Penamas: Journal of Community Service, 6(1), 2026, 37-45
Available at: https://journal.nurscienceinstitute.id/index.php/penamas
EISSN: 2807-3150

Introduction to medical physics: Bridging physics and healthcare

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Received: 2-December-25; Revised: 19-January-26; Accepted: 26- January-26

Abstract

Medical physics is a rapidly developing field, with increasing demand for qualified professionals in Indonesia following regulations requiring hospitals to employ medical physicists. This community service program was conducted to introduce high school students to the applications of physics in healthcare and to improve their understanding and perception of physics as an applied and career-relevant discipline. The activity was carried out in collaboration between Matana University and SMA Stella Maris BSD, featuring interactive scientific talks and expert discussions on medical imaging, radiation therapy, and emerging topics in medical physics. Participants were 11th-grade science-track students, and program effectiveness was evaluated using pre-test and post-test assessments. The results showed a clear improvement in students' understanding of physics applications in healthcare, with average scores increasing from 83.2 to 92.8, representing an improvement of approximately 11.5%. Qualitative feedback further indicated increased student interest in physics and greater awareness of career opportunities in medical physics, biomedical engineering, and healthcare technology.

Keywords: Medical Physics, Science Education, Community Engagement, Healthcare Technology, Interdisciplinary Learning

Abstrak

Fisika medis merupakan bidang yang berkembang pesat, dengan kebutuhan tenaga fisikawan medis di Indonesia yang terus meningkat seiring diberlakukannya regulasi yang mewajibkan rumah sakit memiliki fisikawan medis. Kegiatan pengabdian kepada masyarakat bertujuan memperkenalkan penerapan fisika dalam bidang kesehatan serta meningkatkan pemahaman dan persepsi siswa SMA terhadap fisika sebagai ilmu terapan dan relevan dengan karier. Kegiatan dilaksanakan melalui kolaborasi antara Matana University dan SMA Stella Maris BSD dengan metode ceramah interaktif dan diskusi ilmiah mengenai pencitraan medis, terapi radiasi, serta perkembangan terkini fisika medis. Peserta kegiatan adalah siswa kelas XI jalur sains, dan evaluasi dilakukan menggunakan pre-test dan post-test. Hasil evaluasi menunjukkan adanya peningkatan pemahaman siswa terhadap aplikasi fisika di bidang kesehatan, dengan nilai rata-rata meningkat dari 83,2 pada pre-test menjadi 92,8 pada post-test, atau mengalami peningkatan sebesar sekitar 11,5%. Umpan balik kualitatif juga menunjukkan meningkatnya minat siswa terhadap fisika serta kesadaran akan peluang karier di bidang fisika medis, teknik biomedis, dan teknologi kesehatan.

Kata kunci: Fisika Medis, Pengabdian kepada Masyarakat, Pendidikan Sains, Teknologi Kesehatan, Pembelajaran Interdisipliner.

How to cite: Sinaga, E. P., Budiman, R., Nurdin, M. A., Manik, J. T., & Hasdeo, E. H. (2026). Introduction to medical physics: Bridging physics and healthcare. *Penamas: Journal of Community Service*, *6*(1), 37–45. https://doi.org/10.53088/penamas.v6i1.2585

1. Introduction

Medical physics is a rapidly developing field, and the demand for qualified medical physicists in Indonesia is increasing significantly, especially following the new regulation that requires every hospital to employ a medical physicist (Kementerian Kesehatan Republik Indonesia, 2015). This growing need highlights the importance of introducing medical physics as an interdisciplinary field that bridges physics and medicine, demonstrating its crucial role in improving healthcare quality and patient safety (International Organization for Medical Physics [IOMP], 2020; Podgorsak, 2017).

However, many high school students still perceive physics as a difficult and monotonous subject, often disconnected from real-life applications. This misconception poses a significant challenge in physics education, as students fail to recognize how physics underpins modern technology and everyday life (Sari et al., 2021). Community service programs demonstrate that contextual and technology-supported learning approaches are effective in increasing students' engagement and understanding of scientific concepts, particularly at the secondary education level (Jaedun et al., 2023; Fembriani et al., 2023).

One effective way to change this perception is by introducing medical physics, a discipline that applies physical principles and technological innovation to healthcare. Medical physics plays an essential role in the development of advanced medical technologies such as radiology (X-rays, CT scans, MRI) and radiation therapy for cancer treatment (Podgorsak, 2017). Medical physics plays a crucial role in the development and safe application of diagnostic imaging modalities, including nuclear medicine techniques such as PET and SPECT, which rely on the interaction of radiation with matter for functional imaging (Cherry et al., 2012).Through this field, students can see how physics contributes directly to saving lives and enhancing the quality of life.

Moreover, medical physics is not limited to doctors but involves a variety of specialized professionals. Career paths include medical physicists who design and oversee the safe and effective use of radiation and imaging technologies; radiologic technologists who operate imaging equipment for diagnosis; radiation therapy technologists who deliver targeted radiation treatments; biomedical engineers who develop and maintain medical devices such as MRI or X-ray machines; and nuclear physicists who apply radioactive isotopes for diagnostics and therapy (Khan & Gibbons, 2014; European Society for Radiotherapy and Oncology [ESTRO], 2020). Among diagnostic imaging modalities, computed tomography (CT) represents a key application of physics in medicine, requiring precise control of X-ray generation, image reconstruction, and radiation dose optimization (Kalender, 2011).

The main reason for conducting this community service activity is the existing gap between physics education at the secondary school level and its real-world applications, particularly in the healthcare sector. Although physics is a fundamental science underlying many modern medical technologies, high school students often perceive it as abstract, difficult, and disconnected from everyday life. This perception

can reduce students' motivation to learn physics and limit their awareness of potential career paths in science and technology. As part of Matana University's commitment to promoting relevant and applied science education, this community service program was proposed for SMA Stella Maris. This activity took place on September 11, 2025, and aimed to show students that physics is not merely an abstract theory but a vital discipline with tangible applications, particularly in healthcare. It will also highlight emerging developments such as AI-based medical imaging, proton therapy research, and quantum materials for diagnostics (Price & Fernandez-alonso, 2013)(WHO, 2021; European Society for Radiotherapy and Oncology [ESTRO], 2020). Recent advances in artificial intelligence, particularly deep learning, have significantly improved image reconstruction, segmentation, and diagnostic accuracy in medical imaging systems (Litjens et al., 2017; Topol, 2019). Through this initiative, students are expected to gain a deeper understanding of the real-world relevance of physics, develop curiosity toward scientific innovation, and explore promising career opportunities in medical and technological fields. Ultimately, this program seeks to inspire the next generation to view physics as a dynamic, engaging, and impactful science that contributes to human well-being and the advancement of global healthcare.

This community service program was designed to address these challenges by contextualizing physics concepts through healthcare applications such as medical imaging and radiation therapy. By integrating emerging topics such as AI-based medical imaging and quantum physics, the activity also aims to demonstrate that physics is a dynamic and evolving discipline. Ultimately, this initiative supports Matana University's commitment to applied science education while contributing to the development of students' scientific literacy, career awareness, and motivation to pursue STEM-related fields.

2. Method

The outreach activity was conducted using interactive, demonstrative, and contextual approaches to enhance students' interest and understanding of the real-world applications of physics, particularly in the medical field. The activity began with a scientific talk show presented by Matana University, discussing various applications of physics in healthcare, such as radiology, medical imaging, and radiation therapy. In this session, students were introduced to different medical physics–related professions and promising career prospects in health and technology.

Interactive and case-based learning strategies have been widely applied in community service activities to enhance critical thinking and conceptual understanding, as reported in previous studies (Fembriani et al., 2023; Darmayanti et al., 2023). Community-based educational programs targeting high school students have been shown to broaden students' perspectives on future academic and career pathways, particularly when learning is linked to real-world applications (Myrtana et al., 2023). To enrich the material and provide deeper insights, the outreach activity also featured a guest speaker from the National Research and Innovation Agency (BRIN), who

delivered a presentation on current topics in Quantum Physics, broadening students' perspectives on cutting-edge research and innovation in advanced physics.

The target participants were 11th-grade students from SMA Stella Maris BSD who are enrolled in the science specialization track (including physics). This group was chosen because they are at a stage where they begin exploring future study and career pathways, making it an ideal moment to introduce how physics can be applied meaningfully in healthcare and technology fields. Before the outreach activity, students were given a pre-test to assess their initial understanding of physics and its applications. After the activity, a post-test was administered to evaluate changes in their knowledge, perception, and interest in physics following the engagement.

3. Results

The outreach activity received an enthusiastic response from the 11th-grade science students of SMA Stella Maris BSD. Based on the pre-test results, most participants demonstrated a basic understanding of physics concepts but had limited awareness of their applications in healthcare. Many students initially perceived physics as a challenging and abstract subject, with little connection to real-world contexts.

Preliminary discussion

The outreach activity began with an online Zoom meeting between the Matana University team, the Vice Principal of SMA Stella Maris BSD, and the physics teacher from the school. The meeting served as an opportunity to discuss and gain insights into how the event would be conducted and what topics would be most engaging for high school students. During this discussion, the representatives from SMA Stella Maris BSD expressed great enthusiasm upon learning that medical physics is an existing and important field, with medical physicists playing a crucial role in hospitals. This realization opened up a new perspective and potential career option for students, many of whom had never heard of this field before.

Main Event / Implementation

Figure 1 shows the percentage of all participants at SMA Stella Maris BSD who attended the outreach activity. The participants were students who are members of the science group. From this comparison, it can be seen that the number of female participants (66.66%) is higher than that of male participants (33.34%). This indicates that girls are more interested in pursuing science-related fields. This phenomenon could be a point of further discussion, as the topic of *"women in science"* has gained significant attention and continues to develop, especially in Western countries.

Students were actively engaged throughout the scientific talk and discussion during the outreach session. They expressed curiosity about how physical principles are applied in medical technologies such as X-rays, CT scans, MRI, and radiation therapy. The students remained enthusiastic and participative throughout the day, showing great interest in the field of medical physics.

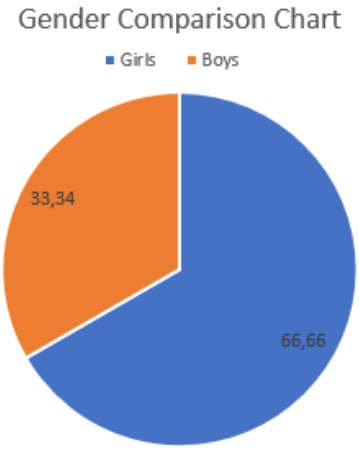

Figure 1. Gender Comparison Chart of Outreach Participants

They were delighted to discover how broad the world of physics is, spanning from the nano and micro scales to the macroscopic level. Moreover, they mentioned that physics is highly applicable in real life, not merely about theories or formulas. Figure 2 shows how the speaker delivered one of the topics in medical physics during the session. Figure 3 illustrates how the students were actively engaged during the session, showing their enthusiasm for learning and discussing medical physics topics.

Figure 2. The Delivery of Materials During the Outreach Activity

Figure 3. Students Actively Engaged During the Outreach Session

The presentation from BRIN on quantum physics also attracted great attention, introducing students to the idea that physics continues to evolve and contribute to modern innovations in medicine and technology. The speaker, Dr. Eddwi Hesky Hasdeo from BRIN, is well known for his research in the field of quantum physics. He also explained how quantum physics plays an important role in medical physics, particularly in technologies such as imaging, radiation therapy, and the development of advanced medical instruments. Figure 4 shows how Dr. Eddwi actively engaged with the students during the session, encouraging questions and discussions about quantum and medical physics.

Figure 4. Dr. Eddwi Hesky Hasdeo Is from Brin Engaging with Students During the Session

Evaluation and Assessment

To evaluate the effectiveness of the outreach activity, both a pre-test and a post-test were conducted. The tests aimed to measure students' understanding of key physics concepts and their ability to connect these concepts to real-world applications in healthcare.

Before the outreach activity began, a pre-test was administered to assess the students' initial understanding of physics concepts and their familiarity with how these concepts are applied in healthcare. The test was designed to ensure that students had not yet been exposed to or influenced by the specific topics discussed during the session, allowing for a fair and accurate measurement of learning progress.

The post-test results indicated a notable improvement in students' comprehension and interest. A majority of participants were able to identify examples of physics applications in healthcare and expressed a greater appreciation for the relevance of physics in daily life. Qualitative feedback collected from open discussion and questionnaires showed that students felt the activity helped them see physics as a useful, exciting, and career-relevant discipline rather than merely a theoretical subject.

Overall, the outreach activity successfully achieved its objectives of increasing students' understanding and motivation toward physics. It also demonstrated that contextual and interdisciplinary approaches, such as linking physics with healthcare, can make science learning more meaningful and engaging. This result highlights the

importance of continuing similar initiatives to inspire young learners and encourage future interest in science, technology, and health-related careers.

Table 1. Average Scores of the Pre-Test and Post-Test

Average Pre-Test Score	Average Post-Test Score
83.2	92.8

As shown in Table 1, the average score increased from 83.2 to 92.8, reflecting an approximate 11.5% improvement in students' overall understanding after the activity. Similar to findings reported in Penamas, the use of innovative and technology-enhanced learning media contributes positively to students' cognitive development, motivation, and perception of learning relevance (Darmayanti et al., 2023; Jaedun et al., 2023).

4. Conclusion

The outreach activity successfully introduced high school students of Stella Maris BSD to the interdisciplinary connections between physics and medicine. Through engaging presentations, discussions, and demonstrations, students gained new insights into how physical principles are applied in healthcare technologies such as X-rays, CT scans, MRI, and radiation therapy.

The collaboration between Matana University, BRIN, and SMA Stella Maris BSD proved to be highly effective in stimulating students' curiosity and motivation to learn physics. The active participation of students throughout the sessions showed that the contextual approach linking physics with real-life applications made the subject more approachable and relevant.

The pre-test and post-test results demonstrated a significant improvement in students' understanding, with an average learning gain of approximately 11.5%. This indicates that the outreach program not only enhanced conceptual comprehension but also changed students' perceptions of physics—from a difficult and abstract subject to one that is practical, inspiring, and closely related to human well-being.

The next target of this community service activity is the expansion of the program to a broader and more sustainable scope. First, the activity will be extended to other senior high schools, particularly those with science specialization tracks, to reach a wider group of students and increase awareness of medical physics at the regional level. Second, future activities will incorporate more hands-on and experiential learning components, such as simple medical imaging simulations, laboratory demonstrations, and problem-based learning modules. This approach is expected to strengthen students' conceptual understanding and practical skills. Third, the program aims to establish a continuous collaboration framework between universities, research institutions, and schools. This includes follow-up mentoring activities, guest lectures, and career guidance sessions related to physics, medical physics, and biomedical engineering. In the long term, this initiative is expected to contribute to the development of a pipeline of students who are interested and well-prepared to pursue higher education and careers in physics, healthcare technology, and related STEM fields.

Overall, the activity achieved its goals of fostering enthusiasm for physics, broadening students' perspectives on potential career paths in science and healthcare, and highlighting the importance of continuous collaboration between educational institutions and research organizations in promoting STEM education.

Acknowledgements

We would like to express our appreciation to SMA Stella Maris BSD for their collaboration and enthusiasm in hosting this outreach activity, especially to Ms. Frist Eka Setyani, the Principal, and Ms. Wahyu Purwaningrum, the Vice Principal.

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