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Developing a noise level detector as a STEM-based science learning medium

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Abstract

Despite its negative impact on student concentration and learning effectiveness, excessive classroom noise is often overlooked. Addressing this issue is critical for creating a conducive learning environment and improving the quality of education. This study aimed to develop a STEM-based classroom noise detector as a learning medium for junior high school students using the ADDIE model, which consists of five phases: analysis, design, development, implementation, and evaluation. In the analysis phase, we identified the need for noise management tools and STEM-based learning media. During the design phase, the noise detector prototype was conceptualized with four thresholds light (35–55 dB), moderate (56–70 dB), heavy (71–85 dB), and very heavy (>85 dB) and equipped with a buzzer warning system for hazardous noise levels. The development phase involved assembling and testing the prototype in a laboratory setting, followed by creating STEM-integrated educational materials. In the implementation phase, the tool was tested in classroom simulations to replicate real-world conditions, ensuring usability and functionality. Lastly, the evaluation phase measured the effectiveness of the device in managing classroom noise and its impact on students' engagement and learning outcomes. This research successfully developed a functional noise detector that not only serves as a practical solution for classroom noise management but also enhances STEM-based learning by stimulating curiosity and fostering hands-on science activities.

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Keywords

Student concentration, Learning effectiveness, Classroom noise, STEM, Learning medium

Introduction

The learning process requires a conducive learning environment, one of which is controlling the noise level in the classroom. Excessive noise can disrupt students' concentration and reduce the quality of the teaching and learning process [1]. In many schools, including at the junior high school level, the issue of classroom noise is often overlooked, even though its impact on the understanding of the material being taught

is quite significant, especially in subjects that require high concentration, such as natural sciences [2]. The lack of awareness about the importance of noise management in the classroom leads to a suboptimal learning environment [3]. This study highlights the issue of inadequate tools and methods for both students and teachers to monitor and control the noise levels in the classroom [4]. This noise not only disrupts the learning atmosphere, but it can also lead to psychological disturbances that negatively impact students' mental health. This study highlights the issue of inadequate and user-friendly tools for both students and teachers to monitor and control noise levels effectively in real-time. The novelty of this research lies in the development of a STEM-based classroom noise detector that not only serves as a practical solution to noise management but also functions as a learning medium to teach science, technology, engineering, and mathematics concepts. Unlike previous studies, this research bridges the gap by combining noise management with STEM education, addressing both environmental challenges, and fostering hands-on, inquiry-based learning experiences for junior high school students. Therefore, we need a simple and effective tool to detect noise levels in the classroom, which can also serve as an integral part of STEM-based science learning (Science, Technology, Engineering, and Mathematics) that stems from real-world problems in schools.

The urgency of this research lies in the increasing need for technology-based education in the digital era. STEM-based learning is becoming increasingly relevant as it can prepare students to face future challenges related to technology and science [5]. Technology integration allows for the integration of this tool into the curriculum, enhancing the interactive learning experience and raising students' awareness of the importance of maintaining an optimal learning environment. In addition, this tool can be a practical solution for teachers to monitor and control classroom noise, which can ultimately enhance the effectiveness of the learning process.

This research aims to develop a Class Noise Level Detector as an interactive STEM-based teaching aid for middle school students. We anticipate that this tool will aid students in comprehending fundamental physics concepts like sound waves, intensity, and decibel, while effectively tackling the noise issues they face daily. In addition, the use of this tool in STEM-based learning also aims to enhance students' skills in technology, science, and mathematics, as well as to encourage critical thinking and innovative solutions to learning environment problems.

Method

This study employs the research and development method, which aligns with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) [6,7]. This study aims to develop and test the effectiveness of a noise detector as a STEM media in junior high school. This study includes all science-teaching students at Unggulan Aisyiyah Bantul elementary school, with a sample of 30 students from a single class. We conducted the sample selection using the simple random sampling technique, assuming

the entire population to be homogeneous. The data collection techniques differ at each stage of ADDIE, according to the research needs. During the analysis stage, researchers gather data from observations, interviews, and literature studies to pinpoint the needs of students, teachers, and noise concerns in the classroom. The design stage involves focus group discussions to design during the development stage; we collect data through interviews to test the prototype. The implementation stage involves collecting implementation data through observations and interviews in the classroom. The evaluation stage is conducted by analyzing all stages that contain feedback about the tool. We utilized qualitative descriptive methods to analyze the collected data, taking into account the stage of the research. We used qualitative descriptive methods to analyze data at different stages of the ADDIE framework. We used observations, interviews, and feedback to identify issues, refine the tool, and evaluate its usability. This analysis helped assess the tool's effectiveness in reducing noise and enhancing STEM-based learning.

Results

The ADDIE stages provide an explanation of the research results.

Analysis

At the analysis stage, the results of observations and interviews indicate that most teachers and students have difficulty managing classroom noise. The thematic data from teacher interviews suggests that students' uncontrolled interactions, their lack of awareness about the impact of noise, and the lack of tools to monitor noise levels in the classroom are the main causes of noise. Literature review results also reinforce these findings, where a noisy learning environment negatively impacts student concentration and learning effectiveness. Factors such as the location of classrooms near busy areas and the absence of noise control mechanisms further exacerbate this situation [8,9]. Additionally, interviews with students revealed that they find it difficult to focus during lessons, especially in subjects that require high concentration, such as science. Data from the literature review also notes that high noise levels can increase psychological stress for both students and teachers. Based on these findings, the need for effective tools to monitor noise becomes very clear. A synthesis of threshold data from several studies indicates that the WHO sets the noise threshold in school environments at 72 dB (A) for general school areas and 35–55 dB (A) inside classrooms during learning. ACGIH sets noise exposure limits for workers with specific durations, for example, 92 dB (A) for 4–8 hours per day and 107 dB (A) for exposures of less than 1 hour [9,10]. This research uses four threshold levels, namely light (0-55 dB), moderate (56-72 dB), heavy (73-85 dB), and very heavy (> 85 dB), as the basis for creating the prototype. This stage also establishes the specifications for the device, which will display both visual and audio information. The visual display shows the results of the sensor readings, while the buzzer, which emits a red color when the device detects very heavy noise, produces the sound.

Design

The results of the focus group discussion (FGD) with teachers and the research team produced an initial design of a noise detector equipped with visual and auditory indicators. The design aims to simplify the tool's understanding and use for both students and teachers. Figure 1 shows the procedure for developing the tool.

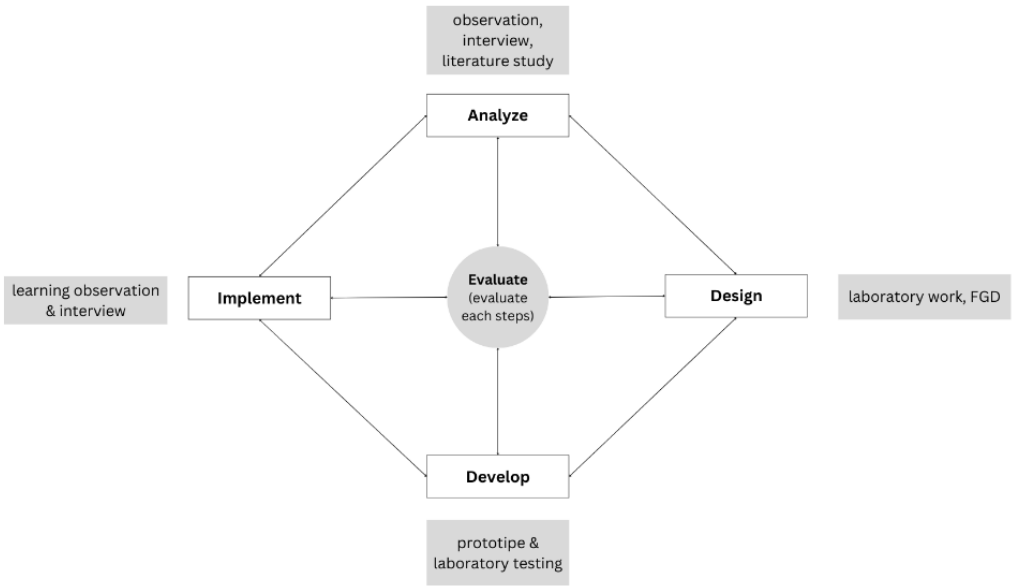

Figure 1. Noise Detector Development Procedure

The device's usage instructions aim to aid students in comprehending fundamental physics concepts like sound waves and noise intensity. Visual indicators in the form of LEDs and warning sounds from the device provide direct notifications regarding the noise level in the classroom. We adjusted in the design process to meet user needs. The teacher offered suggestions on how to utilize the tool in teaching and learning activities. The teacher also suggested the preparation of experimental instructions involving the tool so that students can understand the relationship between theory and practice. The design of this tool has gone through several iterations to ensure that its design is user-friendly and relevant to the classroom learning context.

Development

We have developed and tested the tool prototype in the laboratory. The test results show that the device can accurately detect noise levels with easily understandable indicators. Feedback from teachers and students during this stage indicates that the tool is very helpful in understanding the concept of noise and raising awareness of the learning environment. We made several technical revisions to enhance the tool's functionality based on these results Figure 2 shows how the tool works.

We tested the user instructions and experimental guidelines in addition to developing the tool. Teachers and students provided feedback regarding the content of the guide, especially the experimental section involving the use of tools. We revised the guide to make the instructions clearer and the layout more appealing to students. The test results also show that this tool is capable of increasing student participation during the

learning process, especially when they are directly involved in the noise measurement process.

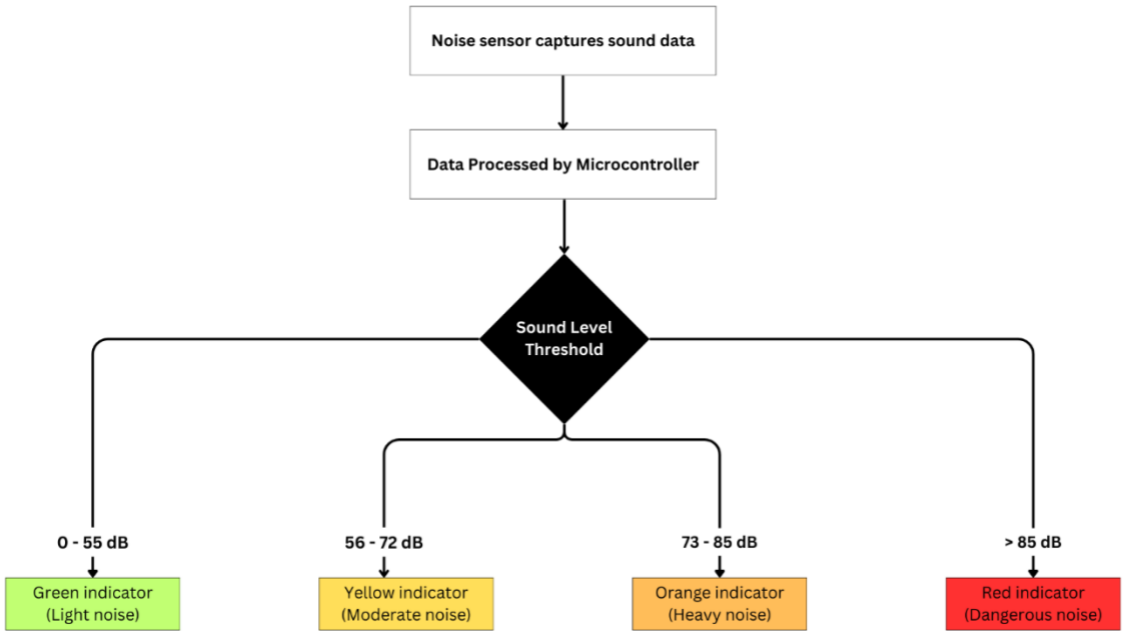

Figure 2. Noise Detector Workflow

Implementation

The use of the tool in the classroom shows positive results. Based on classroom observations and interviews, this tool helps significantly reduce noise levels. Students become more aware of the impact of noise and more active in maintaining a conducive learning environment. The teacher also expressed how the presence of this tool has improved the effectiveness of learning. This is evident in the increase in student engagement during the teaching and learning process. Data collection through interviews also shows that students find this tool intriguing and beneficial. They believe that this tool offers a fresh learning experience, particularly because it incorporates technology that they consider contemporary. The teacher added that this tool makes it easier for them to control the classroom conditions, allowing them to focus on delivering the learning material.

Evaluation

The results of the interview and observation analysis at each stage show that students feel more motivated to learn with the presence of this tool. Teachers also provided positive feedback on the use of this tool, particularly regarding its effectiveness in raising students' awareness to maintain the classroom atmosphere and help students be more engaged in learning. The tool received several suggestions for improvement, including the addition of a feature that automatically records noise data. We can further develop this tool based on the evaluation results, enabling its wider application in various schools.

Discussion

The results of this study indicate that the noise measurement tool has several significant advantages. Firstly, the design of this tool incorporates both visual and auditory indicators, facilitating real-time noise level monitoring for both students and teachers. This ease of use enhances teachers' efficiency in managing the classroom atmosphere. Additionally, the design of this tool provides an advantage in technology integration, making it relevant to the increasingly digital developments in modern education. This tool also serves as an effective STEM learning medium. By integrating science, technology, engineering, and mathematics in its use, this tool not only helps students understand physics concepts such as sound waves and noise intensity but also teaches practical applications of technology in everyday life. The experiment instructions specifically designed to support the use of this tool also enrich the students' learning experience because they are more engaging and interactive.

The positive impact of this tool on students' skills is very real. Students' curiosity directly increases when they use this tool, as it encourages them to explore and understand its workings [11]. Students' enthusiasm for learning also increased, as seen from their active participation in experimental activities [12]. Students develop their problem-solving skills when they encounter real-life situations, such as controlling the noise level in the classroom [13]. Moreover, they hone their critical thinking skills by analyzing the obtained noise data and evaluating the best solutions to create a more conducive learning environment [14]. This tool develops collaboration, communication, and other skills. Students often work in groups to operate the tools, analyze data, and discuss their findings [15,16]. These activities not only support STEM learning but also equip students with 21st-century skills that are crucial for their future. Thus, this tool not only serves as a technical solution for classroom noise but also as a means of holistic development for students.

In addition to those benefits, the integration of this tool in STEM education has a long-term impact on students. This tool prepares students to face the challenges of the digital era by enhancing their technological literacy. Students not only learn to use this tool but also understand the principles of how digital technology works, which form the basis of many modern technologies. Thus, students not only acquire knowledge but also develop adaptive thinking skills that are crucial in facing the changes of the times. This research also demonstrates the tool's ability to foster a more meaningful learning experience [17]. Students are involved in the process of measuring and analyzing noise data, which gives them a sense of responsibility for their own learning outcomes. This approach aligns with the STEM-based learning philosophy that emphasizes hands-on learning and real-world problem-solving [18,19].

Furthermore, the use of this tool helps improve the relationship between teachers and students. Teachers can use the noise data obtained to discuss with students the importance of maintaining a conducive learning environment. This discussion not only enhances students' understanding of the concept of noise but also strengthens their awareness of the shared responsibility in creating a supportive learning environment.

However, this study also notes several constraints that need to be considered. One of the main constraints is the need for teacher training to use this tool optimally. Despite its user-friendly design, teachers require time to comprehend its features and find the most effective ways to incorporate it into their teaching. In addition, there is a need to ensure that this tool is accessible to all schools, including those with limited resources. The results of this research indicate that the noise measurement tool is an innovation that is not only relevant but also has a wide impact on learning. This tool exemplifies the integration of technology, science, and practical learning, thereby enhancing the quality of education.

Conclusion

This research successfully developed a noise detector as a STEM-based science learning medium. The research results show that this tool not only reduces the noise level in the classroom but also enhances students' understanding of physics concepts such as sound waves and noise intensity. This research applies an interactive STEM-based approach that effectively addresses the challenges of the digital era. The use of this tool also contributes to the creation of a more conducive learning environment, which can ultimately enhance the quality of education. In addition, this research contributes to the development of technology-based learning media, which is relevant to curriculum needs. However, to test the sustainability and application of this tool in various other educational contexts, further research is necessary. Further research could also focus on developing additional features for this tool, such as automatic data recording and cloud-based data analysis to enhance its functionality.

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