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Engineering Education Challenges Addressed Through a Case Study

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ABSTRACT

CONTEXT

Engineering education must evolve rapidly to keep pace with technological advancements and meet the demands of the modern job market. Traditional teaching methods often fall short in maintaining student engagement and ensuring academic integrity. Active learning strategies, such as problem-based learning and collaborative projects enhance engagement and retention. Additionally, effective plagiarism detection and ethical training are crucial in maintaining academic integrity. Regular curriculum updates and industry collaboration are essential for aligning coursework with professional standards.

PURPOSE OF THE STUDY

This study aims to address significant challenges faced by the MEC3203 Materials Technology course at University of Southern Queensland, specifically focusing on low student engagement, academic dishonesty, and negative student feedback. The objective was to redesign the course to enhance engagement, uphold academic integrity, and align content with industry needs.

METHODOLOGY

The course redesign involved integrating industry-relevant content and real-world case studies, integrating practical applications through real-world problems and mandatory viva voce sessions, and engaging industry experts through guest lectures. Data was collected through student feedback, course evaluations, and testimonials, and analysed to assess improvements in engagement, academic integrity, and overall satisfaction.

ACHIEVED OUTCOMES

The course redesign led to significant improvements in student engagement, understanding of practical applications, and academic integrity. Students exhibited increased interest and a deeper understanding of practical applications, as evidenced by positive feedback. The mandatory viva voce sessions successfully reduced incidents of academic dishonesty and provided valuable personalised feedback. Guest lectures from industry professionals enhanced motivation and highlighted the practical relevance of coursework. These outcomes suggest that the course redesign effectively addressed the challenges and improved the overall learning experience.

SUMMARY

The MEC3203 Materials Technology course redesign demonstrates an effective approach to improving engagement, academic integrity, and industry relevance in engineering education. The positive impact of these changes underscores their potential for broader application in engineering education, suggesting that similar approaches could benefit other courses and institutions including other levels in adapting to evolving educational and industry standards.

KEYWORDS

Engineering education, student engagement, academic integrity.

Introduction

Engineering education must adapt to meet the demands of a rapidly evolving technological landscape, crucial for students' academic success and career prospects. This is essential not only for students' academic success but also for their career prospects in an increasingly complex job market. Educators face challenges in maintaining student engagement, as traditional methods often fall short. Active learning strategies, such as problem-based learning and collaborative projects, enhance engagement and material retention (Freeman et al., 2014; Prince, 2004). Froyd and Simpson (2008) further highlight the value of student-centred learning, which places students in active roles, increasing their interaction with the content and peers, thereby improving learning outcomes. In addition to enhancing student engagement, the issue of academic integrity is becoming increasingly complex in the digital age. With the proliferation of online resources and digital tools, educators face new challenges in deterring plagiarism and other forms of academic dishonesty. Carroll (2007) and McCabe et al. (2012) outline various strategies for minimising plagiarism, such as the use of plagiarism detection software and fostering a culture of integrity through honour codes and ethical training. Macfarlane et al. (2014) provide a comprehensive review of how universities address academic dishonesty, emphasising the need for ethical training as part of a broader academic integrity strategy. Davis and Harden (2001) also discuss the effectiveness of viva voce exams in assessing deeper understanding.

Curriculum redesign is a complex but necessary process to ensure that engineering education remains responsive to technological and industry advancements. Graham (2012) discusses best practices for achieving excellence in engineering education, noting that successful change requires a systematic and evidence-based approach. Jamieson and Lohmann (2009) also emphasise the importance of fostering a culture of innovation in engineering education, encouraging continuous improvement and adaptation. Aligning coursework with industry needs demands regular updates to curricula, reflecting current practices and technological advancements, often through industry collaboration (Passow & Passow, 2017). Shuman et al. (2005) emphasise the importance of integrating industry-relevant skills into engineering curricula to prepare students for the professional challenges they will face upon graduation. This alignment requires regular updates to curricula, informed by industry trends and professional feedback, ensuring that students acquire the technical and professional skills necessary for success in the workplace. Sageev and Romanowski (2001) report that recent engineering graduates often find gaps between their academic preparation and the skills demanded by employers, particularly in areas like technical communication and project management. Galloway (2007) further advocates for increased collaboration between academia and industry to ensure that engineering education remains relevant in the 21st century.

Problem-based learning (PBL), a core strategy in active learning, focuses on the application of knowledge to real-world problems, helping students develop critical thinking and problem-solving skills (Hmelo-Silver, 2004). PBL is particularly effective in engineering education, where hands-on, practical experience is crucial for understanding abstract concepts. Mills and Treagust (2003) compare PBL with project-based learning, both of which offer significant benefits in engineering by providing opportunities for students to work collaboratively and apply theoretical knowledge to complex, multidisciplinary problems.

Student feedback and course evaluations play a vital role in assessing the effectiveness of educational strategies and informing future improvements. Richardson (2005) provides a detailed review of the instruments used to obtain such feedback.

This article examines MEC3203 Materials Technology, a course for undergraduate mechanical engineering students at University of Southern Queensland (UniSQ). As per the relevant knowledge gathered from an extensive literature review, the course addresses these challenges by engaging students, upholding academic integrity, and providing industry-relevant skills. MEC3203 uses interactive simulations and real-world case studies to enhance engagement and practical understanding. Regular curriculum updates, informed by industry trends and professional feedback, align the course with current standards. Assessments test both theoretical

knowledge and practical skills, offering a holistic evaluation of student learning. By analysing the course strategies and their impact, this article aims to contribute to the broader discourse on effective engineering education practices.

Purpose of this Study

Before Semester 1, 2018, MEC3203 Materials Technology encountered significant challenges impacting course effectiveness and the students' learning experience. A major issue was low student engagement, reflected in poor attendance, minimal participation in class discussions, and reluctance to engage with materials beyond mandatory assignments. This disengagement hindered students' ability to absorb and retain course content and disrupted the overall classroom dynamic. Table 1 reflects the lack of engagement in the course survey (24% response) and dissatisfaction of the students in Semester 1, 2017.

Table 1: Course survey responses by the students in Semester 1, 2017

Frequency of Response Questions with a scale of **5**, and from the **SEC** survey	No Ans	Resp. Rate	Strongly Disagree		2		3		4		Strongly Agree	
SEC01: Overall, I was satisfied with the quality of this course.	22/87	24%	2	9.1%	2	9.1%	4	18.2%	10	45.5%	4	18.2%
SEC02: I had a clear idea of what was expected of me in this course.	21/87	24%	0	0.0%	0	0.0%	7	33.3%	8	38.1%	6	28.6%
SEC03: My learning was assisted by the way the course was structured.	21/87	24%	3	14.3%	2	9.5%	1	4.8%	8	38.1%	7	33.3%
SEC04: My learning was supported by the course resources.	21/87	24%	2	9.5%	2	9.5%	2	9.5%	7	33.3%	8	38.1%
SEC05: I found the assessment in this course reasonable.	21/87	24%	2	9.5%	5	23.8%	4	19.0%	5	23.8%	5	23.8%
SEC06: I received useful feedback in this course.	21/87	24%	2	9.5%	5	23.8%	7	33.3%	2	9.5%	5	23.8%
SEC07: The teaching team supported my learning.	21/87	24%	1	4.8%	3	14.3%	3	14.3%	8	38.1%	6	28.6%
SEC08: Overall, I was satisfied with the quality of teaching in this course.	21/87	24%	4	19.0%	1	4.8%	9	42.9%	3	14.3%	4	19.0%

Academic integrity was another critical concern, with widespread issues of plagiarism, contract cheating, and other forms of dishonesty. Many students copied assignments, collaborated inappropriately on individual tasks, hired others to complete reports, and used unauthorised resources during exams. These practices compromised the integrity of assessments and devalued the learning process.

Additionally, student feedback was predominantly negative, with low evaluation scores indicating dissatisfaction with the course content's relevance, the lack of practical applications, and inadequate instructor support. This feedback showed that the course was not meeting student expectations or providing a satisfactory educational experience. Some sample responses on student feedback in Semester 1, 2017 on necessity of future improvement of the course are extracted in Figure 1.

Q44 - What aspects of this course are most in need of improvement?
Online tutorials must go. Would be such a great course without that painful assessment.
The course.
Should have another assignment instead of electronic tutorials
The workbook could do with more worked examples.
The online tutorials where a lot of work for very little marks. personally I believe that they were good in the aspect that you where refreshing your knowledge of the information, but as they were not worth a lot of marks you struggled to do the amount of work you had to do to do well in them.
English pronunciation of teaching staff.

Figure 1: Student feedback on future course improvement in Semester 1, 2017

Purpose of this case study is to perform a comprehensive review and overhaul of the course to create a more engaging, honest, and supportive learning environment that better meets students' needs and aligns with academic standards.

Methodology

Recognising the need for substantial changes, a multi-faceted approach was adopted to address the challenges faced by the MEC3203 Materials Technology course. The methodology focused on updating course materials, integrating real-world practices, and engaging industry experts to create a more engaging and effective learning environment.

Course material update

The first step was to overhaul the outdated course content with up-to-date, industry-relevant materials. This included introducing real-world engineering failure case studies to stimulate student curiosity, enhance independent learning, and develop essential research and report-writing skills. These case studies provided concrete examples of engineering challenges, prompting students to think critically and apply theoretical concepts to practical problems.

Real-world practice integration

Several strategies were implemented to emphasise the practical application of course content. Real-world case studies were included in teaching materials and assessments, giving students hands-on experience with practical engineering problems. Mandatory viva voce sessions followed major assessments to verify the authenticity of student work, offer personalised feedback, and address individual concerns. Drawing from literature on oral examinations (Pearce & Lee, 2009), these sessions prepared students for real-world engineering scenarios and deepened their understanding of course content.

Industry expert engagement

To bridge the gap between academic learning and practical application, industry experts were invited to deliver guest lectures. These lectures provided students with valuable insights into real-world engineering practices and highlighted the practical relevance of their coursework. Professionals from the field showcased how theoretical knowledge is applied in real-world contexts, increasing student motivation and engagement.

Figure 2 demonstrates the student satisfaction through their course survey feedback comments on the best aspects of the course in Semester 1, 2018 and Semester 1, 2019. The student comments reflect the impact of positive changes in all aspects such as course material update, real-world practice integration, industry expert engagement through guest lectures and others.

By adopting this multi-faceted approach, the course saw significant improvements. The updated course materials made learning more engaging and relevant, while integrating real-world practices ensured students could apply their knowledge effectively. Engaging with industry experts enhanced student motivation and provided a clear link between academic concepts and their practical applications.

Q43 - What were the best aspects of this course?
The best aspect of the course how both assignments were based around the same area which was a diverse in nature which allowed for a thorough concept and understanding a learning of the subject
Providing some much needed development to my research skills.
I have recently been working as a undergrad mechanical engineer and have come to realise how applicable this course is to what I have been doing in regards to failure analysis and material selection.
The quizzes were enjoyable and the questions were of a high standard to assist learning. The lectures provided some good information.
Great communication from lecturer
Very interesting material. Very good broad coverage of topics.
Practice
The two assignments really allowed us to get deep into a particular topic which is a nice change and a necessary part of our education that we don't get from many other courses.
The combination of researching a topic and working on a 'real life situation' added a lot to my learning. It also helped me to develop research and evaluation skills.
The flexibility of the assessment. It allowed us to choose alternative topics if we were interested in a literature review on our final year projects. That kind of flexibility is always welcome in courses.
The assignment topic was quite intriguing and genuinely interesting.
The assessments encompassed alot of minor details which led to a broader way of thinking.
The freedom to research on desired topics.
I was impressed with the continuity between assessment items. Due to my subject selection for assignment 1, all assessment pieces were centred around this topic, allowing me to develop my understanding of that area of engineering.
The guest lecture was excellent. Also, narrowing down the possible number of exam questions was very good.
Easy to access materials and learn at own time.
I learnt how we read things and summarize that , and about literature review.
The way the whole course and assignments flow in to one another.
The assignments
The technical aspects of failure was useful to learn and to have access to the ASM Handbooks was also helpful.
The practical and relevant last assignment which was related to a real world issue and how the course directly related to solving the issue.
teacher was cool
Understanding what is required during each assessment task
Exam prep really allowed me to research into the materials that i had to ignore throughout the semester to focus on the massive assignments
Teaching & Assessments
Gaining experience in writing large(ish) reports.
Assignment content was great.

Figure 2: Student feedback by various cohorts on the course best aspects in Semester 1, 2018-2019

Achieved Outcomes

The implementation of these initiatives yielded significant positive outcomes for the MEC3203 Materials Technology course, greatly enhancing the overall student experience.

Student engagement

Student engagement saw a marked improvement, with feedback indicating heightened interest in the subject and a deeper understanding of practical engineering applications. The updated course content and incorporation of real-world case studies made the material more relevant and interesting, significantly enhancing critical thinking and problem-solving skills (Trevelyan, 2019).

Academic integrity

The introduction of mandatory viva voce sessions ensured the originality of student submissions by providing a robust mechanism for verifying the authenticity of their work. These sessions also offered valuable opportunities for one-on-one interaction between students and instructors, fostering a more supportive and responsive learning environment.

Course evaluations

Course evaluations showed a consistent increase in student satisfaction as shown in Figure 3. Students praised the updated and relevant content, interactive course elements, and guest lectures as evident in Figure 2. Guest lectures by industry professionals were particularly beneficial, demonstrating the relationship between theoretical knowledge and its practical application in the industry.

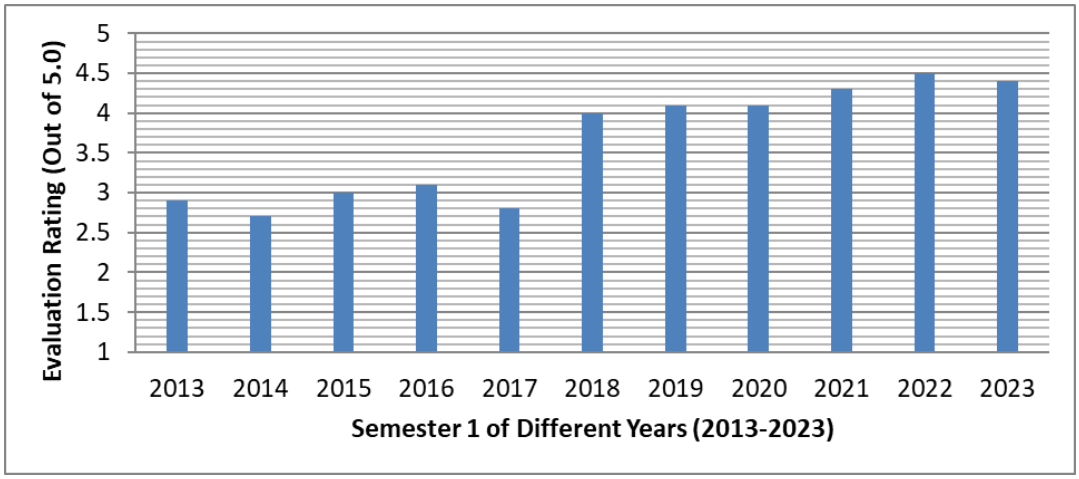

Figure 3: Course evaluation rating in last few years before and after Semester 1, 2018

Voluntary student testimonials underscored the positive impact of these changes. Students emphasised the value of personalised feedback during viva voce sessions and appreciated the integration of real-world problems into the curriculum. These testimonials highlighted how the course's new structure and content significantly enhanced their learning experience, making it more relevant, engaging, and practical.

Table 2 summarises the outcomes achieved from the interventions and objectives set in the MEC3203 Materials Technology course.

Table 2: Achieved outcomes from set interventions and objectives

Intervention	Objective	Outcome
Updating Course Materials	Enhancing relevance and applicability	Increased student interest and understanding
Integrating Real-World Practices	Providing practical experience	Improved critical thinking and problem-solving skills
Engaging Industry Experts	Bridging gap between theory and practice	Higher student motivation and engagement
Implementing Viva Voce Sessions	Ensuring academic integrity and personalised feedback	Decreased incidents of academic dishonesty and supportive learning environment

Contribution to Learning and Teaching Goals

The initiatives in the MEC3203 Materials Technology course significantly contribute to the University's broader learning and teaching priorities. The primary goals of promoting active learning and maintaining academic integrity have been effectively addressed through these strategic interventions. By incorporating real-world engineering failure case studies and practical applications into the curriculum, the learning experience has shifted from passive reception to active engagement. Mandatory viva voce sessions have strengthened academic integrity by ensuring the authenticity of student work and fostering a culture of honesty and ethical behavior.

Another key contribution is the enhancement of industry engagement and the development of employability skills. Regular involvement of industry professionals through guest lectures and advisory committee inputs provides students with direct exposure to current industry practices and trends. This enriches the learning experience and equips students with highly valued skills and knowledge in the job market.

These initiatives have also led to higher student satisfaction and retention rates. Regularly updating course materials, including interactive elements, and consistently providing personalised feedback have significantly enhanced student satisfaction.

Conclusion

The overhaul of the MEC3203 Materials Technology course showcases an effective strategy for tackling the diverse challenges in engineering education. By updating course content, incorporating real-world practices, and involving industry experts, the course has markedly enhanced student engagement, academic integrity, and overall satisfaction. Student evaluation rating has significantly increased from around 3.0 to above 4.0 out of 5.0. The use of interactive simulations, real-world case studies, and mandatory viva voce sessions has made learning more dynamic and relevant, while promoting a culture of honesty and ethical behavior. Institutionalising these innovative practices ensures that the course stays aligned with industry standards and adapts to students' changing needs. The success of these initiatives highlights their broader potential to improve engineering education and better prepare students for successful careers in a competitive global market.

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