ENHANCING TECHNICIANS' KNOWLEDGE OF CDIO THROUGH GENERATIVE AI

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ABSTRACT

In the CDIO ecosystem at Singapore Polytechnic, technicians serve as a critical bridge between academic instruction and hands-on student learning, embodying an essential but often under-recognized role in education. While technicians play a pivotal role in delivering and supporting learning, many view themselves as lacking expertise in teaching and learning compared to lecturers, resulting in a diminished sense of professional identity. To address this gap, we propose a novel approach to professional development tailored for technicians: a personalized, on-demand chatbot that supports continuous, situated learning aligned with their daily responsibilities. The chatbot was developed based on the "5 Moments of Need" theoretical framework, a model that posits five essential moments when learning is most impactful. This framework allows the chatbot to serve as a just-in-time learning resource that technicians can access anywhere and anytime. By leveraging this model, the chatbot is designed to deliver targeted content, formative assessments, and personalized feedback. To test the effectiveness of this approach, a prototype chatbot was introduced to a select group of technicians, providing them with on-demand, personalized learning experiences tailored to their specific needs within the CDIO framework. Initial feedback and usage data indicate that this chatbot has the potential to significantly increase engagement, bolster technicians' confidence in their instructional roles, and accelerate the acquisition of relevant skills. This paper will discuss the potential improvements for enhancing the chatbot's capabilities. The broader implications of this personalized learning tool for the global CDIO community are substantial, offering a scalable, sustainable, and flexible solution that allows technicians to upskill efficiently within their professional environment.

KEYWORDS

Artificial Intelligence, Professional Development, Chatbot, Standards 9, 10

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INTRODUCTION & BACKGROUND

Technicians play an increasingly vital role in the CDIO (Conceive-Design-Implement-Operate) ecosystem of engineering education, particularly in institutions like Singapore Polytechnic. Traditionally regarded as support staff, technicians have seen their responsibilities expand to include aspects of teaching and learning, such as mentoring students in CDIO projects, creating asynchronous instructional content, and assisting in lab-based learning. Despite their growing involvement in instructional practices, many technicians express a lack of confidence in their teaching competence and pedagogical knowledge. This is compounded by their perception of being less qualified than academic staff, which may reduce their willingness to engage in formal professional development focused on education.

Existing professional development (PD) programmes often fall short of meeting technicians' needs. These programmes tend to follow a "just-in-case" model, delivering broad content that is not always directly relevant or immediately applicable to technicians' daily tasks. Furthermore, traditional PD formats like workshops and seminars may not fit well into technicians' work routines, contributing to low engagement and uptake. Literature also suggests that non-academic staff often feel disconnected from pedagogical training designed primarily for academic professionals, further diminishing their motivation to participate.

To address these challenges, this study explores the use of a personalised AI-powered chatbot as an alternative approach to professional development for technicians. Built upon the "5 Moments of Need" framework (Mosher & Gottfredson, 2011), the chatbot offers just-in-time, contextualised learning that technicians can access at their convenience. It provides personalised feedback, formative assessments, and guidance based on a defined body of knowledge aligned with CDIO principles.

By leveraging generative AI, the chatbot facilitates micro-learning and enables technicians to self-direct their learning at a pace and depth suited to their needs. As such, the chatbot not only improves access to professional development but also aligns with the evolving role of technicians in modern engineering education.

This study is guided by the following research questions:

1. How do technicians perceive the chatbot in supporting their professional development needs related to CDIO (Perceived Usefulness)?
2. How easy is the chatbot to use for learning CDIO concepts (Perceived Ease of Use)?
3. What is the level of intention among technicians to continue using the chatbot (Intention to Use)?

LITERATURE REVIEW

Technicians play an essential role in educational settings, bridging the gap between theoretical knowledge and practical application. However, traditional professional development (PD) programs often fail to meet their unique needs. One major limitation lies in the "just-in-case" approach commonly found in PD, where training is delivered as generalized content rather than tailored to the specific, immediate needs of technicians. This approach can lead to disengagement, as technicians often perceive the training content as irrelevant to their practical roles, which require context-specific learning that supports daily tasks (Mosher & Gottfredson, 2011).

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Research highlights additional issues, such as a lack of flexible scheduling in traditional PD, which often relies on scheduled workshops and seminars that may not align with technicians' work responsibilities. Inflexible delivery methods hinder participation and limit the immediate applicability of learned skills (ASAECenter.org, 2017). With rapid technological advancements impacting various fields, technicians frequently require timely training updates that traditional PD formats cannot provide quickly enough (Techademy, 2023). Additionally, technicians, who do not view themselves as equals to academic staff, may hesitate to engage fully in PD activities focused on pedagogy, resulting in limited skill development and low confidence in instructional tasks (Graham & Regan, 2016). This reluctance underscores the need for a new PD approach that fosters engagement and supports the evolving instructional roles of technicians.

An emerging body of literature suggests that technology-enabled solutions could address these limitations, with many experts advocating for "just-in-time" PD as a more effective alternative to the traditional "just-in-case" approach. Just-in-time learning aligns closely with the immediate, context-driven needs of technicians by providing tailored, accessible content that can be applied directly to tasks at hand (Gottfredson & Mosher, 2011). Additionally, technology-based PD tools, particularly personalized chatbots, have shown promise in creating adaptive learning experiences that address individual user needs and knowledge gaps in real time (Khan et al., 2019). These chatbots provide an innovative way to support technicians through interactive, flexible PD that eliminates the time and location constraints of traditional training.

Chatbots can serve as valuable tools for delivering personalized learning aligned with the "5 Moments of Need" framework, which identifies five critical instances when learning support is most beneficial: learning something new, expanding upon existing knowledge, applying or remembering information, solving problems, and adapting to changes (Mosher & Gottfredson, 2011). By offering two-way interactions that adapt to users' learning progress, chatbots facilitate just-in-time learning that supports technicians precisely when they need it. Chatbots can also provide immediate feedback, answer queries, and guide users through customized learning pathways, allowing them to learn at their own pace and according to their specific needs. This capability is particularly relevant to technicians, whose PD needs vary widely based on their roles and responsibilities.

Moreover, chatbots can create a supportive, non-judgmental learning environment that encourages technicians to explore instructional concepts without fear of being compared to academic staff. Research shows that personalized chatbots help reduce anxiety around learning by tailoring content to users' existing knowledge and presenting it in an approachable way (Fryer & Bovee, 2016). This personalized feedback mechanism allows chatbots to monitor learning progress, offer targeted exercises, and suggest relevant resources that align with each user's learning journey (Lemoine & Richardson, 2019). The combination of on-demand, personalized learning and just-in-time accessibility positions chatbots as an effective tool for delivering PD that meets technicians' unique needs.

In summary, the integration of the "5 Moments of Need" framework with personalized chatbot technology offers a transformative solution to the limitations of traditional PD for technicians. By delivering context-specific, adaptive learning experiences, chatbots address technicians' immediate needs while supporting their continuous development in both technical and instructional competencies. This innovative approach aligns with current educational trends emphasizing flexibility, accessibility, and learner-centered PD, marking a significant shift toward more effective professional growth for technicians.

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Using Chatbots to Meet the Unique Needs of Technicians

In response to the professional development needs of technicians within the CDIO framework, this paper presents a personalized chatbot solution designed to deliver on-demand, context-specific learning aligned with the "5 Moments of Need" model. Built on OpenAI's GPT-4 language model. This model was chosen for its advanced natural language processing capabilities and ability to generate contextually appropriate responses from acurated database of CDIO-aligned resources. The following sections outline the key functionalities of this chatbot, its alignment with the 5 Moments of Need, and how it directly supports technicians' unique requirements for professional growth. Please refer to Figure 2 below for the interface.
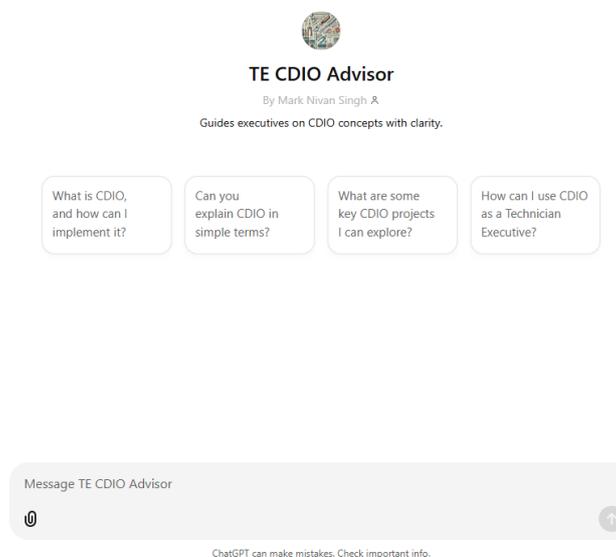

TE CDIO Advisor
By Mark Nivan Singh
Guides executives on CDIO concepts with clarity.

| What is CDIO, and how can I implement it? | Can you explain CDIO in simple terms? | What are some key CDIO projects I can explore? | How can I use CDIO as a Technician Executive? |

Message TE CDIO Advisor

ChatGPT can make mistakes. Check important info.

Figure 1. Chatbot Interface

CHATBOT DESIGN & KEY FUNCTIONALITIES

Flexible Access to Learning Resources

The chatbot is available at any time through a simple link, enabling technicians to access learning support without waiting for formalized professional development sessions. This feature promotes continuous, self-directed learning, which is particularly advantageous for technicians with varied schedules and immediate learning needs (Kumar, S., & Shah, A., 2021).

Prompt-Driven Interactivity

The chatbot is highly responsive to technician prompts, adapting its responses based on the specific learning intentions expressed by the user. For instance, technicians may choose to test their knowledge by prompting the chatbot to create multiple-choice questions (MCQs). Upon completing the questions, technicians receive personalized feedback based on their answers. If needed, the chatbot will offer additional formative assessments or learning resources until the technician decides to conclude the session. Research shows that micro-

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learning strategies, like these brief and targeted assessments, can significantly improve retention and reinforce learning by promoting frequent engagement with new concepts (Li, M., & Tsai, P., 2020).
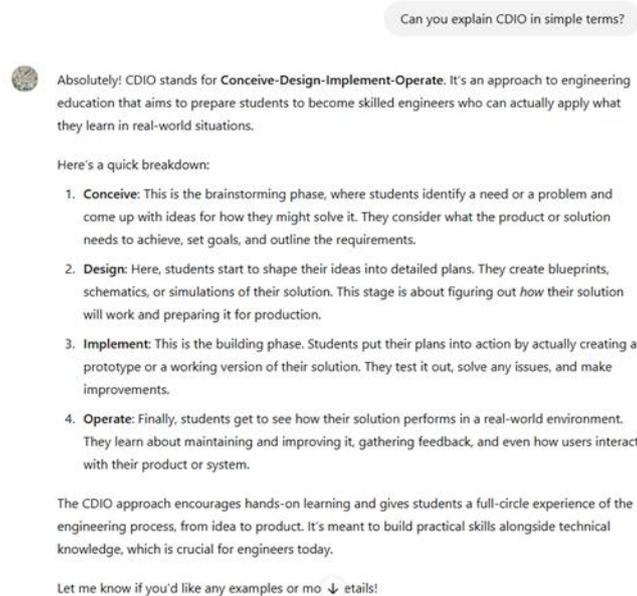

Figure 2. Prompt-Driven Interactivity

Content Integrity and Approved Knowledge

The chatbot's responses are drawn exclusively from an established body of knowledge, ensuring that technicians receive only vetted and relevant content. This design limits the risk of misinformation and aligns with institutional knowledge standards, allowing technicians to build confidence in the accuracy of the information they receive (Smith, J., 2018).
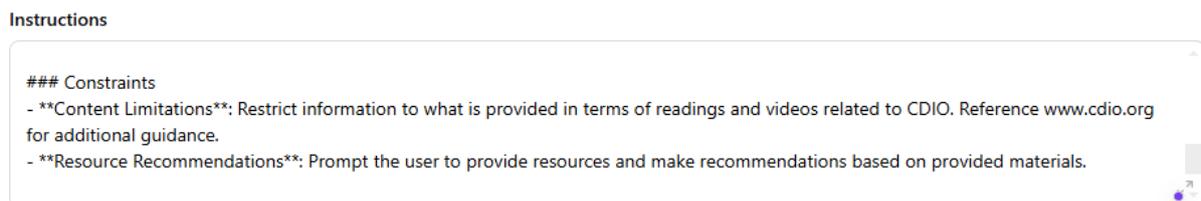

Figure 3. Boundaries provided to the Chatbot to maintain content integrity

Meeting Technicians' Specific Needs

The chatbot's design and functionality are well-suited to meet the specific professional development needs of technicians, as detailed below:

Flexible and Accessible Learning

The chatbot's anytime-access nature ensures that technicians can learn at their convenience, supporting ongoing development without disrupting their core responsibilities (Brown, 2019).

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Personalized Feedback and Adaptive Learning Pathways

Through personalized responses and tailored assessments, the chatbot adapts to each technician's knowledge level, providing customized feedback and suggesting additional resources as needed. This individualized support can help technicians feel more confident and engaged with the learning material (Fryer, L., & Bovee, H., 2016). Figure 5 below shows the ability of the chatbot to provide short formative assessments to test the learning of technicians to ensure that they are learning effectively as well as provide use cases to reinforce learning

Scenario: How a Technician Can Enhance Student Learning in the "Conceive" Phase

Let's say your students are tasked with creating a more energy-efficient air conditioning system. As a technician, you can enhance their experience in several ways:

1. **Provide Background Information and Resources:** Share relevant technical manuals, past project data, or industry reports. For instance, you might explain how different refrigerants impact energy efficiency, helping students understand the constraints and trade-offs.

2. **Encourage Hands-On Exploration:** If possible, arrange for students to examine real-world systems or components (like a dismantled compressor or circuit board) to inspire ideas. Seeing actual parts can help them envision practical solutions and inspire questions about design needs.

3. **Guide Brainstorming Sessions:** Facilitate a brainstorming session where students can share ideas without criticism. You might use a whiteboard to map out different concepts and show them how experienced technicians might think through each possibility, considering both feasibility and creativity.

4. **Introduce Practical Constraints Early:** Share your experience with real-world limitations (like budget or materials). For instance, discuss how a more efficient but expensive material might not be feasible for all users, which could lead students to rethink their design with cost-effectiveness in mind.

Figure 4. Formative Assessment to Check for Learning

In summary, the chatbot's functionalities address the immediate, context-specific learning needs of technicians by aligning with the "5 Moments of Need" framework. By enabling real-time, interactive, and accurate learning experiences, the chatbot represents a significant advancement in professional development approaches for technicians, making PD both accessible and relevant to their evolving roles.

TESTING APPROACH & STATISTICAL ANALYSIS

This study adopted a quantitative approach to evaluate the chatbot's effectiveness based on the Technology Acceptance Model (TAM) constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and Intention to Use (ITU). A validated TAM-based questionnaire (Davis, 1989; Venkatesh & Davis, 2000) was administered to 35 technicians following their interaction with the chatbot.

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Given the exploratory nature of this study and the relatively small sample size, the analysis employed descriptive statistics rather than inferential testing. The rationale for using descriptive statistics is to provide an initial overview of participants' experiences and perceptions. This approach is common in early-phase educational technology evaluations where the aim is to understand user reception before scaling up to broader implementations (Nouri, 2018).

A total of 35 technicians from the School of Electrical and Electronic Engineering and the School of Mechanical and Aeronautical Engineering took part in the questionnaire. Please refer to Annex A for the questionnaire.

Key statistical measures reported include mean, median, and standard deviation for each TAM construct. The analysis focused on highlighting general trends in user responses, which inform future iterations of the chatbot and potential avenues for expanded research.

It is also worth considering that one factor contributing to the variance in user responses—particularly in Perceived Ease of Use—may be differences in English language proficiency among technicians. As the chatbot currently operates exclusively in English, technicians with lower fluency might face challenges in interpreting or constructing effective prompts. This aligns with findings from Lin and Warschauer (2015), who observed that language proficiency significantly impacts learners' interactions with digital tools in educational contexts.

To support ongoing refinement, technicians provided feedback on areas where the chatbot experience could be improved. Suggestions included the provision of sample prompts to help users get started, expansion of the knowledge base to minimise incomplete responses, and inclusion of a simple dashboard to track learning progress. There were also calls to address institutional ethical compliance and to enhance the chatbot's tone to simulate more human-like interaction. While these suggestions were touched upon in earlier sections, their consolidation here serves to highlight key priorities for future development.

Beyond improvements to the chatbot itself, it is also important to consider the broader educational impact of this intervention. As technicians become more confident and competent in applying CDIO principles, the quality of student learning experiences can improve. For example, better-prepared technicians may facilitate more effective lab demonstrations, provide more insightful mentorship during project-based learning, and offer timely, accurate feedback aligned with CDIO goals. This strengthens the link between theory and practice, ultimately enhancing the outcomes of engineering education for students.

One specific limitation raised by participants relates to the perceived tone of the chatbot. While functionally accurate, the chatbot responses were occasionally viewed as too formal or impersonal, lacking the warmth of human interaction. This is a known limitation of current AI-driven dialogue systems, which, despite natural language capabilities, often struggle to convey empathy or adapt tone effectively to diverse user expectations (Følstad & Brandtzæg, 2017). Future iterations could explore integrating sentiment-aware language models or hybrid AI-human support systems to mitigate this.

RESULTS & DISCUSSION

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Limitations of the Technology Acceptance Model

Although the TAM has been validated in many studies, the actual usage of the technology, as opposed to the behavioural intention to use, is rarely monitored. Furthermore, this may lead to a mistaken belief in the acceptability of a technology. For example, a study conducted by Keung et al. found that the TAM predicted that a particular technology was likely to be adopted within the company in question. However, a year later the authors found that the technology was not being used. The TAM was re-applied at the later time and the results from this study were different from the initial TAM assessment. Therefore, there is a question as to whether the TAM can act as an accurate predictor of actual usage rather than behavioural intention to use. The suggestion here then, would be to re-administer the TAM again after a year of implementation.

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CONCLUSION

The personalised chatbot developed for this study demonstrates promise as an innovative and accessible form of professional development for technicians operating within CDIO environments. By offering on-demand learning grounded in the 5 Moments of Need framework, the chatbot addresses many limitations of traditional PD formats while encouraging technician-led, micro-learning experiences. User feedback indicates high levels of perceived usefulness, ease of use, and intention to continue using the chatbot in daily work.

Notably, this study also highlights areas for improvement, such as enhancing tone, expanding the knowledge base, and ensuring inclusivity for varying levels of English proficiency. The findings point to a broader impact: as technicians gain confidence in their CDIO understanding, students benefit from more effective lab supervision, timely mentorship, and stronger integration of theory with practice.

Future work will involve refining the chatbot based on technician input, exploring integration with institutional systems, and extending its application to other professional development domains.

ACKNOWLEDGEMENTS

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