Training and Implementation of DIGICOM to Enhance Elementary Science Learning through Community Service Innovation

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Abstract

This community service program was conducted to enhance the competencies of elementary school teachers in utilizing the innovative teaching aid Digital Image Creator for Optical Microscope (DIGICOM) to strengthen science learning. The program was motivated by the limited availability of digital microscopes in schools and the low ability of teachers to adapt optical learning technologies. The main objective was to train teachers from the Imam Bonjol Teacher Working Group (KKG) in Banjarnegara Regency to modify conventional optical microscopes into digital microscopes integrated with imaging systems. The training was carried out online through a series of activities including lectures, discussions, camera adapter design workshops, DIGICOM implementation, and mentoring with follow-up evaluations. A total of 51 teachers actively participated in the practice sessions and group projects. The results showed a significant improvement in teachers' conceptual understanding, technical skills, and motivation to implement DIGICOM in science learning. More than 85% of participants were able to operate the modified tool successfully and apply it in their schools. These findings demonstrate that the implementation of DIGICOM is an effective educational innovation to improve the quality of science learning in elementary schools and strengthen teachers' digital literacy in science education.

Keywords: *DIGICOM, digital teaching aid, science learning, elementary school, community service*

INTRODUCTION

The microscope is one of the most essential laboratory tools in science learning activities at schools. Through the use of a microscope, students can observe microscopic objects such as cells, tissues, and microorganisms, which form the foundation for understanding abstract scientific concepts. However, science practicum activities in elementary schools are often constrained by the limited number of microscopes and their inefficient use in the classroom. Advances in optical technology and the digitalization of laboratory equipment offer opportunities to overcome these barriers by modifying optical microscopes into digital microscopes that are more affordable, portable, and easy to operate (Ariyanto, 2005; Raya, Hidayatno, & Zahra, 2016). This innovation has the potential to expand students' access to scientific observation activities, which have traditionally been confined to laboratories.

On the other hand, one of the main challenges faced by elementary science teachers is the lack of skills in integrating technology into science instruction. Most teachers still employ conventional methods that emphasize memorization rather than empirical exploration. In fact, the integration of digital technology can strengthen students' critical thinking and scientific observation skills (Subali et al., 2020; Tanang, Djajadi, Abu, & Mokhtar, 2014). Teachers therefore need to be equipped with practical training to learn how to transform simple tools—such as digital cameras and optical microscopes—into innovative, technology-based teaching aids. This gap underscores the necessity for hands-on professional development that enables teachers not only to understand theoretical concepts but also to design and implement effective science learning media.

DIGICOM (*Digital Image Creator for Optical Microscope*) emerges as an innovative solution bridging the gap between pure science concepts and the application of educational technology. This device integrates an optical microscope system with digital imaging technology, allowing observation images to be displayed directly on screens, stored, magnified, and shared online. The use of image processing software such as MATLAB enables contrast enhancement, image quality measurement, and precise edge detection (Ahmad, 2005; Ningtias, Suryono, & Susilo, 2016). Thus, DIGICOM not only enriches students' learning experiences but also promotes the development of contextual and interactive science learning based on observation.

Previous studies have demonstrated that optoelectronic and digital imaging–based learning media can improve students' motivation and learning outcomes in science subjects (Alvian, Yulianto, & Subali, 2017; Susilo, Sutikno, Sunarno, & Sugiyanto, 2016). Furthermore, the modification of simple laboratory tools into digital devices has been proven to expand access to laboratory-based learning in schools with limited resources (Karina, 2009; Mustaqim, 2011). Supported by affordable and applicable digital learning approaches, the development of tools such as DIGICOM provides tangible contributions to improving technological literacy among elementary school teachers and students.

This community service program was designed to enhance teachers' competence in designing and utilizing DIGICOM as a digital teaching aid in science education. The focus of this activity was training and mentoring teachers from the *Imam Bonjol Teacher Working Group* (KKG) in Banjarnegara Regency. Through this program, teachers were trained to modify optical microscopes into digital microscopes integrated with cameras and simple imaging software. The activity not only aimed to strengthen teachers' professional capabilities but also to optimize the quality of science learning in elementary schools and foster a culture of innovation in science education practice in the digital era.

METHODS

This community service program was conducted entirely online using the Zoom Meeting and WhatsApp Group platforms to facilitate lectures, discussions, training sessions, and the collection of teachers' practice results. The participants consisted of 51 elementary school teachers who are members of the

Imam Bonjol Teacher Working Group (KKG) in Banjarnegara Regency, Indonesia. The activity took place over a four-month period, from July to October 2021, and was organized into six structured stages. The approach adopted in this program was participatory training and mentoring, which emphasized the active involvement of participants throughout all stages of the process—from the design and assembly of instructional tools to their implementation in classroom learning.

The main equipment used in the training included a conventional single-ocular optical microscope, commonly available in partner schools. Supporting devices consisted of a digital camera or webcam with a minimum resolution of 0.3 megapixels (e.g., Sierra D320C, 1/3" Sony CCD Color Sensor), a camera adapter made from a 2.4 cm aluminum tube designed to fit the microscope eyepiece and equipped with an additional magnifying lens, a computer or laptop operating on Windows 10 with MATLAB version R2016a software for image processing, and a USB converter to connect the analog camera signal to the computer. Additionally, participants' smartphones were used for documentation, data submission via Google Forms, and communication through WhatsApp Groups. The choice of these components was based on their affordability, availability, and potential for replication in elementary schools, ensuring that the resulting technology could be widely adopted and sustained.

The implementation process consisted of six stages. The first stage, Lecture and Conceptual Discussion, introduced participants to the theoretical foundations of optical microscopy, digital imaging systems, and the role of DIGICOM in enhancing science learning. The second stage involved Training on Digital Camera Principles and Adapter Fabrication, in which teachers learned the working principles of CCD cameras and the process of constructing adapters from aluminum pipes through virtual demonstrations. The third stage, DIGICOM Design and Assembly, required participants to work in groups to assemble the camera adapter, connect it to the microscope, and test the resulting digital images on computer screens. The fourth stage, Installation and Digital Image Testing, focused on installing MATLAB and applying its basic image-processing features such as contrast enhancement, Mean Square Error (MSE), and Peak Signal-to-Noise Ratio (PSNR) analysis.

The fifth stage was Implementation of DIGICOM-Based Science Learning, where teachers applied the knowledge gained from the training to their classroom practices by displaying microscopic images through projectors during science lessons. The final stage, Mentoring and Evaluation, involved continuous online mentoring and assessment of participants' performance based on observation sheets, group assignments, and post-training questionnaires. This structured approach ensured that participants not only acquired theoretical understanding but also practical competence in using DIGICOM for teaching science in elementary schools.

Data analysis employed both quantitative and qualitative descriptive methods. Quantitative analysis was conducted using post-training questionnaires to measure teachers' mastery of the material and their motivation levels. The minimum mastery criterion (KKM) was set at 65%, and scores were categorized into five levels: very high, high, moderate, low, and very low. Qualitative analysis complemented these results by describing the training process, identifying technical challenges, and interpreting participants' feedback regarding DIGICOM utilization in classroom learning. To ensure data validity, triangulation was applied by cross-verifying the results from observations, group project reports, and participant reflections submitted through Google Forms.

RESULTS AND DISCUSSION

The training and implementation of the Digital Image Creator for Optical Microscope (DIGICOM) program were attended by 51 elementary school teachers who are members of the Imam Bonjol Teacher Working Group (KKG) in Banjarnegara Regency, Indonesia. The activities were conducted online using the Zoom Meeting and WhatsApp Group platforms, where participants engaged in six sequential stages, ranging from theoretical lectures and technical workshops to classroom implementation. Based on attendance records and engagement levels throughout the program, all participants actively joined the sessions, achieving a 100% participation rate. This finding indicates that a participatory online learning model can serve as an effective alternative for enhancing teacher competence in the digital era (Rahman, 2020; Sun, Tang, & Zuo, 2022).

Survey results revealed that 96% of participants had never previously attended training related to the use of digital microscopes. However, after the program, 89% of teachers demonstrated strong comprehension of the material, and 85% successfully assembled and operated the DIGICOM device independently. Participants reported that the use of DIGICOM simplified observation-based science instruction, as microscopic images could be directly projected and observed collectively with students. These results align with the findings of Alvian, Yulianto, and Subali (2017), who concluded that digital image–based instructional media improve student motivation and enhance the effectiveness of science learning at the elementary level.

From the implementation perspective, most teachers successfully applied the knowledge gained from the training in their respective schools with positive outcomes. The use of DIGICOM helped them explain microscopic concepts that were previously difficult for students to visualize. For example, the observation of leaf and animal cell specimens became clearer using a CCD camera connected to an optical microscope. This advantage encouraged students to participate more actively in group observation sessions, reinforcing the concept of collaborative learning, which emphasizes interaction and visual exploration (Mishra & Koehler, 2006; Hidayat, 2019). Similarly, Subali et al. (2020) found that DIGICOM training for physics teachers significantly enhanced their pedagogical abilities and technological literacy.

The data analysis further indicated improvements in teachers' motivation and creativity in developing technology-based learning media. As many as 91% of participants stated that the training encouraged them to innovate by utilizing available digital tools, such as school cameras and laptops, to support instructional activities. This result supports the view of Tanang et al. (2014), who emphasized that teacher professionalism requires adaptability to new technologies as part of 21st-century competencies. Moreover, the integration of simple digital devices into instructional aids has the potential to foster teachers' technological pedagogical content knowledge (TPACK), which is essential for effective science education (Koehler & Mishra, 2009).

Despite these significant improvements, several challenges were identified. Approximately 9% of participants encountered technical difficulties during the installation of MATLAB software and in connecting the camera to the microscope. These constraints were largely due to limited school hardware resources and participants' basic computer skills. Therefore, follow-up mentoring programs are necessary to strengthen teachers' technical competence and ensure the sustainability of DIGICOM implementation in schools. Overall, the results confirm that the integration of simple yet contextually relevant technology can serve as an effective strategy for improving the quality of science learning in elementary schools while fostering a culture of innovation among educators (Susilo, Sutikno, & Sugiyanto, 2016; Subali et al., 2020).

CONCLUSION

The training and implementation of the Digital Image Creator for Optical Microscope (DIGICOM) successfully enhanced elementary school teachers' competence in designing, modifying, and utilizing simple technologies to support interactive and contextual science learning. Based on data analysis, this activity not only strengthened teachers' technical abilities in operating digital microscope devices but also fostered their motivation and awareness of the importance of innovation in technology-based learning. The participatory and online mentoring approach proved effective in developing teachers' technological and pedagogical literacy, particularly in contexts with limited access to laboratory facilities. The primary contribution of this program to the field of science education lies in its practical application of the Technological Pedagogical Content Knowledge (TPACK) framework within a real community service context, where principles of pure science—such as optical systems and digital imaging—were integrated with applied pedagogical approaches to improve the quality of elementary science education. Thus, this program provides empirical evidence that simple digital technologies such as DIGICOM can serve as innovative models for strengthening teachers' 21st-century skills and promoting the transformation of science education toward more collaborative, observation-based, and sustainable learning practices.

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