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Enhancing STEM Awareness Through University Outreach Program in Rural School

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ABSTRACT: Clean water awareness through STEM (Science, Technology, Engineering, and Mathematics) activities has become increasingly relevant, especially in rural areas where issues like water pollution and limited access to clean water persist. This paper described an outreach program with the aim of boosting both STEM understanding and health awareness among primary school students in a rural Malaysian community. The sessions were conducted hands-on, involving simple experiments and water filtration demonstrations using readily available materials. These activities highlighted experiential and inclusive learning, aligning with the goals outlined in the Malaysia Education Blueprint 2013–2025. During the program, students explored the science behind water contamination and its health impacts, followed by building their basic water filters. Students responded well during quizzes and interactive tasks, which helped track their learning progress. Notably, their awareness of waterborne diseases and confidence in applying basic filtration methods increased significantly from 15% before the program to full participation and understanding afterwards. Besides gaining knowledge, the activities seemed to shift their attitudes. Many students started asking questions about their household water sources, showing a level of curiosity that was not there before. This kind of learning rooted in real-life context demonstrated that STEM outreach does teach science as well as allows young learners to care about their environment and health. The model used in this program has strong potential to be adapted for other communities where resources may be limited but the need for awareness is in need.

KEYWORDS: STEM; water education; sustainable education; environmental awareness

1. Introduction

Technology is developing rapidly, making STEM education (Science, Technology, Engineering, and Mathematics) more important than ever. It helps prepare young people for the future by equipping them with valuable skills and knowledge. Worldwide, there are ongoing efforts to improve students' skills in critical thinking, problem-solving, and technical knowledge, as these abilities are important for addressing complex social and environmental issues. In Malaysia, STEM education has been marked as a national priority, as stated in the Malaysia Education Blueprint 2013–2025 [1]. The plan emphasises the need to develop the student pipeline in STEM disciplines, the need to tackle declining interest levels in STEM, and ensure equal access to STEM opportunities in all regions. Despite these developments, the number of students pursuing STEM at secondary and higher education levels are still not hitting targets [2].

One positive possibility to close these gaps is through outreach programs led by universities. Colleges and universities have a multitude of academic assets, trained faculty and staff, as well as research capacity that can be leveraged to aid in furthering opportunities for STEM learning in schools. Not only do the schools gain from university outreach programs, but university students also gain valuable opportunities for engaged community service and learning to teach. In relation to STEM education, safe clean water is essential for all forms of life (human and non-human) and has become even more essential/raw material for human daily activities. However, the rural communities that exist throughout the world are still suffering to obtain this basic resource. According to the World Health Organization (WHO), approximately 2 billion people lack access to clean water, which affects their health and well-being [3]. Many isolated areas have limited resources and poorly developed infrastructure, which often leads to polluted water that could make a person sick. People who do not have access to safe drinking water suffer grave health consequences, particularly with vulnerable populations such as children or the elderly [4]. Every year, contaminated water causes more than 500,000 deaths due to diarrheal diseases caused by waterborne illnesses [5]. Water contaminations can also lead to long-term health issues, such as chronic stomach illnesses, or restrict the physical and mental growth of children [6]. Reliance on unsafe water sources often leads to increased illness, placing a burden on healthcare services and limiting productivity, which in turn may perpetuate cycles of poverty within the community [7].

Water pollution typically stems from both natural occurrences and human actions. From human actions, the major sources of water pollution include waste from factories, agricultural runoff, and waste from residential properties. Industrial waste frequently is laden with hazardous waste and heavy metals. In addition, untreated wastewater is often discharged directly into rivers, lakes, and groundwater sources which culminates in pollution [8]. For example, untreated wastewater from textile factories, tanneries, and chemical factories discharge toxins such as cadmium, lead and mercury into rivers and or streams. Those toxins build up in all aquatic life, and ultimately humans consume the aquatic life and are harmed in this transfer. Agriculture can cause a sizable amount of water pollution due to using fertilizers and pesticides. When rain falls on the fields, it quickly washes excess nutrients such as nitrogen and phosphorus into rivers and or lakes, which causes excess nutrient pollution or eutrophication [9]. The consequence of an overabundance of nutrients lowers the levels of oxygen in the water, is harmful to aquatic life, and renders the water undrinkable. Pollution coming from residential properties is leftover sewage from septic tanks and household chemicals that have reached water sources. Many rural communities do not have the proper wastewater treatment in place, therefore it allows for contamination from harmful pathogens like E. coli and those which cause cholera [10]. The situation is exacerbated without proper treatments in place, especially where open defecation and improper waste methods are the norm.

In rural areas, community-led efforts can play a big role in improving access to clean water. These initiatives not only help prevent waterborne diseases but also teach local people about the importance of good sanitation and water hygiene, leading to better health and well-being [11]. For instance, promoting hygiene practices like using water filtration can reduce the incidence of waterborne diseases [12]. Due to that, the knowledge transfer was conducted to educate the participants, especially the young generation about the concept of providing clean water using simple techniques. Awareness and understanding of simple and effective methods help them access clean water. This activity addresses the limited awareness of clean water by using water treatment methods in rural communities. Besides, it also contributes to proactive steps in protecting their health and the well-being of their communities. Ultimately, the research seeks to facilitate the development of a replicable and scalable outreach model for facilitating STEM education among disadvantaged communities. By working closely with schools, the program shows how hands-on learning can help close educational gaps and inspire more students to pursue STEM in the future.

2. Methodology

2.1. Program coordination.

The first step was to identify the key stakeholders for the submission of a proposal. The main stakeholders were the Miri District Education Office (PPD) and the school board. Once obtained approval from the Miri District Education Office (PPD) Miri, we held a follow-up meeting with the school board to finalise the program schedule and gather their input. A total of 100 participants including students, teachers, and parents participated. The school was located in a rural area, and most of the students came from low-income households. The program was organised with a brief opening speech from the headmaster, followed by an engaging session focused on clean water. During this activity, students discovered the causes of surface water pollution and learned how contaminated water can impact their health. To wrap up the presentation, students participated in a quiz designed to reinforce their understanding and keep them involved. To evaluate the program’s effectiveness, students filled out questionnaires before and after the awareness sessions. Figure 1 gives an overview of the activities involved in organizing the awareness program.

2.2. Survey questionnaire.

The survey questionnaire was designed to assess respondents’ understanding of the awareness program. The survey targeted students, teachers, and parents as its primary respondents. It is important to note that the participation of respondents in this survey was completely voluntary. The questionnaires were provided to the respondents both before and after the awareness program. The questions assessed respondents’ knowledge of water filtration methods, risks associated with untreated water, and their personal experiences with water treatment.

The questionnaire was adapted from validated water education tools and reviewed by two education specialists for clarity and relevance. Sample questions include: ‘Do you know how to set up a water filtration system?’, ‘Have you heard of water filtration methods?’, and ‘Do you think untreated water is dangerous for human health?’

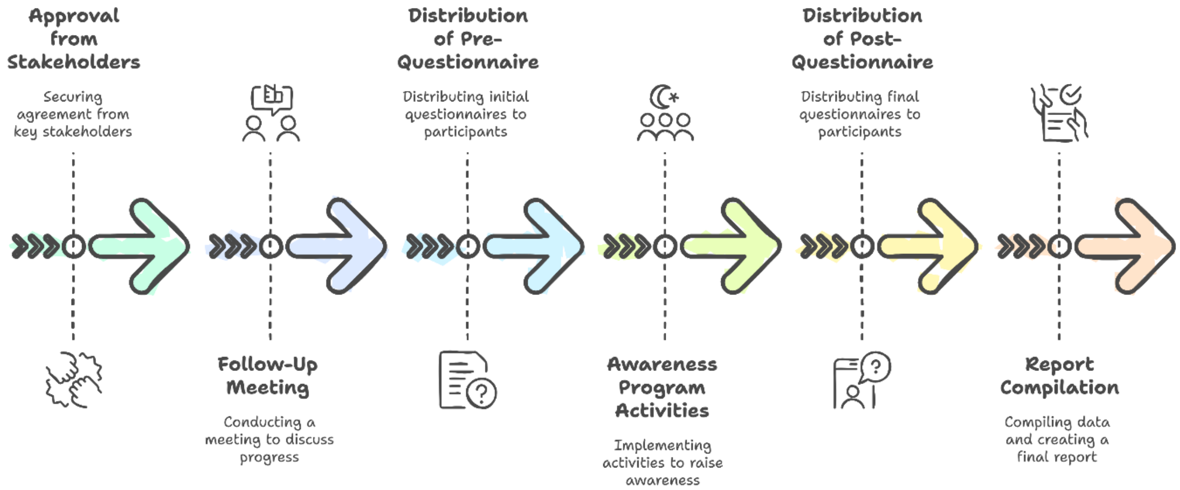

Figure 1. Overview of awareness program activities.

2.3. Data analysis.

Survey data were analysed using descriptive statistics. A comparison of pre- and post-survey responses was conducted using Microsoft Excel to determine learning gains across knowledge, attitude, and skill categories.

3. Results and Discussions

3.1. Seminar session.

The awareness program on water filtration was organised to teach elementary school students a simple way to get clean water through basic filtration. The event took place at Sekolah Kebangsaan in the district of Miri, where the school was selected for its rural location as identified by PPD Miri. The school includes students from preschool through grade six, and most of them come from families with low-income backgrounds. The program focused on showing students the importance of using clean water as well as how water filtration works. The materials used for filtration are easy to find and affordable, making the activity relevant to their everyday lives.

In the seminar activity as shown in Figure 2, Students were introduced to water resources, including their sources such as rivers, lakes, and groundwater, and the importance of these resources in daily life. Even though water is initially clean, it can become polluted by many things like factories, farms, and household waste. This pollution can make water unsafe to use. During the seminar, students learned about health risks from touching or drinking contaminated water, including skin rashes, stomach problems, and infections. They were taught how to spot common signs of waterborne illnesses early on. This practical and context-based learning activity reflects the core principles of environmental education, particularly the emphasis on cultivating awareness, knowledge, and responsible action among learners [13]. Introducing health-focused content through STEM outreach not only reinforces scientific understanding but also supports students in making informed decisions that affect both their health and their communities [14, 15].

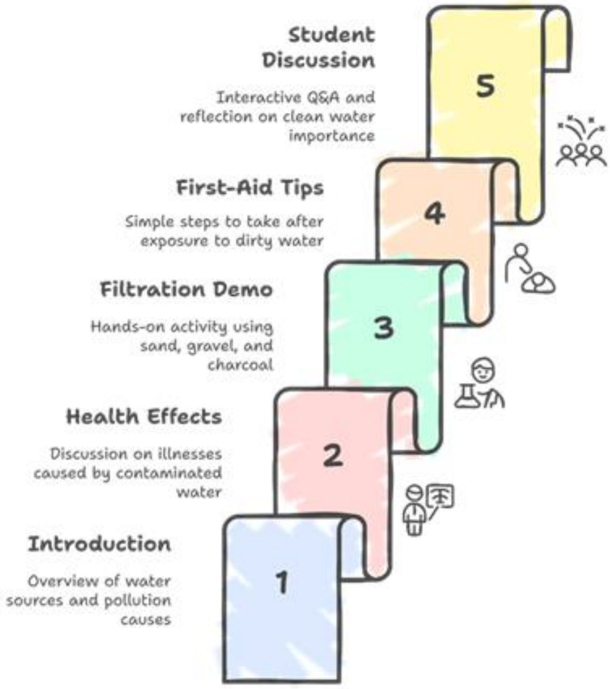

Figure 2. Seminar session flow.

The session also covered simple first-aid steps if someone comes into contact with dirty water, like washing the affected area well, seeing a doctor if symptoms appear, and telling a trusted adult or health worker. As a way to have clean water, students were introduced to water filtration systems. They learned how these systems use different layers of filtration materials such as sand, gravel, and charcoal, to trap dirt and harmful substances. However, it was emphasised that filtered water should still be boiled before drinking to make sure it is safe. This practical activity supported students in learning through experience, a core element of constructivist teaching methods [16]. Learning about how filtration works helped them to connect science ideas to everyday life, which is a fundamental objective of inquiry-based learning [17]. Integrating environmental topics into STEM education enhances interdisciplinary disciplines, which draw connections between science, engineering, and public health. This approach not only makes the topic more interesting but also helps students understand it more deeply. During the seminar, they looked at how filtration works, going beyond a basic explanation. They were also encouraged to ask questions and think about why clean water matters, both for themselves and for their communities.

3.2. Quiz session.

The quiz was included as part of the seminar to check how well students understood the topic, while also encouraging active learning. The quiz questions reflected the seminar content related to major ideas including: how water filtration works; what each filtration medium does; and why clean drinking water is important for our health and safety. Some of the questions reflected the specific roles of sand, gravel, and activated charcoal. Specifically, in the filtration process sand will filter out larger particles, gravel provides a structure to allow for flow, and charcoal is effective at trapping chemical contaminants and odours. This type of content aligns closely with constructivist pedagogy because students are actively involved in building knowledge through participation and reflective learning [18]. Quizzes provide students with immediate feedback and support in the development of metacognitive learning skills [19]. The facilitators were able to help students track their learning, and recognise any misunderstandings. In addition, discussion-based quiz questions also support peer learning which helps with understanding and deepening cognitive engagement [20].

The level of understanding demonstrated by the students during the seminar was impressive. Many of them were able to articulate how filtration works, and they understood the importance of boiling filtered water to eliminate any pathogens remained after physical filtration. This clearly illustrated effective knowledge transfer within science education, as students made connections between theoretical concepts and a real-world example [21]. The activity also promoted inquiry-based learning, as students engaged with scientific concepts through observation, questioning, and reasoning [17]. Their active participation throughout the seminar, including accurate responses to questions, indicates that the session was effective in conveying key content while promoting critical thinking and scientific literacy.

The quiz also offered students a valuable opportunity to collaborate in small groups. This format encouraged them to discuss and reflect on their answers prior to sharing with the wider group. The social interaction enabled peer learning, as students shared their reasoning and built upon one another's ideas. Social interaction is a key element of Vygotsky's sociocultural theory, which highlights the role of dialogue and collaboration in cognitive development [22]. The group discussions demonstrated that students were not only engaging with the content effectively, but also developing essential skills such as cooperation, communication, and problem-solving. These activities reflect principles of student-centred teaching and constructivist learning [23]. Beyond assessing understanding, the quiz worked as a formative tool, which facilitated real-time dialogue through which misconceptions were identified and addressed. For instance, when some students were uncertain about the function of activated charcoal, the facilitator was able to clarify its role in adsorbing chlorine, heavy metals, and other pollutants. This responsive teaching approach, in which instruction is adapted in real-time has been shown to support deeper conceptual learning [24]. By addressing misunderstandings promptly, the activity helped to close knowledge gaps and reinforce a more robust scientific understanding.

3.3. Perceived value of awareness program.

Data were collected through a questionnaire survey in which participants indicated their level of agreement with several statements. Participation was entirely voluntary, and respondents were free to skip any questions if they wished. The survey asked participants to rate their understanding of topics related to the awareness program. Their responses offered valuable insights into how the program impacted their knowledge and perceptions, as summarised in Table 1.

One of the primary goals of the awareness program was to enhance respondents' understanding of clean water and water filtration methods. The pre-seminar survey revealed limited baseline knowledge: only 60% of respondents were aware of water filtration, and just 55% had heard of different filtration techniques. Moreover, only 20% reported practising any form of water purification at home. This gap likely reflects limited access to resources and prior exposure within the community. Nonetheless, 85% recognised that untreated water poses health risks. The post-seminar survey demonstrated a significant increase in knowledge and practical understanding. After the program, all respondents (100%) acknowledged the importance of water filtration and the dangers of untreated water. Furthermore, more than 85% were able to identify specific waterborne diseases and explain their transmission mechanisms. These improvements indicate that the program effectively facilitated meaningful learning.

Table 1. Respondent feedback statement in the awareness program.

		Percentage of agreement (Pre-Seminar)	**Percentage of agreement (Post-Seminar)**
Knowledge	Do you know what water filtration is?	60%	100%
	Have you ever heard of water filtration methods?	55%	100%
	Do you think untreated water is dangerous for human health?	85%	100%
	Have you ever practised water filtration at home?	20%	100%
Aspiration	Can you think of any ways that water filtration can be beneficial?	50%	100%
	Can you name any uses for filtered water?	40%	100%
	Can water filtration help in improving the life quality?	65%	100%
	Do you want to use filtered water for your daily activities such as drinking or cooking?	75%	100%
	Have you seen any examples of water filtration systems in your community?	30%	100%
Skills	Do you know how to set up a water filtration system?	15%	100%
	Do you think it is easy to set up a water filtration system?	25%	100%
	Have you considered implementing a water filtration system in your home?	35%	100%
	Do you agree with implementing a water filtration system in your school?	70%	100%

From a pedagogical perspective, this outcome aligns with the principles of situated learning, which emphasise the importance of contextually relevant knowledge and real-world application to promote deeper understanding [25]. By connecting water safety concepts to the student's everyday experiences, the program supported learners in constructing practical knowledge that is transferable beyond the classroom setting. Additionally, the use of formative assessment through pre- and post-surveys reflects best practices in educational evaluation, enabling instructors to measure learning gains and adjust instruction accordingly [26]. This approach supports learner-centred education, where feedback loops help both students and educators monitor progress and address misconceptions. Given that respondents come from lower-income backgrounds with potentially limited access to clean water, improving their knowledge and awareness carries particular importance. Health education programs that are tailored to community needs have been shown to increase both knowledge and behaviour change, thereby contributing to better health outcomes and empowerment.

In relation to aspiration, the program had a clear impact on respondents' understanding of water filtration, its benefits, and its uses. Initially, only 50% of respondents could identify that water filtration could be beneficial, and 40% of them could name specific uses for filtered water. However, 100% of respondents were able to identify these benefits and uses after the program, showing a complete shift in their awareness. Respondents understood that filtered water is better for drinking, cooking, and other daily activities that improve health and safety.

Besides, 65% of respondents initially believed that water filtration could improve quality of life, and this percentage increased to 100% after the program. These changes suggest that respondents developed a clearer understanding of how access to clean water can enhance their daily lives, particularly in underserved areas. This increase in aspiration and understanding shows the success of transformative learning, where students change how they see things by thinking deeply and learning from real-life problems [27]. The program provided real-life learning experiences that helped respondents link abstract health ideas to their everyday lives. These approaches are a core principle of experiential and contextual learning [28,29].

Increased interest in using filtered water for drinking and cooking from 75% before the program to 100% afterwards demonstrates not only knowledge acquisition but also enhanced self-efficacy and learner agency. When individuals feel confident in applying knowledge in practical contexts, it signals a move toward empowerment through education, especially in underserved communities [30]. Moreover, before the program, only 30% of respondents had seen examples of water filtration systems in their community. After the program, all respondents gained exposure to these systems. This shift highlights the value of place-based learning, where students learn through real-life experiences in their own communities, making the content more meaningful and motivating [31]. By combining visual exposure, hands-on activities, and group discussions, the program aligned with constructivist educational theory. These approaches encourage students to actively build their own understanding instead of just receiving information [32]. Overall, the outcomes reflect effective science pedagogy that supports conceptual understanding, attitude change, and real-world application.

When it comes to skills, the program’s activities demonstrated that respondents could confidently set up the filtration technique on their own. Facilitators guided students through scaffolded instruction—beginning with background visuals and leading questions before transitioning to a hands-on activity. This method reflects principles of constructivist and experiential learning, enabling students to build conceptual understanding through personal engagement. Initially, only 15% of respondents knew how to construct a water filtration system, and about 25% perceived the process as easy to perform. However, after the program, these numbers increased to 100%, showing that the interactive, hands-on activities helped students learn the skills well. Using everyday materials like sand, gravel, and charcoal helped participants realise that creating a simple water filter is not only feasible but also affordable, even in areas with limited resources. This aspect aligns well with experiential learning theory-dominant scholarly approaches to understanding sustainability, which stress the validity of experiential or real-life practice in constructing new abilities for purposeful action and understanding [25]. Prior to the program, only 35% of participants had thought to implement a water filtration system in their homes. By the end of the program, all of the participants expressed an interest in having this option, noting that the experience of building a system not only enhanced their technical competence but also increased their motivation and sense of self-efficacy [31]. For participants from low-income households, the program offered a sustainable and affordable means of securing access to safe drinking water. This reflects the objectives of life skills-based education, which seeks to equip learners with practical abilities that promote health, well-being, and resilience in everyday life [33].

In addition, there was a sizeable increase in support for establishing water filtration/ purification systems at schools too. Initially, 70% of respondents endorsed this idea, but following the program, support reached 100%. This shift highlights the growing awareness of communal health benefits and the importance of institutional infrastructure in promoting equity. Providing clean water at school contributes to a safe and inclusive learning environment, an essential component of a rights-based approach to education [34]. The pedagogical design of the program reflected constructivist principles, particularly the use of inquiry and task-based learning, where learners engage in solving authentic problems using available resources (Fosnot, 2013; Thomas, 2000). By empowering students with both knowledge and practical skills, the program fostered autonomy, agency, and collaborative decision-making—hallmarks of effective science education and community empowerment.

3.4. Feedback and areas for improvement.

Feedback from participants provided valuable ideas about the strengths and areas for improvement in the current awareness program. Following the session, the school has expressed interest in integrating water and hygiene topics into their STEM activities. The headmaster expressed appreciation for the activities carried out during the event. The effective delivery of important information to the students met the school's expectations and aligned well with its educational objectives. While the school has planned several activities for students throughout the year, all teachers hope that similar events can be included in the program in the coming years.

According to local education stakeholders, the awareness program was seen as valuable and suitable for implementation at the primary school level. Activities like these can help develop students' understanding of clean water practices and environmental awareness from an early age. This type of learning activity encouraged them to attend school regularly and helped to instil an interest in continuous learning. They congratulated everyone involved, especially teachers, students, and parents who contributed to the success of the event and expressed their willingness to support similar activities in the future for other schools in the Miri region.

3. Conclusion

In conclusion, the awareness program effectively engaged students and deepened their understanding of the importance of using clean water for health and well-being, as well as the implementation of water filtration. This program was integrated into the school curriculum and encouraged the students' continued learning and engagement with water filtration systems in their homes and schools. The experiential learning activities created authentic experiences for students and helped them develop ways to reflect on their learning, understand why they learned it, and how to apply their learning to daily living. The program allowed students to learn about water filtration systems through experience and reflection, as it was appropriately created along the tenets of constructivist learning principles. Students were able to relate new knowledge to their prior understanding and everyday context. This made their learning meaningful and, perhaps without realising it, empowered them to take control of their health. The program also helped students develop important life skills and build confidence to make informed decisions about their water use and hygiene. Life skills have been widely recognised for providing people with the information and resources they need to successfully deal with everyday obstacles and positively improve their communities. This program proved to be a powerful starting point which encouraged enthusiasm and inspired discussion; in the next iterations, more content and interactive components could expand on this early work. The continual project activities will also help enable students to address water-related issues and enhance the overall health and sustainability of their communities.

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Author Contribution

Conceptualisation: Muhammad Noor Hazwan Jusoh, Tony Hadibarata. Methodology: Muhammad Noor Hazwan Jusoh, Paran Gani. Data Collection: Tony Hadibarata, Paran Gani. Data Analysis: Muhammad Noor Hazwan Jusoh, Tony Hadibarata. Writing: Muhammad Noor Hisyam Jusoh, Tony Hadibarata, Paran Gani.

Competing Interest

The authors declare no competing interests related to the content or publication of this article.

References

[1] Ali, G.; Jaaffar, A.R.; Ali, J. (2021). STEM education in Malaysia: Fulfilling SMEs' expectation. *Modeling Economic Growth in Contemporary Malaysia*, *43–57*. http://doi.org/10.1108/978-1-80043-806-420211005.

[2] Idris, R.; Govindasamy, P.; Nachiappan, S. (2023). Challenge and obstacles of STEM education in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *13*, 820–828. http://doi.org/10.6007/IJARBSS/v13-i4/16676.

[3] Arora, N.K.; Mishra, I. (2022). Sustainable development goal 6: Global Water Security. *Environmental Sustainability*, *5*, 271–275. http://doi.org/10.1007/s42398-022-00246-5.

[4] Adelodun, B.; Ajibade, F. O.; Ighalo, J. O.; Odey, G.; Ibrahim, R. G.; Kareem, K. Y.; Bakare, H. O.; Tiamiyu, A. O.; Ajibade, T. F.; Abdulkadir, T. S.; et al. (2021). Assessment of socioeconomic inequality based on virus-contaminated water usage in developing countries: A review. *Environmental Research*, *192*, 110309. http://doi.org/10.1016/j.envres.2020.110309.

[5] Velleman, Y.; Blair, L.; Fleming, F.; Fenwick, A. (2023). Water-, Sanitation-, and Hygiene-Related Diseases. In *Infectious Diseases*; Shulman, L. M., Ed.; Springer: New York, USA, pp 189–219.

[6] Guerrant, R. L.; DeBoer, M. D.; Moore, S. R.; Scharf, R. J.; Lima, A. A. M. (2013). The impoverished gut—a triple burden of diarrhoea, stunting and chronic disease. *Nature Reviews Gastroenterology & Hepatology*, *10*, 220–229. http://doi.org/10.1038/nrgastro.2012.239.

[7] Kurniawan, T. A.; Meidiana, C.; Goh, H. H.; Zhang, D.; Jiang, M.; Othman, M. H. D.; Anouzla, A.; Aziz, F.; Mahmoud, M.; Khan, M. I.; et al. (2024). Social dimensions of climate-induced flooding in Jakarta (Indonesia): The role of non-point source pollution. *Water Environment Research*, *96*, e11129. http://doi.org/10.1002/wer.11129.

[8] Kapoor, D.; Singh, M. P. (2021). Heavy metal contamination in water and its possible sources. In *Heavy Metals in the Environment*; Kumar, V., Sharma, A., Cerdà, A., Eds.; Elsevier: pp 179–189.

[9] Khan, M. N.; Mohammad, F. (2014). Eutrophication: Challenges and Solutions. In Eutrophication: Causes, Consequences and Control: Volume 2; Ansari, A. A., Gill, S. S., Eds.; Springer: Dordrecht, Netherlands, pp 1–15.

[10] Mavhungu, M.; Digban, T. O.; Nwodo, U. U. (2023). Incidence and Virulence Factor Profiling of Vibrio Species: A Study on Hospital and Community Wastewater Effluents. *Microorganisms, 11*, 2449. http://doi.org/10.3390/microorganisms11102449.

[11] Evaluation of the costs and benefits of water and sanitation improvements at the global level. (accessed on 1 May 2025) Available online: https://iris.who.int/handle/10665/68568.

[12] Shayo, G. M.; Elimbinzi, E.; Shao, G. N.; Fabian, C. (2023). Severity of waterborne diseases in developing countries and the effectiveness of ceramic filters for improving water quality. *Bulletin of the National Research Centre*, *47*, 113. http://doi.org/10.1186/s42269-023-01088-9.

[13] May, T. S. (2000). Elements of success in environmental education through practitioner eyes. *The Journal of Environmental Education*, *31*, 4–11. http://doi.org/10.1080/00958960009598639.

[14] Shayo, G. M.; Elimbinzi, E.; Shao, G. N.; Fabian, C. (2023). Severity of waterborne diseases in developing countries and the effectiveness of ceramic filters for improving water quality. *Bulletin of the National Research Centre*, *47*, 113. http://doi.org/10.1186/s42269-023-01088-9.

[15] May, T. S. (2000). Elements of success in environmental education through practitioner eyes. *The Journal of Environmental Education*, *31*, 4–11. http://doi.org/10.1080/00958960009598639.

[16] Council, N.R.; Behavioral, D.o.; Sciences, S.; Education, B.o.S.; Learning, C.o.S.O.-o.-S.S. (2015). Identifying and supporting productive STEM programs in out-of-school settings. National Academies Press: Washington D.C., USA. https://doi.org/10.17226/21740.

[17] Tillinghast, R.C.; Appel, D.C.; Winsor, C.; Mansouri, M. (2020). STEM outreach: A literature review and definition. Proceedings of the 2020 IEEE Integrated STEM Education Conference, pp 1–20.

[18] Chen, J.C.; Huang, Y.; Lin, K.Y.; Chang, Y.S.; Lin, H.C.; Lin, C.Y.; Hsiao, H.S. (2020). Developing a hands-on activity using virtual reality to help students learn by doing. *Journal of Computer Assisted Learning*, *36*, 46–60. https://doi.org/10.1111/jcal.12389.

[19] Constantinou, C.P.; Tsivitanidou, O.E.; Rybska, E. (2018). What is inquiry-based science teaching and learning? In *Professional Development for Inquiry-Based Science Teaching and Learning*; Tsivitanidou, O.E., Gray, P., Rybska, E., Louca, L., Constantinou, C.P., Eds.; Springer: Cham; pp 1–23. http://doi.org/10.1007/978-3-319-91406-0_1.

[20] Spector, J.M.; Ifenthaler, D.; Sampson, D.; Yang, J.L.; Mukama, E.; Warusavitarana, A.; Dona, K.L.; Eichhorn, K.; Fluck, A.; Huang, R. (2016). Technology enhanced formative assessment for 21st century learning. *Educational Technology & Society*, *19*, 58–71. http://doi.org/10.1007/s10758-014-9224-6.

[21] Hudesman, J.; Crosby, S.; Flugman, B.; Issac, S.; Everson, H.; Clay, D.B. (2013). Using formative assessment and metacognition to improve student achievement. *Journal of Developmental Education*, *37*, 2.

[22] Burke, R.A.; Jirout, J.J.; Bell, B.A. (2025). Understanding cognitive engagement in virtual discussion boards. *Active Learning in Higher Education*, *26*, 157–176. https://doi.org/10.1177/14697874241230991.

[23] King, D.; Ritchie, S.M. (2012). Learning science through real-world contexts. In Second International Handbook of Science Education; Fraser, B., Tobin, K., McRobbie, C., Eds.; Springer: Dordrecht: Netherlands. pp 69–79.

[24] Sarmiento-Campos, N.-V.; Lázaro-Guillermo, J.C.; Silvera-Alarcón, E.-N.; Cuellar-Quispe, S.; Huamán-Romaní, Y.-L.; Apaza, O.A.; Sorkheh, A. (2022). A look at Vygotsky's sociocultural

theory (SCT): The effectiveness of scaffolding method on EFL learners' speaking achievement. *Education Research International*, *2022*, 3514892. http://doi.org/10.1155/2022/3514892.

[25] Hoidn, S.; Reusser, K. (2020). Foundations of student-centered learning and teaching. In The Routledge International Handbook of Student-Centered Learning and Teaching in Higher Education; Hoidn, S., Klemenčič, M., Eds.;Routledge: Oxfordshir, UK. pp 17–46.

[26] Ahamed, H.R.; Hanirex, D.K. (2024). A deep learning-enabled approach for real-time monitoring of learner activities in adaptive e-learning environments. Proceedings of the 2024 7th International Conference on Circuit Power and Computing Technologies, pp 846–851.

[27] Bell, R.L.; Maeng, J.L.; Binns, I.C. (2013). Learning in context: Technology integration in a teacher preparation program informed by situated learning theory. *Journal of Research in Science Teaching*, *50*, 348–379. https://doi.org/10.1002/tea.21075.

[28] Li, Z.; Yan, Z.; Chan, K.K.Y.; Zhan, Y.; Guo, W.Y. (2023). The role of a professional development program in improving primary teachers' formative assessment literacy. *Teacher Development*, *27*, 447–467. http://doi.org/10.1080/13664530.2023.2223595.

[29] Bay, U.; Macfarlane, S. (2011). Teaching critical reflection: A tool for transformative learning in social work? *Social Work Education*, *30,* 745–758. https://doi.org/10.1080/02615479.2010.516429.

[30] Chabeli, M.; Nolte, A.; Ndawo, G. (2021). Authentic learning: A concept analysis. *Global Journal of Health Science*, *13*, 1–12. http://doi.org/10.5539/gjhs.v13n1p1.

[31] Barrett, E. (2007). Experiential learning in practice as research: Context, method, knowledge. *Journal of Visual Art Practice*, *6*, 115–124. https://doi.org/10.1386/jvap.6.2.115_1.

[32] Laverack, G. (2007). Health Promotion Practice: Building Empowered Communities. McGraw-Hill Education: New York, USA.

[33] Smith, G.A. (2013). Place-based education: Practice and impacts. In International Handbook of Research on Environmental Education; Stevenson, R.B., Brody, M., Dillon, J., Wals, A.E.J., Eds.; Routledge: Oxfordshir, UK. pp 213–220. https://doi.org/10.4324/9780203813331.

[34] Bakar, S. (2021). Investigating the dynamics of contemporary pedagogical approaches in higher education through innovations, challenges, and paradigm shifts. *Social Science Chronicle*, *1*, 1–19. https://doi.org/10.56106/ssc.2021.009.

[35] Kauts, D.S.; Saini, J. (2022). Life skill based education: A systematic narrative review. *MIER Journal of Educational Studies Trends and Practices, 407–422*. https://doi.org/10.52634/mier/2022/v12/i2/2261.

[36] Lundy, L.; McEvoy, L. (2009). Developing outcomes for educational services: A children's rights-based approach. *Effective Education*, *1*, 43–60. https://doi.org/10.1080/19415530903044050.