to simply memorise information for exams, encouraging long-term retention instead. When students can recall and apply what they have learned easily, they experience a sense of accomplishment and enjoyment, which might keep them engaged with the subject matter. This continuous learning approach will help to reduce the risk of forgetting the theory and concepts, giving a sense of progress to students (Chen and Yang, 2020).

Repetitive leaning, combined with self-reflection, will help students to be able to control and plan their learning thus helping them to adapt to university style learning, which is more independent and active (Dhutta at al., 2023). When students take time to reflect on their learning process, they become more aware of their strengths, weaknesses, and areas of improvement. This can help them to identify which learning methods work best for them and to set their personal learning goals, which might lead to them enhancing their engagement in learning (Ng et al., 2022).

Implementation of the project

Repetitive learning and self-reflection was implemented in the Mechanical Science module in the Engineering Foundation Year. The module has two sessions of 45 minutes teaching per week and consists of five sub topics. Each topic has its own teaching allocation as shown in Table 1. Every three weeks, one slot of repetitive teaching is dedicated to reviewing a topic that the students have already learnt.

During the traditional teaching sessions, the students were given the learning outcomes at the beginning of the class. Students need to know what the key points are and what learning activities they should engage in. Then, during the repetition class, the students were asked about the learning outcomes of the repetition topic. This is to help students recall the learning objective and the cognitive processes that they require to achieve success in that topic. In addition, this activity can help students to use the learning outcomes as a checklist to assess their performance.

Topics	Weeks of Teaching	Repetition Class
Elasticity	2 weeks	2 repetitive
Statics	3 weeks	2 repetitive
Kinematics and Motions	3 weeks	3 repetitive
Linear Dynamics	4 weeks	4 repetitive
Rotational Dynamics	3 weeks	4 repetitive
Field Theory	4 weeks	1 repetitive

Table 1: Showing the teaching allocation of each topic in Mechanical Science module

During traditional teaching, students were presented with simple and straightforward problems related to the topic. These questions typically involved one or two straightforward solutions and were confined to a single topic. This approach aimed to help students build foundational problem-solving skills and develop their understanding of the subject matter. In contrast, during repetitive learning, students were introduced to increasingly complex problems. These problems required higher-order thinking, demanding that students perform in-depth analysis and apply concepts and equations from multiple topics. During these tasks, they received guidance on how to recall and apply the theories they had learned to solve the problems.

After the repetitive learning class, the students were given a self-reflection form to assess their learning. An example of the self-reflection form is given in Figure 1. It is used to help students assess their performance by grading their own understanding and achievement. Through the self-reflection, the students were able to plan their own ways of improving learning. At the end of the session, the self-reflection form is submitted through Blackboard to monitor the students' performance and for the lecturer to adjust the learning activities for subsequent sessions.

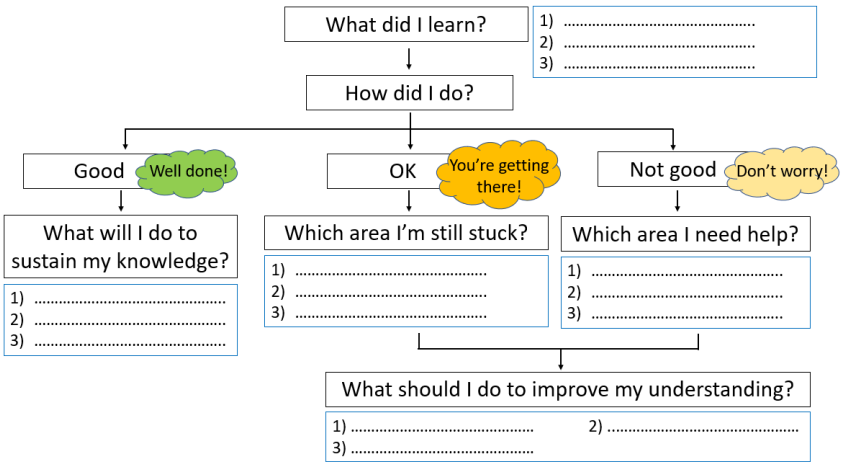
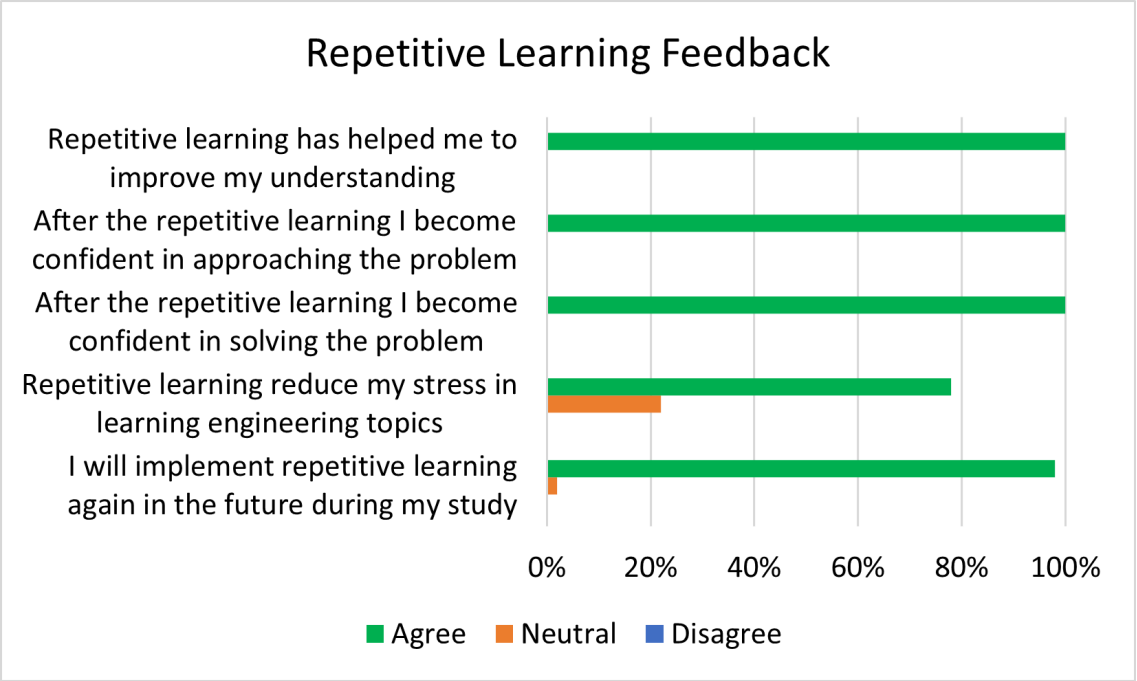


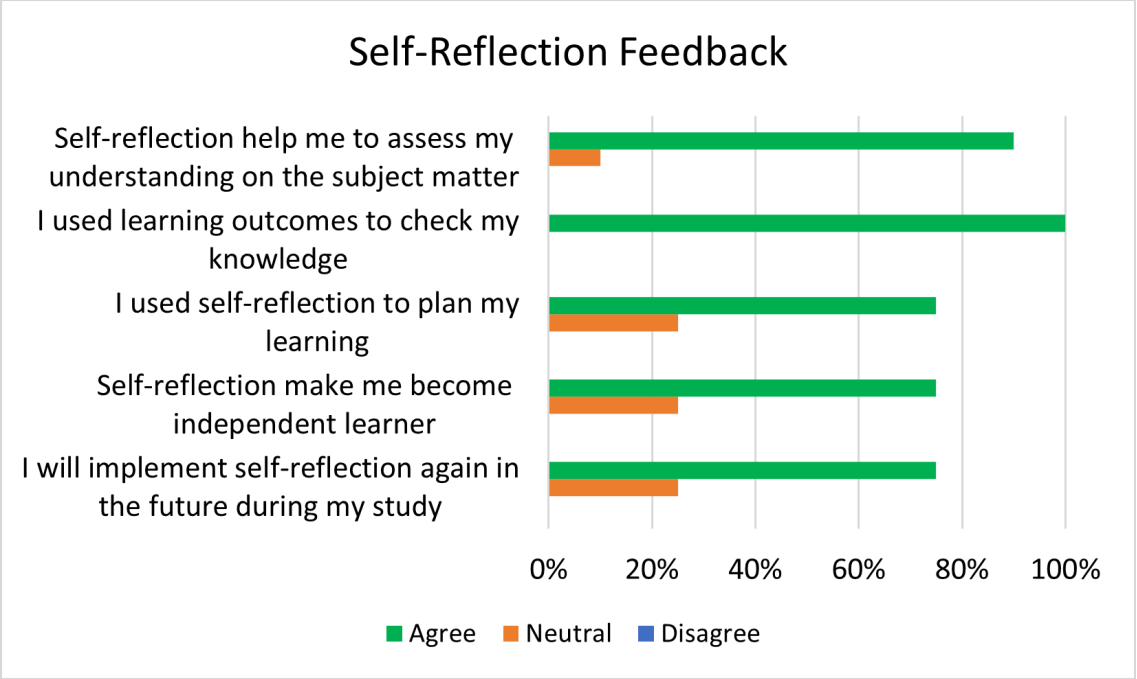
Figure 1: An example of the self-reflection form used by students to assess and plan their learning after the repetitive session

Feedback and findings

To gain insight into how students perceived the repetitive learning and self-reflection activities, student feedback was gathered through questionnaires at the end of Semester 2Sixty responses were received from 94 students. On the feedback form students were asked to rate several statements about the impact of the repetitive learning on their experience of learning as either Agree, Neutral or Disagree. Figure 2 provides the feedback obtained for both repetitive learning and self- reflection.



(a)



(b)

Figure 2: Student feedback on repetitive learning and self-reflection

For repetitive learning, all students strongly agreed that the repetitive learning had helped them develop and improve their understanding of the subject matter. In addition, all students felt that repetitive learning made them more confident in approaching and solving engineering problems. Most students agreed that they would

use the repetitive technique in the future as they progressed to their chosen degree. For self-reflection, most students agreed that self-reflection could help them assess and plan their learning.

In addition, students were asked to include their comments on the questionnaire about how repetitive learning had impacted their learning. Figure 3 shows examples of the comments.

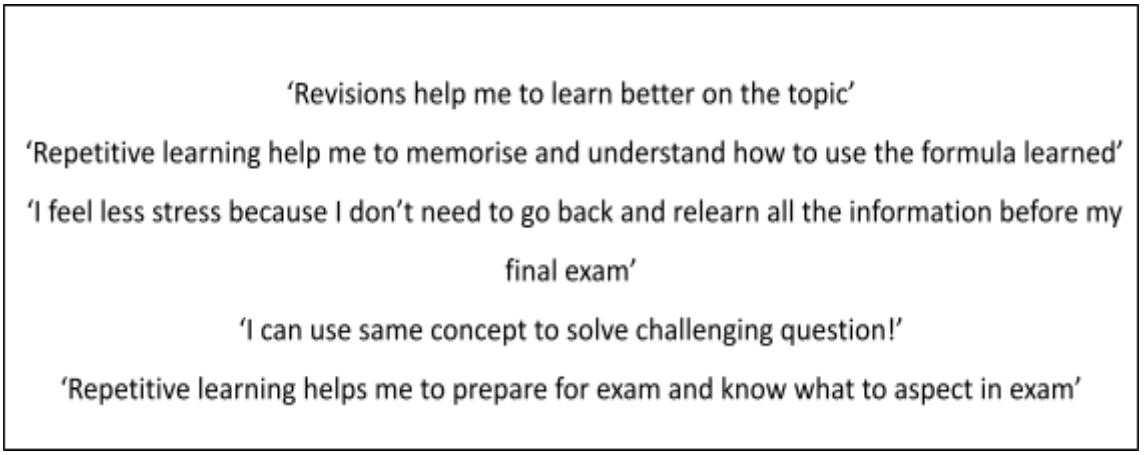


Figure 3: Student comments on repetitive learning

The feedback given by the students suggested that the combination of repetitive learning and self-reflection encouraged deeper learning throughout the duration of the module.

In addition to the feedback from students, the effectiveness of repetitive learning and self-reflection in enhancing student learning was assessed through teacher observations during class. From the observations, it was evident that these learning techniques helped students develop a deeper understanding of the subject matter. During the class, students were able to connect problems with the relevant theory and recall the appropriate equations needed to solve engineering problems. This observation aligns with the student comment: 'I can use same concept to solve challenging question!'

Furthermore, as the class progressed, it became clear that students approached engineering problems with increasing confidence and a more systematic approach, even when tackling more complex tasks. This aligns with student comments such as 'Repetitive learning helps me memorize and understand how to use the formulas learned', which suggest that students believe repetitive learning improves both their understanding and retention of the material. The comment 'I feel less stress because I don't need to go back and relearn all the information before my final exam' suggests that the techniques also contributed to reducing stress among students, as they felt well-prepared in advance of the exam week.

Furthermore, integrating self-reflection in students' activities has shown a positive impact on their learning. Through my communication with students, it became evident

that students were able to understand what they needed to learn based on the learning outcomes provided at the beginning of each session. The students used the learning outcomes as a checklist to assess their achievements through self-reflection. As a result, they were able to plan improvements in their learning activities and identify topics or areas where they needed additional help or support. For example, some students highlighted in their forms that they needed more complex questions on certain topics or extra lessons from tutors. By planning their own learning journeys, the process contributed to their development as independent learners.

Discussion

Although repetitive learning gained positive feedback from students, there is a need to structure the repetitive learning efficiently. One factor that might need to be addressed is the number of repetitions, i.e. how many are needed so the students will be able to benefit from them effectively? Each year, lecturers must manage their teaching according to the timetable given by the University. They also need to ensure that the whole syllabus is delivered to students. Such constraints on class time might hamper the effectiveness of repetitive learning. Therefore, a well-planned teaching schedule for repetitive learning is essential to ensure its positive impact. For the Mechanical Science module, I need to ensure that the repetitive learning is effectively planned into the module timetable and the teaching schedule. To make room for this, some topics will need to be removed from the current syllabus to allow sufficient time for repetitive learning activities.

The number of repetitive tasks also depends on the level of difficulty of the topic. For topics students find simple and straightforward involving basic concepts and less calculation, fewer repetitive sessions are needed to prevent ‘overlearning’ (Rohrer and Pashler, 2007). A greater number of repetitive classes can be devoted to more intense and difficult topics such as those that require knowledge across multiple concepts. This helps students to better develop deeper understanding on topics that are more challenging.

In addition, educators must understand that repetitive learning is not about repetition of teaching. It is about repeating a task or practice that involves different kinds of problems. The problem or task that students faced became more complex as the students progressed through the series of repetition. Through my observation in the class, I noted that repetitive learning helped students to recall and memorise the engineering equations, symbols and scientific terms for each topic. Students were also more confident in solving engineering problems as they progressed through the module, and were able to grasp new information and connect the concepts to previous topics. This shows that by using questioning and problem-solving practice, repetitive learning can promote students’ thinking leading to deeper learning.

For self-reflection to be used continually by students, educators must highlight the importance of self-reflection. Students need to understand the importance of changing and improving, which is not limited to their learning progress but applies to other aspects of life too (Biggs and Tang, 2011). Educators can introduce different techniques for reflection through teaching (Philip, 2006). One such technique is peer feedback, which allows students to review and evaluate their peers' approaches to engineering problem-solving. Through peer feedback, students can identify common errors or mistakes and analyse why the mistake occurred and how to prevent it (Tien, 2019). Moreover, evaluating their peers' problem-solving methods helps students broaden their perspectives on how to approach and solve engineering problems (Zeng and Ravindran, 2025).

Conclusion

Repetitive learning integrated with self-reflection techniques has been introduced in teaching on the Engineering Foundation Year at the University of Southampton. Repetitive learning has had a positive impact on students' learning. Integrating this technique with self-reflection can help to build students' engagement and develop their skills as independent learners. Although these techniques have shown a benefit to learning, some factors such as the number of repetitions and the planning of the repetition task need to be properly considered to help students achieve optimum success in their learning. Additionally, emphasising the importance of continuous improvement can encourage students to use the reflection techniques to assess and plan their learning performance. Students should feel comfortable exploring their mistakes and thinking critically about their progress.

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