HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

February 2025. 13(1)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 65-78

HydroTechPure Prototype Development: Dual Mode Filter-Based Water Purification Tool as a STEM-Based Learning Tool

Nahadi[1*], Wiwi Siswaningsih[1], Miarti Khikmatun Nais[1] , Triannisa Rahmawati[1], Atep Rian Nurhadi[1], Hayuni Retno Widiarti[2], Ari Syahidul Shidiq[3] Agnes Suci Evriliani[1], Aztiannisa Zahra[1], Liana Ambar Sari[1], Ahmad Nafran Razani[1], Qurrotu Aini Zahran[1], Muhammad Fiqri Rahman[1], Fajar Abdurrahman[1]

[1] Chemistry Education Study Program, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 207, Bandung, Indonesia, 40154
[2] Department of Chemistry Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Jl. Semarang No. 5, Malang, Indonesia, 65145
[3] Chemistry Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36A, Kentingan, Surakarta, 57126
[*] Corresponding Author e-mail: nahadi@upi.edu

Article History
Received: 19-12-2024
Revised: 16-02-2025
Published: 28-02-2025

Keywords:
HydroTechPure prototype; dual mode filter-based; water purification tool; STEM-based learning tool

Abstract
Water is one of the most fundamental basic needs for human life. However, disparities in the availability of clean water remain a significant challenge in Indonesia. This study aims to develop a water purification device to address this issue. The research method employed was the ADDIE model, which consists of five stages, with this study focusing on analysis, design, and development, which serve as scope of this study. The result of a water purification, named HydroTechPure, utilizes a dual filter system with high quality absorbent materials and is constructed from acrylic materials, enhanced by 3D design technology and Arduino integration. The development of this device aligns with the sixth goal of the Sustainable Development Goals (SDGs), which emphasizes ensuring access to clean water and sanitation for all. HydroTechPure was developed at FabLab Edu UPI. Beyond its primary function, HydroTechPure is envisioned as a tool for integrating STEM based learning, aiming to foster students' motivation and environmental awareness.

How to Cite: Nahadi, N., Siswaningsih, W., Nais, M., Rahmawati, T., Nurhadi, A., Widiarti, H., Sidiq, A., Evriliani, A., Zahra, A., Sari, L., Razani, A., Zahran, Q., Rahman, M., & Abdurrahman, F. (2025). HydroTechPure Prototype Development: Dual Mode Filter-Based Water Purification Tool as a STEM-Based Learning Tool. Hydrogen: Jurnal Kependidikan Kimia, 13(1), 65-78. doi:https://doi.org/10.33394/hjkk.v13i1.14082

https://doi.org/10.33394/hjkk.v13i1.14082

INTRODUCTION

Clean water is one of the most fundamental basic needs due to its vital function in life. Almost all human activities require water, especially for household needs (Zulhilmi & Idawati, 2019). Clean water plays an essential role for humans. With water making up about 80% of the human body, it serves as a crucial solvent and nutrient carrier, making it necessary for humans to continuously fulfill their water needs for survival (Kornita, 2020).

In general, clean water is often defined as water that is suitable for use as raw water for drinking, which also implies its suitability for bathing, washing, and sanitation. Most clean water needs to be boiled until it reaches a boiling point before consumption to eliminate bacteria and potential sources of disease (Permenkes RI, 1990). A global comparison of water needs indicates that the normal daily water consumption per person is approximately 20 liters, with 4 liters allocated for drinking and the rest for other activities (Fogden & Wood, 2009).

Studies conducted by international organizations such as UNICEF report that poor drinking water quality can contribute to the spread of various diseases. Viruses present in unsafe drinking water have been linked to various illnesses, including diarrhea, cholera, and other digestive disorders. According to a report from the United Nations Children's Fund (UNICEF), globally, low drinking water quality has led to an increased probability of child mortality under the age of five (U5), reaching nearly 1.3 million deaths per year (UNICEF, 2024).

During the 2015–2020 period, the allocation of balance funds, particularly the Special Allocation Fund (DAK), was primarily focused on the distribution of infrastructure development, especially clean water and environmental sanitation, each year. On the other hand, the distribution of the General Allocation Fund (DAU) also aims to improve health indicators. The health aspect is a key component in calculating the Human Development Index (HDI), in addition to the DAU distribution, which also uses the HDI formulation. Access to clean water serves as one of the transmission channels for improving public health indicators (Sukartini & Samsubar, 2016).

Several studies conducted by the World Bank on the impact evaluation of clean water assistance programs in various developing countries generally report a positive influence of access to clean water on economic activities. Some transmission mechanisms linking clean water access to economic aspects include: Productivity and income channels, Sanitation and health channels, and Education channels (UNICEF, 2001). The following are several studies on sanitation and clean water worldwide, reported by the World Bank in a program titled *World Development Report* (World Bank, 1994).

In the transmission of increased productivity and income, several studies have reported a link between access to clean water and increased productivity and income opportunities through participation in the labor market. A World Bank study in Honduras found that increased access to clean water in urban and rural areas, particularly among the lowest-income quintile (Q5) or the poorest communities in Honduras, had a significant impact. After the implementation of a clean water pipeline program in the country, the World Bank conducted an impact evaluation study and reported that the average household income for those with access to clean water increased, with the following details. Household income increased by an average of 7.32% for households with access to clean water, and nearly 11% for households that had access to both clean water pipelines and improved sanitation facilities.

A World Bank study in Sri Lanka in 1998 reported that the economic benefits of providing access to clean water in the country included a time substitution effect, particularly for housewives, allowing them to participate in the labor market. Before the clean water project, most housewives spent their time carrying water from springs or rivers. After water access was distributed to villages, most areas studied experienced an increase in female labor force participation in both formal and informal job markets, particularly among housewives. This increase in female workforce participation was predicted to boost household income by nearly 20% per month.

Rosen and Vincent (1999) examined clean water access among poor households in Nigeria. Their study reported that increased access to clean water was linked to improved health indicators for residents who gained access to clean water. The study focused on poor households in three villages, covering approximately 1,900 households in Nigeria. After five years of having access to clean water, researchers reported that in villages with clean water access, the under-five mortality rate (U5MR) dropped to 2.8%. Before the clean water supply was introduced, the infant mortality rate had been recorded at 6.7%.

In Paraguay, the World Bank also conducted an impact evaluation study on the expansion of clean water access, focusing on 122,000 poor households that previously experienced frequent diarrhea outbreaks. The study concluded that outbreaks of diarrhea and digestive-related diseases, or stomach distress, were reduced by nearly seven times in areas with access to clean water compared to those without it. Other studies reported similar findings. Skoufias, in a World Bank report, conducted research on 1,600 households that gained access to clean water in Romania. His study found that the significant increasing Z-score value, an index measuring child health for children under five years old (U5), for households with clean water access.

An increase in clean water access has also been linked to improvements in education indicators in rural areas that received clean water access. A World Bank study focusing on several regions in Africa reported that better water access was associated with improved school attendance rates, particularly among female primary school students. Furthermore, a World Bank study in 2001 found that before the Nigerian government received clean water assistance from the World Bank, the absenteeism rate for female primary school students in Nigerian villages was as high as 60% or more. This was because many children in these villages had to help their parents fetch water from other villages with access to clean water. After receiving clean water assistance, school absenteeism rates decreased to 16%. A similar phenomenon was also observed in a 2002 World Bank study on Bangladesh.

Based on research findings, the need for safe drinking water remains a fundamental issue that has not been evenly distributed across Indonesia. This indicates that access to water, including clean drinking water, is still highly unequal in the country. This disparity in access to safe drinking water is also suspected to be one of the causes of inequality and the relatively low Human Development Index (HDI) achievements in Indonesia and the Asia-Pacific region in general (UN, 2006). There are still few studies examining access to clean water in Indonesia, except for research by Patunru (2015), Komarulzaman et al. (2014), and Febriany et al. (2013). Patunru (2015) studied variations in clean drinking water sources at the household level and the likelihood of diarrhea outbreaks in a village, using data from the 2007 and 2011 National Socioeconomic Surveys (Susenas). This study focused on three provinces that frequently experience water scarcity: West Nusa Tenggara, East Nusa Tenggara, and Papua.

On the other hand, the challenges faced by developing countries like Indonesia are not only related to infrastructure provision but also to addressing factors affecting water distribution and quality. One major challenge is water pollution caused by human activities, such as untreated domestic and industrial waste. Additionally, climate change has worsened the situation by affecting rainfall patterns and reducing the availability of clean water sources in certain regions. This condition forces both the government and society to seek innovative solutions in water resource management (Kummu et al., 2016).

The severe disparity in access to clean water in Indonesia is concerning, as excessive use of clean water can threaten food availability and overall public well-being. With population growth, changing water consumption patterns, and the impacts of climate change, maintaining sustainable water use will become an increasingly difficult challenge in the future (Kummu et al., 2016). Poor waste management from households, improper disposal of untreated agricultural waste, and natural processes polluting rivers are only a few of the many factors contributing to water contamination. Beyond issues related to clean water resources, continuous water pollution will also have negative effects on both the environment and public health (Ani & Harahap, 2022).

A study by Komarulzaman et al. (2014) examined the relationship between household access to clean water and housewives' habits of boiling water before drinking. The availability of clean water access and the habit of boiling water before consumption were expected to reduce the likelihood of diarrhea outbreaks and acute diarrhea in villages and districts, using data from the 2007 and 2012 Demographic and Social Surveys. Komarulzaman et al. concluded that piped water access, good environmental sanitation, and household income negatively affected diarrhea incidence. A particularly interesting finding from this study was that housewives' habit of boiling water before drinking and their level of education were not statistically significant factors in determining the likelihood of diarrhea outbreaks.

A study by Febriany et al. (2013) focused on the impact of access to clean water and improved sanitation on the under-five mortality rate (U5MR) and child growth stunting. This study used data from the 2009 and 2010 National Socioeconomic Surveys (Susenas). Overall, the analysis found a negative correlation between increased clean water access and improved sanitation with under-five mortality rates and child stunting.

In this regard, people are encouraged to find solutions when water from wells or other sources becomes murky, dirty, or odorous, so that it can be purified and made suitable for use. There is a strong relationship between waste and water within waste management systems. Various treatment technologies have been developed to convert waste into valuable materials and resources, significantly reducing the amount of waste ending up in landfills. The reduction of toxins, residues, emissions, and pollution produced by waste also has the potential to lower water contamination levels in soil (Fatimah et al., 2020).

One of the continuously developed solutions is water purification technology as a mitigation measure against clean water challenges. Through the integration of technology and education, it is expected that society can increase awareness and capability in maintaining water quality. By involving various stakeholders—including the government, educational institutions, and the general public—issues related to clean water access can be managed more effectively and sustainably. Water purification is a process used to remove dissolved contaminants from water, producing water suitable for human use, such as drinking and cooking (Budiman et al., 2017).

Water purification can be carried out through two main approaches: simple methods and complex methods, depending on the level of water contamination and its intended use. Simple methods, such as filtration using slow sand filters, activated carbon, gravel, and cloth, are commonly used at the household level. Additionally, sedimentation—where water is left undisturbed until dirt particles settle—is also an effective simple solution. On the other hand, complex methods involve advanced technologies such as reverse osmosis (RO), desalination, ultrafiltration, ozonation, and disinfection using ultraviolet (UV) light. These technologies can filter small particles, ions, and microorganisms, resulting in high-quality water. Such methods are typically implemented on a large scale, such as in drinking water treatment plants or industrial sectors (Ilyas et al., 2021).

Education on water purification techniques and the importance of proper sanitation needs to be enhanced to maintain clean water quality. Public awareness of the benefits of clean water, its health impacts, and proper sanitation practices should be continuously promoted through various media (R. Widiastutie, 2023). One strategy that can be implemented is improving students' environmental literacy, which refers to the ability to understand, analyze, and find solutions to environmental issues (Hulyadi et al., 2024; Anggraini et al., 2022). The education sector must begin integrating digital literacy into general learning as a foundation for various emerging literacies (Nugraha, 2022). Based on findings and analyses, research on digital literacy in Indonesia's education sector from 2012 to 2023 has been a primary focus. This research revealed that the most frequently studied keywords, closely related to digital literacy development in education, include "Literacy, Technology, Literacy Skills, Data, and Teachers" (Sri Astuti Iriyani et al., 2023).

One of the main difficulties in learning is the lack of internal understanding among students. This problem often stems from low student engagement and motivation during the learning process, influenced by various factors such as uninteresting teaching methods, overly complex subject matter, or a lack of relevance to students' daily lives (Astafani et al., 2024). In a study by Yanti et al. (2017), it was suggested that high school chemistry teachers implement project-based and contextual learning approaches, as these methods can enhance students' skills and help solve real-world problems.

Project-based learning allows students to gain knowledge through hands-on experiences, collaboration, and participation in practical tasks. In this approach, well-designed projects serve as effective tools to motivate students in understanding the subject matter. This method prioritizes active learning, where students are directly involved in designing, planning, and executing projects that are relevant to the curriculum (Kamaruddin et al., 2023). To support contextual learning, various approaches can be applied to help students analyze key concepts in real life while also developing 21st-century skills. One widely used approach is Science, Technology, Engineering, and Mathematics (STEM) education (Bulu & Tanggur, 2021; Hulyadi et al., 2024). The STEM can be applied in water purification education effectively.

Through STEM-based learning, students are encouraged to explore scientific principles related to the chemical and physical properties of water, the technologies used in purification processes, engineering skills in designing water purification systems, and mathematical applications in analyzing process efficiency (Srikoom, 2018). By understanding the connection between science and technology in water purification, students develop greater awareness of environmental issues such as clean water scarcity and waste management (Hulyadi et al., 2024). Engaging students in hands-on learning—where they actively participate in understanding and experimenting with water purification techniques—can significantly enhance their motivation to learn. According to Yanti et al. (2017), using tangible tools in learning enables students to engage in practical and relevant activities. This active involvement fosters a sense of contribution toward solving environmental issues like water scarcity. When students realize that their learning outcomes can have real-world benefits, they tend to be more motivated to participate actively and absorb knowledge effectively (Hulyadi et al., 2023).

(Baran et al., 2021; Bulu & Tanggur, 2021; Effendi & Yoto, 2024) reported that the STEM approach applied in learning can also enhance students' curiosity. By integrating science, technology, engineering, and mathematics, students are encouraged to develop critical and analytical thinking skills. This process provides them with a more engaging and problem-solving-oriented learning experience, thereby strengthening their motivation for deeper learning. Research conducted by Suwardi (2021) indicates that students involved in STEM-based learning tend to exhibit increased enthusiasm and perseverance in their studies. Based on these findings, the development of water purification tools is crucial in addressing the complexities of the 21st century and enhancing students' thinking competencies.

METHOD

This research is a type of development research (Research & Development). This research was conducted referring to the ADDIE development model. The aim of using the ADDIE model is that the model can support program performance and provide dynamic and effective development. The stages of developing the ADDIE development model are as follows: 1) Analyze or analyze learning media needs on the topic of water purification using a STEM approach; 2) Design or design of water purification equipment products; 3) Develop or product development for water purification equipment; 4) Implementation or application of the product, where researchers will explore the feasibility of the water purification tool by validating it with experts before implementing it in the student learning process; 5) Evaluation or evaluation is the final stage which at this stage assesses the advantages, performance or performance of the water purification equipment that has been used in the learning process. This research is limited to the development stage. The research flow diagram is as follows:

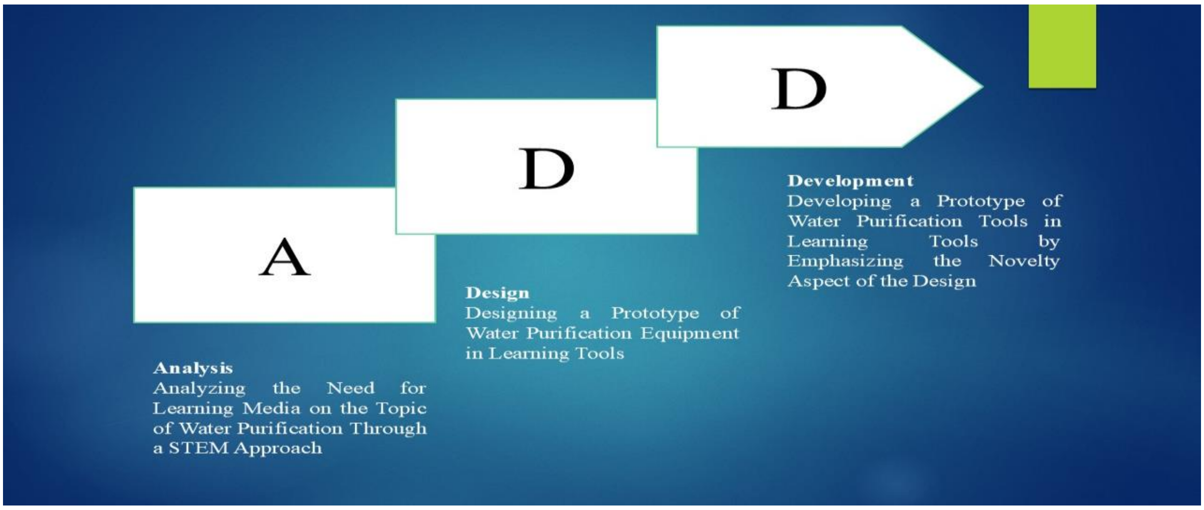

Figure 1. Research Flow Diagram

RESULTS AND DISCUSSION

Water is one of the most fundamental necessities due to its crucial role in life (Zulhilmi & Idawati, 2019). The disparity in clean water availability remains a significant issue and challenge in Indonesia. Another challenge is water pollution caused by human activities, such as untreated domestic and industrial waste. Climate change further exacerbates the availability of clean water sources in certain regions (Kummu et al., 2016). Today, the Sustainable Development Goals (SDGs) program emphasizes the importance of access to clean water and proper sanitation, as it is the sixth goal that must be achieved (Humaida et al., 2020; Rizki et al., 2022).

One mitigation measure that can be implemented is the development of water purification technology to ensure the availability of safe and usable water. Water purification is a process aimed at removing contaminants from water, making it suitable for daily use (Budiman et al., 2017). This topic can be integrated into STEM-based learning (Science, Technology, Engineering, Mathematics) to raise students' awareness of the importance of clean water management. Based on this, this research aims to develop a water purification tool that can be applied in the learning process through a STEM approach.

The research begins with an analysis through a needs assessment, conducted by distributing questionnaires regarding the use of learning media. The results of the needs assessment questionnaire indicate that approximately 48–52% of students and university students use learning media in the learning process, with textbooks and PowerPoint presentations still dominating as the primary tools. Students also stated that learning becomes easier when using media and that it increases their motivation and confidence in the learning process (Zhang, 2019). Based on this, there is a need for innovation in the use of learning media, one of which is the development of a water purification tool as a learning aid.

The development of a water purifier using a dual filter system is an innovative step in addressing water quality challenges. This tool, named HydroTechPure, is designed with an integrated approach, utilizing 3D design technology and Arduino-based control systems, providing both a practical and educational solution. The development process begins with the design phase, carried out using CorelDraw X6, a graphic design software that enables the creation of both 2D and 3D models with high precision. This stage is crucial, as the initial design determines the overall success of the system. CorelDraw X6 functions like other design software, where users must create layouts with specific dimensions based on their needs. The research team carefully designed the water purifier using CorelDraw X6, considering both technical and aesthetic aspects. This software allows users to create detailed designs, including determining the dimensions of each component as required.

In this design process, components such as the water reservoir, filter placement, water flow path, and outer casing were carefully arranged to ensure proper assembly without the risk of detachment. The model was also designed with ergonomic considerations, ensuring that the tool is easy to use for various audiences, including the general public and students in an educational context. In general, the water purifier is designed in a rectangular shape, with dimensions of 30 cm in length, 20 cm in width, and 45 cm in height. The outer casing is made of acrylic, chosen for several reasons, Lightweight – Acrylic reduces the overall weight of the system, despite the numerous internal components. Easy to shape – Acrylic can be easily cut, drilled, or molded with simple tools to match the pre-designed specifications. Affordable – Compared to 3D printing, which has a relatively higher cost, using acrylic as the final casing makes the tool more cost-effective and accessible to a broader audience.

In addition to the acrylic casing, another crucial external component is the base platform, which facilitates mobility. The wooden platform plays a key role in the HydroTechPure design, serving as both a foundation and providing stability, especially since the acrylic casing is lightweight. The platform is designed with dimensions of 31 cm in length and 21 cm in width, slightly larger than the main casing to ensure optimal stability. Wood was chosen for its strength and durability in supporting the overall structure of the tool. Using CorelDraw X6, the platform design was created to align with the casing, ensuring a sturdy yet aesthetically pleasing appearance. The majority of this research’s development activities were conducted at the Fabrication Laboratory Education (Fablab Edu), Faculty of Mathematics and Science Education (FPMIPA), Universitas Pendidikan Indonesia (UPI).

Fablab Edu is a newly inaugurated innovation lab, established in May 2023 as part of a collaboration between UPI and Sogang University, South Korea, under the Leading University Project for International Cooperation (LUPIC). This collaboration aims to strengthen the scientific and educational capabilities of future science educators. Fablab Edu is expected to maximize creativity among students and future educators, allowing them to explore modern technology, enhance their creativity, and develop innovative solutions that align with real-world needs.

Fablab provides access to cutting-edge technologies that support the development of educational products, including HydroTechPure. It is envisioned as not only an innovative workspace but also a learning center that enhances students' scientific and technological competencies.

After the design phase was completed, the design file was further processed using RDWorks V8, a software that refines the design by determining which parts require cutting and engraving techniques. These two techniques are essential in material processing, especially using laser machines**,** Cutting – This process completely separates material based on a specific design. It uses high-intensity lasers to burn or melt the material at designated areas, resulting in precise cut-outs. Engraving – Unlike cutting, engraving does not fully separate the material. Instead, it burns the surface layer, creating permanent patterns, text, or images for decorative or labeling purposes. Engraving is often used for adding logos, inscriptions, or intricate designs on wood, acrylic, metal, or glass. By combining cutting and engraving, the final product achieves precision and aesthetic appeal (Lasercut, 2022). Once the cutting and engraving instructions were finalized, the computer directed the CNC LS 1390 150-Watt laser machine with a CO_2 gas laser source to execute the cutting and engraving processes on wood. This step produced the base components of the purifier, ensuring they were both functional and visually refined.

The interior components of the device, made from acrylic, are meticulously designed to support the water filtration system, which serves as the core function of this tool. The complete design of HydroTechPure can be seen in the following image.

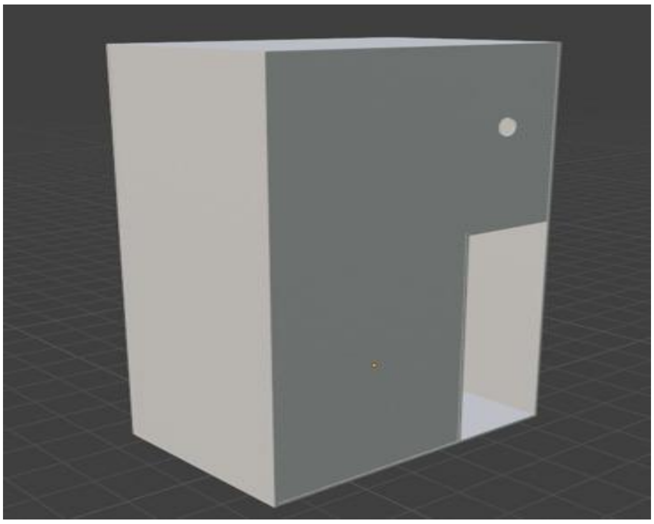

Figure 2. Tool design

The dual-filter system implemented in HydroTechPure ensures an effective and efficient water purification process. The first stage involves a contaminated water reservoir, where water passes through a ceramic filter designed to remove bacteria, heavy metals, and stabilize the water's pH. This filter plays a crucial role in ensuring that the water is free from microbiological and chemical contaminants that could be harmful to health. After passing through the first filter, the water enters the second purification stage, where it flows through a purifying filter made of high-quality absorbent materials that remove chlorine, trihalomethanes (THMs), organic pollutants, and colorants (Mewes, n.d.). Once the water has passed through the second filter, it is stored in a clean water reservoir. This dual-filter combination allows HydroTechPure to produce clean, safe water for daily use.

Following these two filtration stages, the purified water is pumped using a water pump connected to an Arduino system, ensuring optimal water pressure and a stable flow rate through both filters without damaging their structure. This integration with Arduino enhances efficiency while maintaining energy savings (Hikmarina et al., 2023). Additionally, LED indicators connected to Arduino help monitor water volume, making it easier for users to operate the device. Contribution to Sustainable Development Goals (SDGs) and STEM-Based Learning. Beyond its technical advantages, HydroTechPure supports the Sustainable Development Goals (SDGs), particularly Goal 6: Clean Water and Sanitation (SDGs, n.d.). With its ability to filter various contaminants, this device offers a practical solution to improve water quality in diverse environmental conditions.

Furthermore, HydroTechPure is designed as an educational tool that aligns with STEM-based learning (Science, Technology, Engineering, and Mathematics). It provides students with an understanding of the importance of clean water quality and purification processes (Srikoom, 2018). By engaging with HydroTechPure, students not only learn the scientific principles behind water filtration but also gain hands-on experience, fostering their creativity and innovation for future developments. STEM education encourages students to actively engage in exploration, discovery, and problem-solving, making the learning process interactive and contextual. For example, students work collaboratively to design solutions for real-world challenges, such as building a water purification system. This approach bridges theory and practice, equipping students with practical skills relevant to modern industry needs.

In STEM-based learning, teachers act as facilitators, helping students develop curiosity and logical thinking. Experimental learning, simulations, and digital technologies play essential roles in this process. Additionally, students are encouraged to adapt to rapid technological advancements and tackle complex challenges by developing higher-order thinking skills. The HydroTechPure system incorporates various STEM disciplines, making it a holistic learning tool that encourages interdisciplinary thinking and the development of 21st-century skills:

1. Science – The project applies scientific principles related to the physical and chemical properties of water and the mechanisms of water filtration and contaminant removal.
2. Technology – The research utilizes Arduino-based microcontroller technology to control LED indicators and a water pump for an automated purification process.
3. Engineering – The project involves technical design and engineering skills, including the fabrication of the acrylic structure, base platform, pump system, and integration of filters to ensure efficiency and usability.
4. Mathematics – Precise calculations determine the dimensions of the acrylic case and base, water pressure levels, and energy efficiency required for optimal functionality.

This combination of STEM elements makes HydroTechPure not only an innovative device but also an educational tool that encourages students to think across disciplines and develop practical problem-solving skills. The HydroTechPure system offers several educational and practical benefits:

1. Raising Environmental Awareness – The device educates students and communities about the importance of clean water and the processes involved in water purification.
2. Encouraging Educational Innovation – STEM-based research projects like this promote critical thinking, problem-solving, and creativity, which are essential for modern workplaces that demand technological adaptability and interdisciplinary collaboration.
3. Energy Efficiency & Sustainability – The HydroTechPure system is designed to be energy-efficient, utilizing eco-friendly technology to provide a sustainable solution for clean water access.

These aspects align with previous research on STEM education. According to Srikoom (2018), STEM-based learning engages students in studying the scientific principles of water purification, applying technology in filtration processes, designing engineering solutions, and using mathematical calculations to analyze purification efficiency. Additionally, Yanti et al. (2017) found that hands-on learning with practical tools enhances student engagement by providing real-world applications. When students actively participate in problem-solving activities, such as developing water purification systems, they feel a stronger sense of contribution toward addressing global environmental challenges, such as water scarcity.

Research conducted by Suwardi (2021) indicates that students engaged in STEM-based learning tend to show increased enthusiasm and perseverance in their studies. Therefore, the researcher hopes that by developing and implementing a water purification device as a learning medium, it can contribute to enhancing students' motivation in the learning process. Several previous studies support these findings, particularly in the context of water purification education. Research by Sari et al. (2021) revealed that the design of a modular filtration device based on Gravity Driven Membrane (GDM) successfully increased student motivation. Similarly, a study on the development of student worksheets (LKPD) for water purification activities by Nurokctavianti (2022) demonstrated a positive impact on student motivation. A related study by Ariana et al. (2022) also showed that the Project-Based Learning (PjBL) approach in water pollution topics increased student engagement. Additionally, an alternative approach, such as workshops and historical field trips on water filtration, as conducted by Wibowo et al. (2021), demonstrated that such activities enhanced student motivation and awareness regarding the water filtration process.

Based on these previous studies, it can be concluded that various approaches can be applied to support learning in water purification topics, ultimately boosting student motivation. Therefore, the development and implementation of a water purification device in the learning process through a STEM approach is expected to further enhance student learning motivation. Overall, HydroTechPure represents an innovative approach to addressing water quality challenges, combining technical efficiency with educational value. With its dual filtration system, Arduino-based pump, and aesthetically designed acrylic structure, this device is not only effective in removing contaminants but also user-friendly, energy-efficient, and environmentally friendly. HydroTechPure is a tangible step toward a better future, where clean water becomes accessible to everyone, while also raising awareness and fostering creativity among younger generations in preserving water resources for the sustainability of our planet.

CONCLUSION

This study aims to develop a water purification device that will be used in the learning process through a STEM approach to increase student motivation. The successfully developed water purification device is HydroTechPure, which applies a dual filter system technology using high-quality absorbent materials and is made of acrylic. This device is integrated with 3D design technology and an Arduino-based control system, developed at FabLab Edu UPI. The advantages of HydroTechPure are not only limited to its technical aspects but also support the achievement of SDG Goal 6. This water purification device as a learning medium is expected to be applied through a STEM approach to raise environmental awareness, encourage educational innovation, ensure energy efficiency, and be environmentally friendly. Furthermore, it is hoped to increase student motivation in learning, as supported by various previous studies.

RECOMMENDATIONS

Recommendations related to the development of water purification equipment include the need to improve technology through the integration of sensors capable of providing indications of water quality. Apart from that, trials of the tools developed need to be carried out in the learning process, so that they can be implemented in STEM-based educational activities to increase student motivation.

ACKNOWLEDGEMENTS

This research was supported by the Chancellor of the Indonesian University of Education and the Ministry of Education, Culture, Research and Technology

BIBLIOGRAPHY

Anggraini, N., Nazip, K., Amizera, S., & Destiansari, E. (2022). Penerapan Model Problem Based Learning Berbasis STEM Menggunakan Bahan Ajar Realitas Lokal terhadap

Literasi Lingkungan Mahasiswa. *BIOEDUSAINS: Jurnal Pendidikan Biologi Dan Sains*, *5*(1), 121–129. https://doi.org/10.31539/bioedusains.v5i1.3589

Ani, N., & Harahap, A. (2022). Kajian Kualitas Air Sungai. *BIOEDUSAINS: Jurnal Pendidikan Biologi Dan Sains*, *5*(1), 8.

Ariana, R. M., Rasmawan, R., & Sartika, R. P. (2022). Pengembangan Lkpd Berbasis Project Based Learning pada Materi Pencemaran Air di SMP Pontianak. Jurnal Education and Development, 10(2), 259-268.

Astafani, A., Resmawati, R. F., & Luqmanul, E. (2024). *Jurnal Inovasi Pendidikan Kimia Systematic Review : Faktor- Faktor Kesulitan Belajar Materi Kimia*. *18*(2).

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The ınfluence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills. *Journal of Turkish Science Education*, *18*(4), Article 4. https://doi.org/10.36681/tused.2021.104

Bulu, V. R., & Tanggur, F. (2021). The Effectiveness of STEM-Based PjBL on Student's Critical Thinking Skills and Collaborative Attitude. *Al-Jabar : Jurnal Pendidikan Matematika*, *12*(1), 219–228. https://doi.org/10.24042/ajpm.v12i1.8831

Budiman, A., Wahyudi, C., Irawati, W., & Hindarso, H. (2017). Kinerja Koagulan Poly Aluminium Chloride (PAC) dalam Penjernihan Air Sungai Kalimas Surabaya Menjadi Air Bersih. *Widya Teknik*, *7*(1), 25–34. http://journal.wima.ac.id/index.php/teknik/article/view/1258

Effendi, M. I., & Yoto, Y. (2024). Pembelajaran Abad-21 Melalui Model Project Based Learning Terintegrasi STEM (PJBL-STEM) dalam Meningkatkan Kemampuan Berpikir Tingkat Tinggi. *Briliant: Jurnal Riset dan Konseptual*, *9*(1), Article 1. https://doi.org/10.28926/briliant.v9i1.1637

Fatimah, Y. A., Govindan, K., Murniningsih, R., & Setiawan, A. (2020). Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. *Journal of Cleaner Production*, *269*, 122263. https://doi.org/10.1016/j.jclepro.2020.122263

Febriani, H., Fatonah, Y., & Erlyta, N. N. (2013). Pengaruh Akses Air Bersih dan Peningkatan Sanitasi Lingkungan terhadap Angka Kematian Bayi Usia di Bawah Lima Tahun dan Perlambatan Pertumbuhan Fisik Anak. *Jurnal Kesehatan Masyarakat*.

Fogden, J., & Wood, G. (2009). Access to Safe Drinking Water and Its Impact on Global Economic Growth. Bothell, WA, *USA: HaloSource Inc*.

Hartanto, B., Mulyawan, R., Meidira, G., Zikrian, M. Z., & Nuraini, P. (2024). Inovasi Sistem Penyaringan dan Pemantauan Kualitas Air Berbasis IoT. *Warta Akab*, *48*(1), 61–67.

Hikmarina, R., Sari, S., Yanti, H., & Rahmi. (2023). Inovasi Penjernihan Air Sebagai Solusi Ketersediaan Air Bersih Di Desa Pandan Sejahtera. *Jurnal Pengabdian Masyarakat Pinang Masak*, *4*(1), 9–14. https://doi.org/10.22437/jpm.v4i1.22511

Hulyadi, H., Bayani, F., Ferniawan, Rahmawati, S., Liswijaya, Wardani, I. K., & Swati, N. N. S. (2024). Meeting 21st-Century Challenges: Cultivating Critical Thinking Skills through a Computational Chemistry-Aided STEM Project-Based Learning Approach. *International Journal of Contextual Science Education*, *1*(2), 57–64. https://doi.org/10.29303/ijcse.v1i2.609

Hulyadi, H., Bayani, F., Muhali, M., Khery, Y., & Gargazi, G. (2023). Correlation Profile of Cognition Levels and Student Ability to Solve Problems in Biodiesel Synthesis. *Jurnal*

Penelitian Pendidikan IPA, *9*(6), Article 6. https://doi.org/10.29303/jppipa.v9i6.3130

Humaida, N., Aula Sa'adah, M., Huriyah, H., & Hasanatun Nida, N. (2020). Pembangunan Berkelanjutan Berwawasan Lingkungan (Sustainable Development Goals) dalam Perspektif Islam. *Khazanah: Jurnal Studi Islam Dan Humaniora*, *18*(1), 131. https://doi.org/10.18592/khazanah.v18i1.3483

Ilyas, A., et al.,. (2021). Teknologi Pengolahan Air: Metode Filtrasi dan Desinfeksi. *Jurnal Teknologi Lingkungan*, 24(2), 235-241.

Iriyani, S. A., Milla, D., & Lede, Y. K. (2023). Perkembangan Literasi Digital dalam Pendidikan: Sebuah Tinjauan Bibliometrik. *Jurnal Literasi Digital dan Pengabdian Masyarakat*, 1(2), 41-49. doi:10.57119/litdig.v1i2.88

Kamaruddin, I., Suarni, E., Rambe, S., Sakti, B. P., Rachman, R. S., & Kurniadi, P. (2023). Penerapan Model Pembelajaran Berbasis Proyek dalam Pendidikan: Tinjauan Literatur. *Jurnal Review Pendidikan Dan Pengajaran*, *6*(4), 2742–2747. https://journal.universitaspahlawan.ac.id/index.php/jrpp/article/view/22138

Komarulzaman, A., Smith, J., dan de Jong, E. (2014). *Clean Water, Sanitation, and Diarrhea in Indonesia.*

Kornita, S. E. (2020). Strategi Pemenuhan Kebutuhan Masyarakat terhadap Air Bersih di Kabupaten Bengkalis. *Jurnal Samudra Ekonomi Dan Bisnis*, *11*(2), 166–181. https://doi.org/10.33059/jseb.v11i2.1883

Kummu, M., Guillaume, J. H. A., De Moel, H., Eisner, S., Flörke, M., Porkka, M., Siebert, S., Veldkamp, T. I. E., & Ward, P. J. (2016). The world's road to water scarcity: Shortage and stress in the 20th century and pathways towards sustainability. *Scientific Reports*, *6*(December), 1–16. https://doi.org/10.1038/srep38495

Lasercut Depok. (2022). Perbedaan Laser *Grafir* dan Laser *Cut*. [online]. Available: https://lasercutdepok.com/perbedaan-laser-grafir-dan-laser-cut/

Mewes, D. (n.d.). *Bicycle-Powered Arduino Water Purification System (Using UVC Light)*

Nita, Latang, & Muftihatul. (2024). Penerapan Model Pembelajaran Project Based Learning untuk Meningkatkan Motivasi Belajar Peserta Didik. *Global Journal Pendidikan Dasar*, *3*(1), 136–155.

Nugraha, D. (2022). Literasi Digital dan Pembelajaran Sastra Berpaut Literasi Digital di Tingkat Sekolah Dasar. *Jurnal Basicedu*, *6*(6), 9230–9244. https://doi.org/10.31004/basicedu.v6i6.3318

Patunru, A. (2015). *Access to Safe Drinking Water and Sanitation in Indonesia. Asia % the Pacific Policy Studies, vol. 2, no.2*.

Peraturan Menteri Kesehatan RI No.416/MENKES/PER/IX/1990," Syarat-syarat dan Pengawasan Kualitas Air. *Jakarta: Departemen Kesehatan Republik Indonesia*.

Perserikatan Bangsa-Bangsa. (2006). *HDI In Asia and Pacific United Nations for Development Programme (UNDP).*

R Widiastutie. (2023). Dampak Krisis Air Bersih Terhadap Kesehatan dan Strategi dalam Mengatasi Permasalahan Di Perkampungan Ciwantani RW 17. *Jurnal Ilmiah Ekonomi Dan Manajemen*, *2*(2), 114–120.

Rachmawati, T. K., & Hasanah Dewi Lestari. (2024). Penerapan Pembelajaran Berbasis Proyek Dalam Konteks STEM Pada Pembelajaran IPA Untuk Melatih Keterampilan

Berpikir Kritis. *Prosiding Seminar Nasional Keguruan dan Pendidikan (SNKP)*, 2(1), 189–195.

Rizki, K., Sood, M., & Husni, V. (2022). Keamanan Manusia Dalam Rencana Aksi Daerah: Implementasi Tujuan Pembangunan Berkelanjutan (Sustainable Development Goals) di Provinsi Nusa Tenggara Barat. *Papua Journal of Diplomacy and International Relations*, *2*(1), 59–80. https://doi.org/10.31957/pjdir.v2i1.1944

Rosen, S. and Vincent, J.R. (1999). *Household Water Resources and Rural Productivity in sub-Saharan Africa: A Review of the Evidence. Harvard Institute of International Development.*

Sari, I. N., Khery, Y., Nufida, B. A., Hatimah, H., & Hendrawani, H. (2023). Gagasan Perancangan Alat Filtrasi Bongkar Pasang berbasis Gravity Driven Membran (GDM) untuk Meningkatkan Motivasi Siswa. *Jurnal Ilmiah IKIP Mataram*, *8*(2), 242-255.

SDGs. (n.d.). *The 2030 Agenda for Sustainable Development's 17 Sustainable Development Goals (SDGs).*

Sri Astuti Iriyani, Milla, D., Lede, Y. K., & Kholidi. (2023). Perkembangan Literasi Digital dalam Pendidikan: Sebuah Tinjauan Bibliometrik. *Indo-MathEdu Intellectuals Journal*, *4*(2), 1289–1301. https://doi.org/10.54373/imeij.v4i2.349

Srikoom, W. (2018). What is STEM education? In *Research Gate*. https://doi.org/10.1126/science.1194998

Sukartini, N. M., & Samsubar, S. (2016). Akses Air Bersih di Indonesia. *Jurnal Ekonomi Kuantitatif Terapan*, *9*(2), 10.

https://www.neliti.com/publications/228355/akses-air-bersih-di-indonesia

Suwardi. (2021). STEM (Science, Technology, Engineering, and Mathematics) Inovasi Dalam Pembelajaran Vokasi Era Merdeka Belajar Abad 21. *PAEDAGOGY : Jurnal Ilmu Pendidikan Dan Psikologi*, *1*(1), 40–48. https://doi.org/10.51878/paedagogy.v1i1.337

United Nation for Children Funds. (2001). *Sanitation for All-Promoting Dignity and Human Right. UNICEF Data.*

United Nation for Children Funds. (2024). Under-Five Mortality. *UNICEF Data*. [online] Available: https://data.unicef.org/topic/child-survival/under-five-mortality/

Wibowo, T. U. S. H., Namirah, I., Solfarina, S., Nurhasanah, A., Maryuni, Y., Yuwono, A. B., & Karima, F. R. (2023). Workshop dan Field Trip Sejarah Filtrasi Air Masa Kesultanan Banten Untuk Membangun Kepedulian Siswa Terhadap Lingkungan. *Archive: Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 35-45.

World Bank. (1994). *World Development Report. The World Bank, London.*

Yanti, Y., Harun, I., & Rasmawan, R. (2017). Penerapan Metode Proyek Dalam Proses Pembuatan Alat Penjernihan Air Menggunakan Prinsip Koloid Program Studi Pendidikan Kimia Universitas Tanjungpura. *Artikel Penelitian*.

Zhang, L. (2019). Application Research of Automatic Generation Technology for 3D Animation Based on UE4 Engine in Marine Animation. *Journal of Coastal Research*, *93*(sp1), 652. https://doi.org/10.2112/SI93-088.1

Zulhilmi, & Idawati. (2019). Pengelolaan Konsumsi Air Bersih pada Rumah Tangga di Kecamatan Peudada Kabupaten Bireun. *Jurnal Serambi Akademica*, *7*(5), 657. https://doi.org/10.32672/jsa.v7i5.1523