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BRIDGING CALCULUS AND ENGINEERING PRACTICE: AN INSTRUCTIONAL VIDEO SERIES BY UiTM CAWANGAN PULAU PINANG EDUCATORS

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ABSTRACT

Calculus is a core subject in engineering education, yet many students find it abstract and struggle to connect its concepts with practical engineering applications. This perceived disconnect often leads to low engagement, surface-level understanding, and difficulty in applying mathematical knowledge in real-world engineering contexts. To address this issue, we have developed Bridging Calculus and Engineering Practice, an instructional video series designed to contextualize fundamental calculus concepts through practical engineering applications. The series consists of three short episodes, each highlighting a specific calculus topic and its relevance in engineering, such as rate of change in thermodynamics, definite integrals in salt mixing in Continuous Stirred Tank Reactor (CSTR), and optimization in engineering design. Each video combines clear conceptual explanations, real-world scenarios, and animated visuals using digital tools such as Canva. This approach enhances student engagement, supports independent learning, and promotes deeper understanding by making learning more relevant and application focused. This initiative aligns with the SUSED2025 theme of Transforming Education, Driving Innovation, and Advancing Lifelong Learning for an Empowered World by leveraging digital media to enhance mathematics education and empower engineering students with meaningful, lifelong learning experiences.

Keywords: *Calculus in engineering, Instructional video, Real-world application, Lifelong learning, UiTMCPP*

INTRODUCTION

Engineering students often face challenges when learning calculus due to the abstract nature of mathematical concepts presented without context. Although calculus is foundational in solving real-world engineering problems, many students struggle to connect classroom theory with practical applications (Grizzle, 2025). Traditional teaching methods often lack the visual and applied elements needed to address diverse learning preferences, especially among engineering students (Fiorella, 2022; Rahman, Sook Ling, & Yin, 2024).

To address this pedagogical gap, we developed the *Bridging Calculus and Engineering Practice* video series. This initiative is grounded in the belief that instructional videos incorporating engineering-based applications, animated explanations, and digital storytelling can promote better conceptual clarity and foster active, independent learning (Pinter & Siddiqui, 2024). The series aims to enhance student engagement and support lifelong learning by bridging mathematical concepts with real-world engineering practice.

METHODS

The project involved the design, production, and pilot testing of a three-part instructional video series, each focusing on a calculus concept linked to practical engineering challenges:

Episode 1: Understanding Rate of Change in Thermodynamics – applying derivatives to analyze temperature changes in thermal systems.

Episode 2: Definite Integrals in Salt Mixing in a Continuous Stirred Tank Reactor (CSTR) – using integration to determine the amount (or mass) of salt in the tank over time.

Episode 3: Optimization in Engineering Design – solving real-world design problems using maxima and minima principles.

Topics were selected based on core calculus applications frequently encountered mostly in mechanical, electrical, and civil engineering (Bilbao et al., 2025). Visual content and animations were created using Canva, designed to simplify complex concepts and maintain attention through multimedia learning techniques (Fiorella, 2022).

The development was informed by Mayer's cognitive theory of multimedia learning, which emphasizes reducing extraneous load and fostering meaningful connections (Yendra et al., 2024). Each video followed a microlearning structure—short, focused content pieces—to optimize attention span and reinforce concept retention (Rahman et al., 2024). The Engineering faculty peer-reviewed the materials to ensure accuracy and relevance to current courses.

RESULTS AND DISCUSSION

The *Bridging Calculus and Engineering Practice* initiative successfully produced a three-part instructional video series aimed at contextualizing key calculus concepts for engineering students. Each episode was structured using microlearning principles, designed to be concise, visually engaging, and focused on real-world applications. Table 1 outlines the focus and structure of each episode:

Table 1.: Overview of instructional video episodes and learning objectives

Episode	Calculus Concept	Engineering Application	Learning Objective
1	Rate of Change (Derivatives)	Thermodynamics – Temperature change in heating/cooling	Understand and apply derivatives to analyse temperature variation
2	Definite Integrals	Salt Mixing in CSTR – Accumulation of salt over time	Use integration to compute total salt content in a tank system
3	Optimization (Maxima/Minima)	Engineering Design – Minimize material usage in container	Solve design problems using critical points and optimization principles

Each video was created using Canva and included narration, animations, and visual cues to reinforce key points. Engineering educators at UiTM reviewed the content to ensure its technical accuracy and pedagogical clarity.

The design of the videos aligns with Mayer's (2005) Cognitive Theory of Multimedia Learning, which emphasizes dual-channel processing, reduced cognitive load, and the importance of integrating verbal and visual explanations. The microlearning structure—featuring short, focused episodes—caters to modern learners' attention spans and supports incremental concept building. Furthermore, the instructional design draws on constructivist learning theory, promoting meaningful connections between abstract calculus concepts and the engineering challenges students will face in their fields. This relevance is particularly vital in applied disciplines like mechanical, civil, and chemical engineering, where mathematical modeling plays a central role. The inclusion of practical examples also supports situated cognition, helping students better understand not just the "how" of mathematics, but the "why" behind its use in engineering contexts.

Although a formal pilot test could not be conducted within the project timeframe, anticipated outcomes were projected based on indicators from similar interventions reported in the literature. Table 2 shows the projected educational outcomes based on prior evidence. The expectation that 85 % of students would report increased engagement aligns with meta-analytic evidence showing strong positive effects of video-based instruction in STEM and mathematics (Magallanes & Dio, 2024). Similarly, the projected 70 % increase in concept mastery aligns with observed learning gains associated with active cognitive engagement during video watching (Lee et al., 2024). These results suggest strong potential for effectiveness, especially in improving student motivation and contextual understanding—two major hurdles in traditional calculus instruction.

Table 2.: Projected educational outcomes based on prior evidence

Indicator	Expected Outcome	Basis
Student Engagement	85% report increased interest in calculus	Based on similar studies using video-based instruction
Conceptual Understanding	70% score improvement in post-video quiz	Simulated from formative assessment models
Perceived Relevance	90% find examples helpful and industry-linked	Feedback from peer reviews and prior surveys
Instructional Clarity	4.5/5 average rating in peer review	Based on internal faculty evaluation

These anticipated outcomes, while theoretical, highlight the promising impact of contextualized, multimedia-rich learning materials in enhancing calculus instruction for engineering students. The combination of visual learning strategies and real-world relevance positions the video series as a scalable model for STEM education innovation. However, it is important to note that without empirical data from actual users, these outcomes remain hypothetical. A pilot study will be necessary to validate these projections and assess actual student learning outcomes.

Future Work and Implications

Moving forward, the project will focus on conducting formal pilot testing with engineering students to evaluate the effectiveness of the video series in enhancing conceptual understanding, engagement, and knowledge transfer. Formative assessments, such as embedded quizzes and reflective prompts, will be integrated to support active learning and provide measurable outcomes. Expanding the series to cover additional calculus topics—such as differential equations, numerical methods, and multivariable calculus—will further support curriculum alignment and broader learning objectives. Collaborations with other institutions are also envisioned to scale the initiative nationally, promoting innovation in mathematics education. This effort underscores the transformative potential of digital media in fostering application-oriented, lifelong learning in line with the SUSED2025 agenda.

CONCLUSION

The Bridging Calculus and Engineering Practice video series demonstrates the potential of digital media to transform the teaching and learning of mathematics in engineering education. By embedding calculus in real-world engineering scenarios, students not only gain a better grasp of concepts but also develop the ability to transfer knowledge to practical applications. This approach supports the goals of SUSED2025 by advancing innovative, lifelong learning through accessible and engaging digital content. Future directions include expanding the series to cover additional topics, integrating quizzes for formative assessment, and wider dissemination across Malaysian higher education institutions.

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REFERENCES

Bilbao, J., Bravo, E., Chen, Y., & Kim, S. (2025). Introducing computational thinking in calculus for engineering. *International Journal on Technical and Physical Problems of Engineering, 16*(1), 239–246. . https://arxiv.org/abs/2502.10400

Fiorella, L. (2022). Multimedia learning with instructional video. In R. E. Mayer & L. Fiorella (Eds.), The Cambridge Handbook of Multimedia Learning (3rd ed.). Cambridge University Press.

Grizzle, J. (2025, January 5). *Calculus for the modern engineer: Putting the joy back in learning advanced mathematics* (Version 1). arXiv. https://doi.org/10.48550/arXiv.2501.10406

Lee, H., Kim, J., & Park, Y. (2024). Revisiting instructional videos: Active cognitive engagement as a predictor of achievement in STEM learning. *Computers & Education*, 213, 105003. https://doi.org/10.1016/j.compedu.2024.105003

Magallanes, R. S., & Dio, R. V. (2024). Meta-analysis on the effects of video-based instruction on students' academic performance in science and mathematics. *International Journal on Social and Education Sciences (IJONSES)*, *6*(2), 383–397. https://doi.org/10.46328/ijonses.1897

Pinter, L., & Siddiqui, M. F. H. (2024). Enhancing calculus learning through interactive VR and AR technologies: A study on immersive educational tools. *Multimodal Technologies and Interaction*, *8*(3), 19. https://doi.org/10.3390/mti8030019

Rahman MA, Sook Ling L and Yin OS. Interactive Learning System for Learning Calculus [version 2; peer review: 1 approved, 2 approved with reservations]. *F1000Research* 2024, 11:307 (https://doi.org/10.12688/f1000research.73595.2)

Yendra, N. Y., Harahap, R., Nugroho, R. A., & Dewi, N. R. (2024). Mobile multimedia based-microlearning and assessment on calculus to improve student mathematical understanding. *Journal of Education Technology*, *8*(4), 595–602.