STEM education, environment, and industries – Toward achieving the Sustainable Development Goal through a knowledge transfer programme

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Abstract. STEM education is important for protecting the environment. However, efforts to educate industries on environmental protection should be made to ensure sustainable practices within those industries. This study aims to report on efforts made to educate an industry on environmental protection using the case of wastewater treatment technology through a knowledge transfer programme (KTP) by a university. The KTP was conducted to expose industrial players, who were the research participants, to the issue of protecting the environment through the introduction of new technology in treating industrial wastewater. The main content included sharing knowledge on current bio-based technology and how the industry may be able to adopt the new technology for environmental protection. The participants were also exposed to a national study on the need for new technology in wastewater treatment. After the programme, they assessed the programme's effectiveness and the outcomes. The key finding is that the KTP has increased the participants' knowledge and awareness of the importance of adopting new technology in wastewater treatment as a means for achieving sustainable cities and communities. This effort is critical to ensuring the success of translating the Sustainable Development Goals (SDGs) among industries.

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1 Sustainable Development Goals and STEM education

Sustainable Development Goals (SDGs) have become the world's agenda for creating a sustainable world by 2030. The SDGs encompass 17 goals, two of which are to create sustainable industry, innovation, and infrastructure (#9) and sustainable cities and communities (#11) [1]. Achieving the SDGs is essential to ensure that the environment, cities, and communities are protected and preserved from any kind of pollution potentially produced by industries. Yet, industries have been reported to face challenges in ensuring environmental protection, particularly because they need to generate profits while minimising costs [2].

1.1 Industries and environmental protection

Industries have a responsibility to protect the environment, including cities and communities [3]. As parties involved in treating substances, including waste produced by other industries, they need to ensure that the waste from the treatment process can be safely released into the environment.

One party capable of providing recent technologies is universities because they possess expertise in creating new technologies through their research [4, 5]. Thus, universities can assist industries in treating waste using up-to-date technologies. A knowledge transfer programme (KTP) can be conducted by universities for industries to achieve this purpose [6].

1.2 Knowledge transfer programme and STEM education

Science, technology, engineering, and mathematics (STEM) education is crucial for the creation of a sustainable world [7]. STEM education should be provided to all parties, including industries. Many STEM education efforts are typically undertaken either in schools or universities [8, 9]. However, there have not been many STEM education programmes focusing on environmental protection specifically designed for industries. Therefore, industries should be exposed to STEM education oriented toward environmental protection because they are the parties that potentially produce waste from manufacturing processes in factories.

Yet, the form of STEM education delivered to industries should be customised and not delivered in the same manner as in educational institutions. Industries comprise of knowledgeable and skilled workers who likely have vast experience in dealing with day-to-day tasks related to wastewater treatment. Thus, the approach must be made appropriate for them.

The educational programme that can be developed for industries is a knowledge transfer programme (KTP). KTP is an appropriate platform to deliver STEM education for industries because many universities use KTP to share expertise with industries (and relevant parties) [10]. This type of KTP should be oriented toward environmental protection to achieve the SDGs.

2 Methodology and Programme

In this research project, a team of three universities, namely Universiti Teknologi Malaysia (UTM), Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), and Universiti Tun Huseein Onn Malaysia collaborated in conducting a knowledge transfer programme (KTP) in the state of Negeri Sembilan, Malaysia. The KTP was conducted in June 2023 and lasted for one day. It targeted an industry responsible for managing waste from other industries or parties, with a primary focus on wastewater treatment. The industry was chosen as the

programme and research participant due to its significance in the field. A total of 13 workers participated in the KTP, representing various divisions including operation, training, and management.

The knowledge transfer programme (KTP) was primarily focused on promoting the use of new technology in wastewater treatment. However, the primary goal of the effort was to protect the environment. This is because the technology developed by the research team is oriented toward providing a better tool to treat wastewater using bio-based substances.

When conducting the KTP, the research team exposed the participants to the importance of environmental protection. The key point was to increase the awareness of the participants regarding the significance of ensuring a safe and sustainable environment for cities and communities.

Then the participants were introduced to the new technology developed by the research team for treating wastewater. This new technology utilised bio-based substances that are relatively easy to access and supply. The primary objective of this segment was to promote the adoption of the new technology among industrial players. Hands-on activities were also organised for the participants to demonstrate the functionality of the new technology. Demonstrations were conducted to cultivate the interest of the participants.

Afterwards, the participants were exposed to a national-level study on the need for new technology in wastewater treatment. The outcomes of the study were shared with the participants to enhance their understanding of the current perspectives of various stakeholders regarding these needs.

Finally, the participants were given an evaluation form to assess the effectiveness of the programme and its outcomes. The digital form was distributed to them after all major content was delivered. The evaluation was in Malay language, as many of the participants could understand the national language. The evaluation form consisted of a Likert scale (1-5) that queried participants about their perceptions regarding the potential increase in their awareness, knowledge and skills concerning wastewater treatment and its technologies. Additionally, participants were asked for their opinions, through an open-ended question, regarding improvements for the KTP. Data were primarily analysed using descriptive analysis, with thematic analysis employed to analyse the responses to the open-ended question.

3 Findings and discussion

The first finding indicates that over 80% of the research participants reported an increase in their knowledge of bio-based wastewater treatment technology after completing the knowledge transfer programme (KTP). They predominantly selected a scale 4 or 5 for the item assessing knowledge increment.

The finding suggests that a significant majority of the participants may have gained crucial knowledge for implementing new, environmentally sustainable technology in wastewater treatment. Figure 1 displays the result for the first finding. The item is translated as “I feel that my knowledge on wastewater treatment technology has increased after going through the programme.”

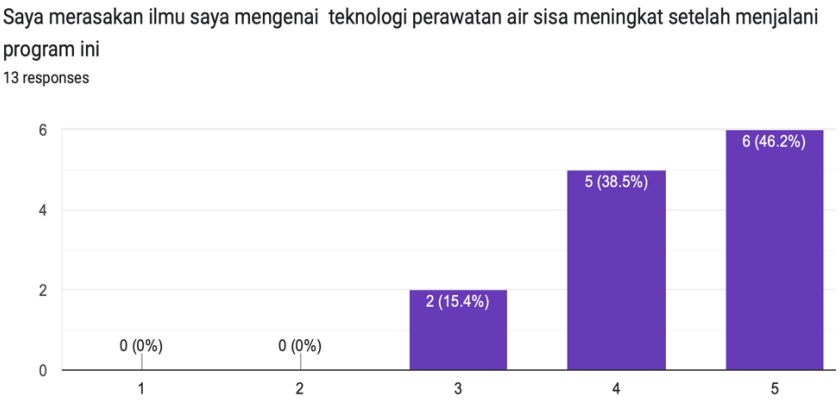

Fig. 1. Knowledge increment among the participants.

The first finding is significant as it highlights the value of the KTP in imparting essential knowledge to participants regarding technology in wastewater treatment, particularly emphasising the sustainability and utility of bio-based technology for the industry. The second finding reveals that nearly 80% of the participants perceived that the KTP has heightened their awareness of the significance of treating wastewater using new technology. Figure 2 illustrates the outcome of the second finding. The translated statement for the item is "I feel that this program makes me more aware on the importance of treating wastewater using a new technology."

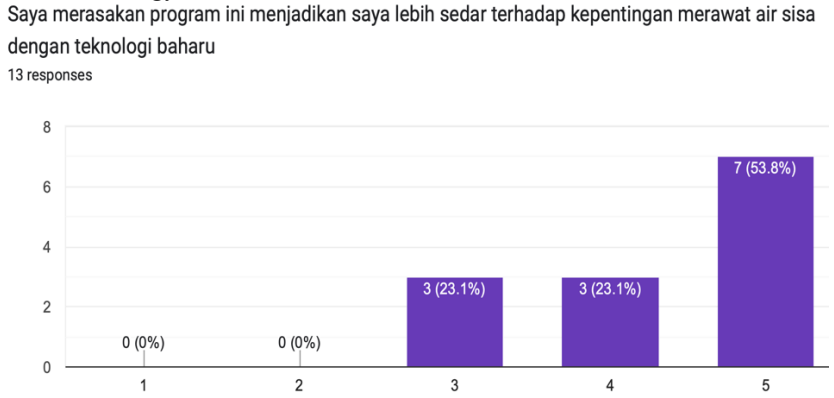

Fig. 2. Awareness increment among the participants.

The finding suggests that the KTP plays a critical role in increasing participants' awareness of new technology for wastewater treatment. Awareness is crucial as it prompts industrial players to consider utilising new technology to protect the environment, thereby contributing to the creation of sustainable cities and communities.

The third finding is that some participants suggested several contents to be included into the KTP in the future. One participant stated that:

"To add estimated cost for each product (new technology used) and how much cost is needed for pilot or commercialisations."

This suggestion appears to be relevant among industrial players, as they are typically focused on profit-making and cost-saving. Therefore, it is a particular point that needs to be taken into account when conducting a KTP for industries. Another participant provided a similar response, whereby he or she suggested that:

"To cover overall aspects of WWTP operation including Capex, Opex, and resources. The technology proposed seems promising on technical part, but industrial players are more concerned on the cost and operational."

The participant seems to highlight concerns regarding the cost and operational aspects of the new technology proposed for wastewater treatment. He or she recognises the value of adopting the new technology but expresses a desire to understand its pricing and practical aspects.

The third finding is important because it highlights the key concerns of the industry regarding the adoption of new wastewater treatment technology, specifically focusing on cost and operation. This finding aligns with existing literature [2], indicating consistency between participant feedback and prior research.

4 Recommendations and conclusion

Overall, this study reveals that the knowledge transfer programme (KTP) designed for the industry has effectively enhanced the knowledge and awareness of the participants regarding the importance of adopting new technology in wastewater treatment to protect the environment and promote sustainability among industrial players. However, participants expressed concerns regarding the cost and practicality of implementing the new technology. The next step that should be taken is to enhance the KTP by incorporating elements related to cost calculation and practical considerations of the proposed new technology. This is crucial because both existing literature and feedback from the industry site suggest the importance of considering cost and operational aspects for the adoption of new technology by industries.

Universities should indeed consider the real issues of cost and operation when offering KTPs or proposing new technologies to industries. This approach ensures that the solutions provided are not only innovative but also practical and feasible for implementation within industrial settings.

Indeed, involving industrial players as research partners in projects can be beneficial. This approach allows industries to provide insights to academia regarding the development and adoption of new technologies, aligning with the goal of achieving sustainable cities and communities as stated in the SDG [1]. Collaboration between universities and industries fosters a more holistic understanding of real-world challenges and facilitates the creation of effective solutions that address the needs of both academia and industry.

This study contributes not only to the practice of sustainability in industries but also to the literature on STEM education within the context of industries, rather than educational institutions [8, 9]. STEM education is seldom tailored for industries, so this study can enrich the literature on STEM education by addressing sustainability practices in industrial settings. By highlighting the importance of providing STEM education tailored to the needs of industries, this research fills a gap in the existing literature and emphasises the significance of incorporating sustainability principles into industrial education initiatives.

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References

1. United Nations, https://sdgs.un.org/goals (2024)
2. B. Oyewo, V. Tauringana, I. Tingbani, J. Env. Mgment, **349,** 119563 (2024)
3. A. Salim, M. Mustafa, A. Karim, (2024). *Migr. Letters*, **21**, 1 (2024)
4. G. Mao, Y. Han, X. Liu, J. Crittenden, N. Huang, & U. M. Ahmad, *Chemosphere*, **288**, 132483 (2022)
5. A. Soares, *Env. Sci and Ecotech*, **2** (2020)
6. S. Mohd, S. R. Rahmat, M. S. Samsurijan, A. Azman, *Int. J. Acad. Res. in Bus. & Soc. Sci*, **8**, 1 (2018)
7. R. AlAli, K. Alsoud, F. Athamneh, *Sustainability*, **15**, 16 (2023)
8. L. D. English, *Int. J. Sc. & Math Edu.*, **15** (2017)
9. G. Weaver, W. Burgess, *Transforming institutions: Undergraduate STEM education for the 21st century*, Purdue University Press (2015)
10. V. L. S. Fioravanti, F. Stocker, F. Macau, *Innov. & Mgmt. Rev.*, **20**, 1 (2023)