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Perceptions of Students Towards The Scientist-Teacher-Student Partnership (STSP) in Medical Physics Subjects

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Abstract

Medical Physics is a branch of physics application that is developing very rapidly. Therefore, the contextualization of Medical Physics is crucial for future physics teachers. This research aims to implement Student-Teacher-Scientist Partnerships (STSP) in Medical Physics and explore students' perceptions of the learning experience through this program. STSP in this research involved prospective physics teachers as students, lecturers in medical physics courses as teachers, and medical physicists as scientists. The benefits of this research are to provide a learning experience of medical physics directly from experts (medical physicists) as a provision for prospective physics teachers to strengthen their knowledge of medical physics content and how to teach it, and to be a recommendation for learning strategies that support contextual physics learning. Implementing STSP in medical physics courses includes planning, implementation, and evaluation activities for one semester of lectures; lectures by the foremost scientists were held in 7 meetings (1 meeting = 2 x 60 minutes). The planning stage includes activities to equalize perceptions between scientists and related lecturers. The course was primarily student-centred, with case study discussions conducted online via Zoom meetings. The scientists were located in East Java Province, Indonesia, while the teachers and students were in East Kalimantan Province, Indonesia. The evaluation stage was carried out by exploring students' perceptions of the program implementation, the results of which can later be used as a reference for the continuation of the program implementation. Results indicated that STSP activities facilitated easier comprehension of medical physics, increased interest in further study, and highlighted connections between course topics and secondary school curriculum.

Keywords: medical physics, physicists, scientist, STSP

INTRODUCTION

Improving the quality of teacher education is a top priority for most countries throughout the world to achieve scientific progress (Kurniati, Suwono, Ibrohim, Suryadi, 2022; Hermann, Kisiel, Muzikar, Dapretto, & Bookchin, 2016), economic development (Saat, Fadzil, Adli, & Awang, 2021), and a better future (Sukmayadi & Halim Yahya, 2020). The quality of teaching by teachers depends not only on the in-depth mastery of the subject to be taught but also on the ability to apply learning

strategies that make it easier for students to understand the subject (Efwinda & Mannan, 2020). This knowledge and these skills can be obtained by enriching prospective teachers' learning and teaching experiences (Haryanto, Efwinda, & Sulaeman,2024; Haryanto, Efwinda, Sulaeman, & Sholeh, 2023).

Preparation for the development of prospective teachers is the first step in supporting the development of a country. Educational institutions for prospective teachers must facilitate learning activities that enable prospective teachers to master knowledge and teaching skills (Sulaeman, Efwinda, & Putra, 2022). The condition of prospective physics teachers is a gap between their knowledge of physics principles and how to teach them (Nyssan, 2023).

In learning activities, investigative activities are essential (Eltanahy & Forawi, 2019) and are also one of the characteristics of science learning (Sotero, Alves, Arandas, & Medeiro, 2020). Physics is a branch of natural science; its learning includes physical and mental activities and emphasizes skills to scientifically discover and explore natural phenomena and the environment of everyday life. Many physics concepts and principles are difficult to understand, for example, in the branch of medical physics (Sudirman, Kennedy, & Soeharto, 2023).

Medical physics is a branch of physics used for health services (Maas et al., 2021), especially for diagnosing and treating human diseases (Bawaneh & Hamida Moumene, 2020). Historically, medical physics began with developing the safe handling of radium in cancer treatment (Endo, 2021). The scope of medical physics, in addition to radiotherapy, includes other specialty areas, including Nuclear Medicine, Diagnostic and Interventional Radiology, Imaging and non-ionizing medicine, Clinical Audiology, and Clinical Neurophysiology (Maas et al., 2021). Given its broad and essential role in modern healthcare, the medical physicist occupation is formally recognized as a profession by the International Labor Organization (Bojórquez, Rendón, & Rojas-López, 2023). Becoming a medical physicist requires mastery of content, using health technologies (Caruana et al., 2021) and practical competence in the real world (Fagerstrom, 2023).

Integrating medical physics topics into the school curriculum can stimulate learning relevant to everyday life and inspire students to view physics as a possible future employment opportunity (Fagerstrom, Gao, & Robertson, 2019; Fagerstrom, 2023; Tabakova, 2020). Connecting career opportunities with learning activities will connect students more to the topics taught (Buckley, 2016). Unfortunately, many students are unaware of career opportunities in medical physics (Santoso, Jupitz, & Lin, 2021). Introducing and teaching this science more deeply is fundamental because of its contextual topics. However, in the physics learning process, students think that learning physics is a collection of abstract facts and formulas; contextual learning is still not dominating (Fagerstrom, 2023). Therefore, there is a need for contextualized medical physics learning strategies, especially those that can strengthen the content and enrich the learning experience of prospective physics teachers, as a provision for them in the future when they become teachers.

The gap in mastery of physics concepts and the limited pedagogical abilities in teaching them can be bridged with collaboration between scientists and lecturers to produce professional future physics educators (Nyssan, 2023). Linking various sources of knowledge in the school environment (Sotero, Alves, Arandas, & Medeiros, 2020), such as between the scientific community and science educators, is also increasingly popular as an approach to science education (Fadzil, Saat, Awang, & Adli, 2019). Discussion and joint work activities can make learning more meaningful (Pelobillo, 2023) and benefit those involved (Cook-Sather, Salmeron, & Smith, 2023).

One form of collaboration that is currently becoming popular is Student-Teacher–Scientist Partnership (STSP) (Çavaş, Çapar, Çavaş, & Yahşi, 2021; Fadzil et al., 2019; Ismail et al., 2022; Saat et al., 2021, 2023). A scientist is someone who becomes an expert through a gradual process, starting with postgraduate training and continuing as his or her career progresses, who not only learns theory but learns by doing to produce knowledge

that can be utilized in scientific and non-scientific settings (Goolsby, Cravens, & Rozance, 2023). Scientists work in professional practices that use science, technology, engineering, and maths through scientific methods to solve real-world problems (Luo, Zhao, Wing, & So, 2022). From a student's perspective, scientists study nature with broad insight, make observations and experiments, and innovate (Ozkan & Topsakal, 2023).

STSP is a collaboration between scientists, teachers, and students that provides meaningful learning by involving students in actual and authentic scientific research (Houseal, Abd-El-Khalick, & Destefano, 2014). STSP helps students enrich their learning experience, improving procedural skills and opportunities to explore topics related to learning scientifically (Çavaş et al., 2021). The STSP program is also believed to bridge school learning regarding important societal issues (Bernstein & Mckenney, 2023).

Several studies related to the implementation of the STSP program, for example, were carried out by Çavaş et al. (2021), who researched teachers' opinions regarding the STSP program and showed positive views from teachers, especially teachers who had never had previous experience collaborating with scientists. The other research is by Ufnar & Shepherd (2019), who implemented the STSP program for teacher professional development, and by Saat et al.(2021) on the professional development of Science, Technology, Engineering, and Mathematics (STEM) teachers. The STSP program is not only beneficial to teachers, but it is also beneficial to students; for example, research by Westbrook et al. (2023) shows that there has been an increase in student learning outcomes through the STSP program; this is also in line with the research results of Fadzil et al. (2019), which shows positive perceptions from students towards the STSP program.

Students who participate in the STSP program will have the opportunity to gain new experiences and be able to use them as a reference when they become teachers in the future. A person's experiences influence their perception of something (Kurniawan et al., 2023). Hopefully, the implementation of STSP can form a positive perception of it. However, from previous studies, no research has applied the STSP program to the medical physics course and explored students' perceptions of the STSP program in that course. Therefore, this research explores students' perceptions of the STSP program in the medical physics course.

Specifically, in this research, the terms scientist, teacher, and student refer to the collaboration among three parties: medical physicists as scientists, lecturers as teachers, and prospective physics teacher students as students. Building upon previous contributions, our study moves the field forward because the results of this study will provide new information about the application of STSP in learning applied subjects such as medical physics, which can ultimately serve as a basis for developing educational programs for policymakers. This research aims to implement STSP in Medical Physics and explore students' perceptions of the learning experience through STSP. Some research questions to guide research activities include the following:

1. What information do students learn in the medical physics course through the STSP program?
2. What is the role of the STSP program based on students' perceptions of interest in studying medical physics?
3. What are the overall benefits of the STSP program based on student perceptions?

METHOD

The research design used in this study is mixed-method research, which collects both quantitative and qualitative data and both types of data. Qualitative data is the primary data, and quantitative data is complementary. This study involved 124 Mulawarman University, Indonesia students representing the first, third, and fifth semesters. Several of these students attended lectures with scientists in 2 meetings discussing the scope, general description, and job opportunities in medical physics. Furthermore, as many as 40

students in the fifth semester attended lectures with scientists in 7 meetings.

Implementing the STSP program in the medical physics course includes planning, implementation, and evaluation stages. The planning stage provides for activities to equalize perceptions between scientists and related lecturers:

1. Essential contents that need to be given in medical physics lectures
2. Division of tasks for delivering the topic and the learning resources used
3. The teacher proposes approaches, strategies, and learning models.

After an agreement is reached, the Semester Learning Plan for the course will be updated, including the lecture implementation stage, by implementing the lesson plan. Medical physics lectures were held in 14 lecture meetings, one mid-test meeting, and one final-test meeting for 16 lecture meetings. Lectures by scientists were mainly held in 7 meetings (@1 meeting = 2 x 60 minutes) covering topics: Introduction to physics in the medical field, career potential in the field of medical physics, types of radiation, introduction to medical physics in radiology, radiotherapy, nuclear medicine, as well as introduction to radiation protection.

Medical physics courses through STSP were carried out primarily through student-centered learning through case study discussions conducted online via Zoom Meetings. Lectures are conducted online due to the location of the university and the domicile of the scientist, which is relatively far away. The scientists were located in East Java Province, Indonesia, while the teachers and students were in East Kalimantan Province, Indonesia.

At each lecture meeting with scientists, scientists open lectures with case studies related to medical physics, especially those based on their experience in the hospitals where they work. In addition, the scientist also facilitates discussion sessions for students to ask about various health cases among students. Students in groups are also encouraged to identify problems related to medical physics to be discussed further in the learning process. Although conducted online, lecturers and scientists try as much as possible to present to students the real picture of the work life of the medical physicist profession; for example, using lecture sessions, online scientists also show the hospital room where they work and various technological devices or facilities that they usually use to work, for example in determining the correct radiotherapy dose.

The evaluation stage of STSP implementation was carried out using a questionnaire instrument to explore students' perceptions of program implementation, the results of which could later become a reference for continuing program implementation. In addition to using a questionnaire, at the final session of the lecture meeting, some students were also directly asked to give their responses regarding their experience of attending medical physics lectures with scientists.

This study used a questionnaire instrument of student perceptions of the STSP Program as a data collection technique. The data source in this study was a total of 124 physics education students. The research questionnaire used is adapted from a research questionnaire that has been used by Fadzil et al. (2019). The questionnaire totaled 11, seven open, and four closed questions with yes or no answer options. The questionnaire was distributed online via Google Forms at the end of the medical physics lecture meeting. The questions on the questionnaire are presented in Table 1.

The data analysis technique used in this research was quantitative descriptive to calculate the percentage of students' answers to questions with dichotomous options and qualitative descriptive using KH-coder software to obtain an overview of participants' perception tendencies regarding implementing the STSP program in the medical physics course.

Table 1. The questions on the questionnaire

Question	Type of question	
	Open question	Closed question
Write down what new information you obtained from studying medical physics through the STSP program.	√	
Do you have any difficulties understanding the subject presented by practitioners? Yes/No		√
If so, please elaborate!	√	
If it is related to the secondary school curriculum, do you think it contains a topic related to medical physics? Yes/No		√
If so, at what level? And on what topic?	√	
Can collaborative activities with scientists in lectures help you better understand the topic related to medical physics? Yes/No		√
If yes, what activity do you think plays the most role? Why? If not, why?	√	
Does this guest lecture activity with practitioners increase your interest in studying science/physics? Yes/No		√
Please explain your reasons.	√	
What do you think about the involvement of practitioners in medical physics lectures?	√	
What benefits do you gain from guest lectures involving practitioners?	√	

RESULT AND DISCUSSION

1. New information on the medical physics course through the STSP program

The tendency of students' perceptions about the information they obtain in the STSP in the medical physics course is presented in Figure 1.

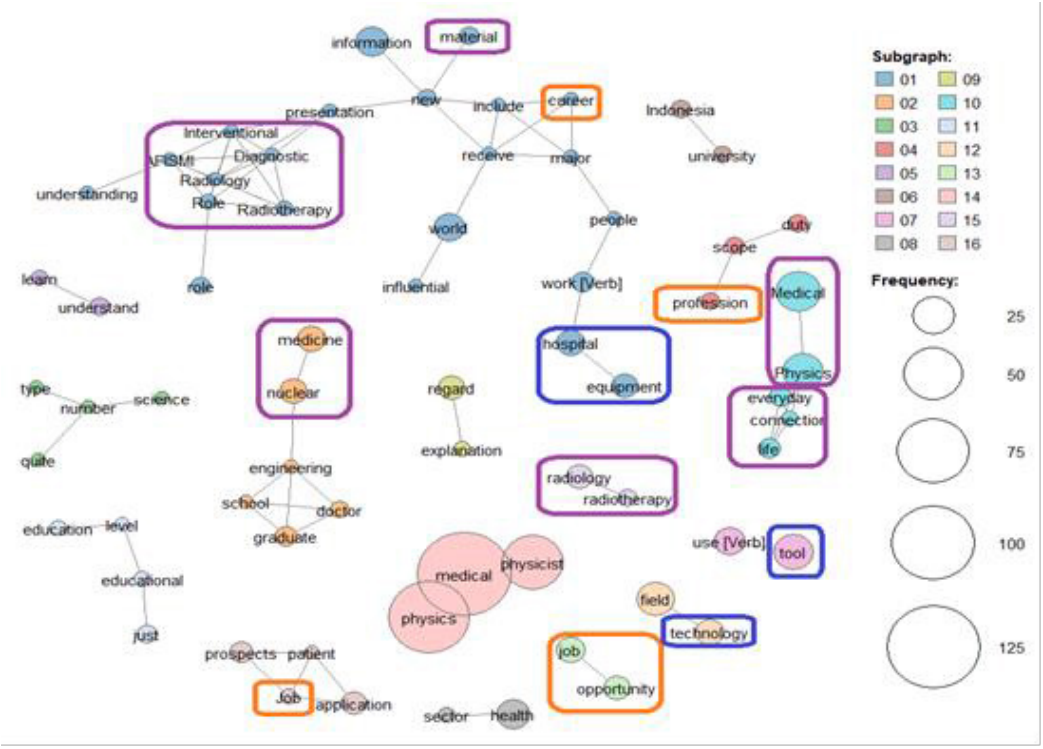

Figure 1. Students' perceptions about the information they obtain in the STSP Program

Figure 1 shows that STSP facilitates them in obtaining information that medical physics is an important field and has many connections with the medical world and various medical tools used in medical physics. The results of this study are supported by Westbrook et al. (2023), who showed that STSP can significantly improve students' science content knowledge. The respective knowledge and skills that teachers and scientists possess, combined in the collaborative process, are used to design and implement learning activities that enrich students' learning experiences.

In-depth Medical physics covers multiple fields, such as interventional diagnostic radiology, radiotherapy, and nuclear medicine (Bezak et al., 2023; Fraser et al., 2022; Tsapaki, 2020). The educational level and requirements to become a medical physicist are pretty long, and various career opportunities exist (Paul, 2022). Applying physics concepts in the medical world is very important to improve the quality of medical care, ensure safe and effective medical technology, and is closely related to everyday life.

As many as 12% of students said they had difficulty understanding the subject, but the other 88% said they had no difficulty. Experienced challenges include the use of terms in medical physics that they are not familiar with or have never heard of before, explanations regarding technological tools in the field of medical physics that they have seen for the first time, as well as several presentations in English.

As many as 23% of students think there are no topics in the medical physics subject that can be connected to physics or science lessons at the secondary school level. Still, as many as 77% of students think that there are topics in medical physics that can be connected to physics or science lessons at the secondary school level. In detail, the trends in selecting educational levels that can be integrated and appropriate topics based on student perceptions are presented in Figure 2.

In general, medical physics subjects in the middle school curriculum can be taught at the high school level, especially in mechanics, electricity, magnetism, modern physics, optics, electromagnetic waves, and medical technology. This is following the learning outcomes document by the Indonesian Ministry of Education, which states that understanding physics for high school students includes topics about measurements, mechanics, fluids, vibrations and waves, thermodynamics, magnetic electricity, modern physics and radioactivity, digital technology, and the sustainability of energy and the surrounding natural environment (Kemendikbudristek BSKAP RI, 2022).

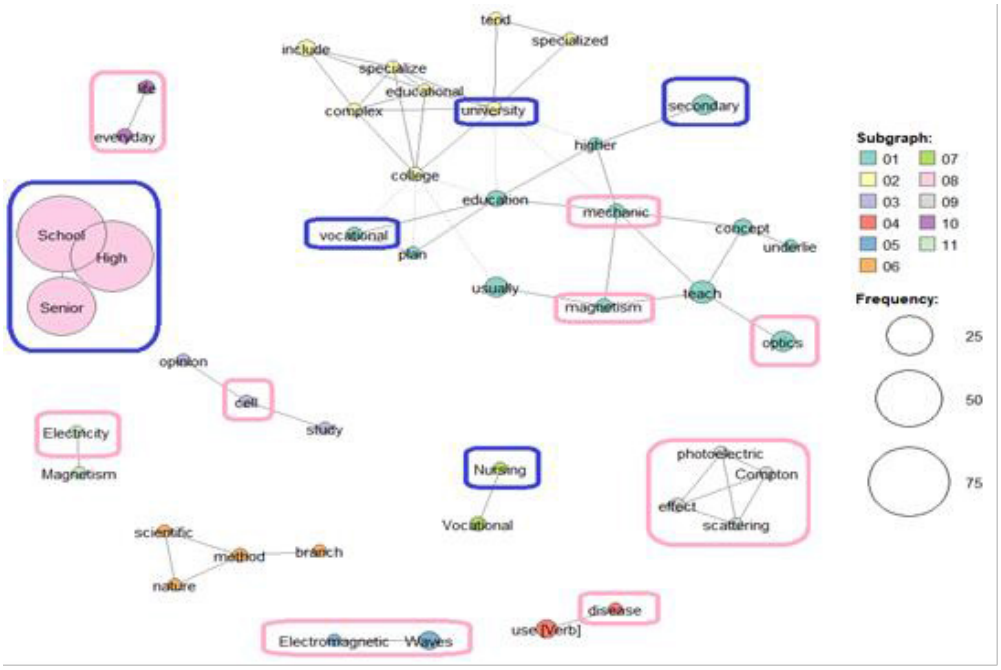

Figure 2. Students' perceptions of educational levels for Medical Physics Content

The urge to improve the quality of science learning, especially physics, is now even higher (Sulaeman et al., 2022). There is also a view that medical physics can be included as a student interest option in the secondary school curriculum, especially in the current Merdeka Curriculum, by including the specific topic of radiation in the physics subject. Several students said medical physics topics could be taught in biology and physics subjects, and at the Vocational High School level, related to the health sector, such as Nursing or Medical Vocational Schools.

All students agree that the activities in the STSP program can help them better understand the existing subject related to medical physics. Among the most critical activities, according to them, include question and answer sessions, explanations using original videos carried out by scientists themselves, the use of varied literature, scientists explaining directly from the hospital, and simulating several activities they usually do, as stated by S25, S44, and S72.

S25: "*The activity that played the most role was the question and answer session and explanation using video. In the question and answer session, the questions are usually related to applications in everyday life and real events. Explanations using videos are instrumental because they are accompanied by visualizations, making it easier to understand and use his original videos*."

S44: "*The activity that plays the most role is presenting the topic by visualizing the photos and literature used, which is very valid and varied. "Scientists explain the topic concerning direct experience so we can understand what happens in the field*."

S72: "*The activity that plays the most role is lectures involving experts directly; we can see when physicists work because in several meetings, even online, they often show the activities that medical physicists do and the tools they use directly in hospitals, then there are also simulations about tools and videos about various things related to medical physics*."

2. The role of the STSP program on interest in studying Medical Physics

As many as 83% of students thought that the STSP program could increase their interest in studying physics, especially medical physics, while another 17% stated that this activity did not increase their interest in studying medical physics.

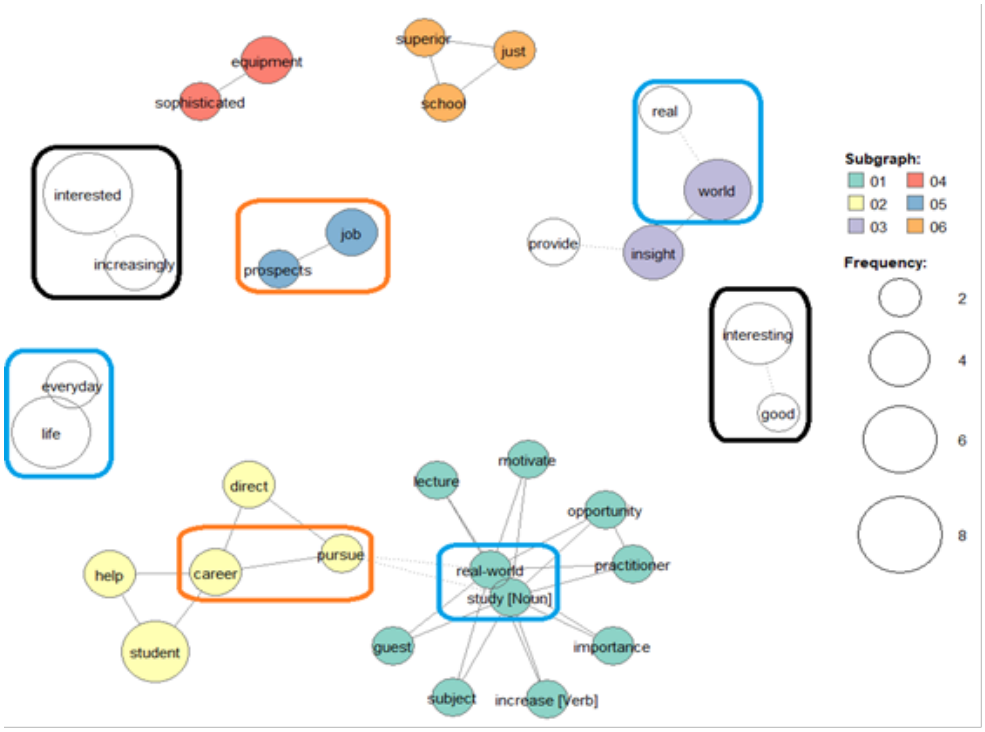

Figure 3. Student Perception of the STSP Program

Figure 3 shows that based on students' perceptions, their interest in studying physics/science can increase through STSP because direct interaction with experienced scientists provides new and in-depth insights into the application of physics in the real world so that students can see the relevance and importance of science or physics in the real world—everyday life.

The results of this study align with research by Fadzil et al. (2019), where most students as research participants agreed that STSP activities can increase their interest in studying Science, Technology, Engineering, and Mathematics (STEM) fields. Through STSP, students can better connect what they learn with real-life situations, enhance learning experiences, provide opportunities to explore topics in science, and introduce related careers.

Exposure to the subject by scientists provides additional motivation to pursue further studies in science or physics, as students see the career opportunities and real-world applications that may be available. Students feel inspired to delve deeper into science or physics after hearing practical experiences from medical physicists, which can help them understand physics concepts better. This activity opens students' views on the diversity of occupational fields that can be accessed with an educational background in science or physics, including in the medical field. By seeing the application of physics in the health sector, students become more interested in studying medical physics and understanding how physics concepts can be used in health services. Thus, STSP activities with scientists can be a powerful tool to motivate students and increase their interest in studying science or physics. These results follow research by former researchers (Sulaeman et al., 2024), which shows the positive perception of prospective teachers towards the role of a scientist.

3. Overall benefits of the STSP program

Students view the involvement of scientists in STSP very positively. They felt that the presence of scientists provided a better understanding and direct experience, which was very helpful in understanding the subject of medical physics. Apart from that, the involvement of scientists is also considered to provide motivation, inspiration, and broader insight into the world of work and careers in medical physics. These opinions show that collaboration between education and field practitioners (scientists) benefits students' learning experiences and advances knowledge in this field.

In general, the benefits obtained through STSP involving scientists based on student perceptions are that they provide real benefits in understanding, knowledge, and career preparation in the field of medical physics, in detail as follows:

a. Addition of new knowledge and insights regarding the relationship between medical science and physical science, for example, stated by S3 as follows:
   S3: "*Adding knowledge that I did not know about the world of medicine related to physics*."
b. A better understanding of medical physics, including processes, tools, and applications in the medical world, as stated by S5, as follows:
   S5: "*The benefits I get are the new knowledge scientists have conveyed, such as becoming a medical physicist, job prospects, tools, and their application to patients. This activity is new for me and adds to my insight*."
c. Know job and career prospects in the field of medical physics as well as motivation and inspiration to pursue a career in a related field, for example, as stated by S28 as follows:
   S28: "*Information related to real experience from scientists, even though in the future I want to be a teacher, I can explain jobs related to physics to my students in the future that I did not get before at the secondary school level*."
d. Obtain direct information and experience as well as a deeper understanding of specific topics from experienced scientists, as stated by S48 as follows:
   S48: "*Obtain more detailed and new knowledge from experienced scientists*."
e. Understand the relationship between academic concepts and real-world applications in the field of medical physics, as stated by S56 as follows:
   S56: "*As a real application, scientists can help connect academic concepts with real-world applications and help us understand why learning is important*."

f. Increase interest and awareness of the importance of physics in everyday life and the medical world, for example, as stated by S89 as follows:
S89: "*I can gain new experiences and insights about medical physics daily."*

This research reveals that the STSP program has provided students with new information about medical physics. Students' content knowledge of science can increase through STSP (Westbrook et al., 2023). Although some students had difficulty understanding the subject presented, most felt that this activity was beneficial in understanding the medical physics subject. Most of the students also stated that there was a connection between medical physics subjects and the secondary school curriculum. The results of this research align with Saat (Saat, Fadzil, Adli, & Awang, 2021), which shows that through STSP, teachers can connect the curriculum, science content, and applications in everyday life.

Activities that play the most role in increasing students' understanding include question and answer sessions, explanations using videos, varied literature, simulations, and direct demonstrations from scientists. The learning experience can be enriched through STSP (Fadzil et al., 2019). Additionally, most students feel the STSP program can increase their interest in medical physics. These findings indicate that the STSP program involving scientists can significantly benefit students in understanding and improving their interest in medical physics. This result shows the importance of collaboration between education and field practitioners in enriching students' learning experiences and advancing knowledge in medical physics.

Some limitations of this study are that although the study involved 124 students, this sample size may not be large enough to generalize the results broadly to a larger population of students at various institutions. Participants in this study were limited to students from one university in Indonesia, which may not reflect the diversity of students from different backgrounds and educational contexts. Although the analysis techniques used include quantitative and qualitative descriptives, further analysis, such as regression analysis to identify factors that influence student perceptions, can increase understanding of the program's impact in more depth. Paying attention to these limitations can be a starting point for further, more in-depth, and broader research exploring the impact and effectiveness of the STSP program and students' understanding of medical physics.

Further studies can be conducted to explore effective learning strategies in the STSP program to improve students' understanding of the medical physics subject. Additional research can deepen understanding the relationship between the secondary school curriculum and medical physics subjects to strengthen integration between the two fields. Further studies could also investigate the long-term impact of the STSP program on students' interest and achievement in studying and developing a career in medical physics. Research comparing the effectiveness of the STSP program with other learning methods in increasing students' understanding and interest in medical physics can also be conducted to gain deeper insight.

CONCLUSION

Based on the description of the research results, it can be concluded that the information students learn in the medical physics course through the STSP program includes an understanding of fundamental physics concepts applied in a medical context, the use of medical technology tools, and physical processes that occur in the world: medicine, and the relationship between physical science and medical practice. Based on student perceptions, the STSP program is vital in increasing interest in studying medical physics. The activities carried out in the program, such as question and answer sessions, video explanations, use of varied literature, simulations, and live demonstrations from scientists, provide a better understanding of the medical physics subject and overall increase students' interest in learning more about the field. The overall benefit of the STSP program based on student perceptions is that it provides a deeper understanding of medical physics, new knowledge about the relationship between medical science and physical science, a better understanding of the processes and

applications of physics in the medical world, information about job and career prospects in the field medical physics, as well as increasing interest and awareness of the importance of physics in everyday life and the medical world. The STSP program also provides hands-on experience through interactions with experienced scientists, helping students understand academic concepts better and relate them to real-world applications in medical physics. The limitation of the study is that the implementation of the STSP program in this study was carried out online, so for future research, it is recommended to be able to implement STSP with direct interaction between scientists and students, not only online. In addition, because the results showed that students' interest in learning medical physics could increase through STSP, we recommend the STSP program be applied as one of the learning strategies that can be used in physics learning, especially medical physics. Another suggestion is to expand the scope of the research, not only exploring the perceptions of the parties involved but also their effectiveness on the development of various student learning outcomes.

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REFERENCES

Bawaneh, A. K., & Hamida Moumene, A. B. (2020). Flipping the Classroom for Optimizing Undergraduate Students' Motivation and Understanding of Medical Physics Concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(11), 2–16. https://doi.org/10.29333/ejmste/8561

Bernstein, D., & Mckenney, S. (2023). Boundary Crossing in Student-Teacher-Scientist-Partnerships: Designer Considerations and Methods to Integrate Citizen Science with School Science. *Instructional Science*, *51*(5), 1–40. https://doi.org/10.1007/s11251-022-09615-3

Bezak, E., Borrás, C., Hasford, F., Karmaker, N., Keyser, A., Stoeva, M., Trauernicht, C., Yeong, H. C., & Marcu, L. G. (2023). Science diplomacy in medical physics – an international perspective. *Health and Technology*, *13*(3), 495–503. https://doi.org/10.1007/s12553-023-00756-0

Bojórquez, M. H., Rendón, X. L., & Rojas-López, J. A. (2023). Perception and Recognition of Clinical Medical Physicist Roles and Responsibilities by Specialist Physician Staff: The First Mexican Survey. *Journal of Medical Physics*, *48*(4), 328–332. https://doi.org/10.4103/jmp.jmp_81_23

Buckley, L. (2016). SU-F-E-08: Medical Physics as a Teaching Tool for High School Science Curriculum. *Medical Physics*, *43*, 3354–3354. https://doi.org/https://doi.org/10.1118/1.4955694

Caruana, C. J., Karenauskaite, V., Mornstein, V., Vano, E., Pace, E., Lammertsma, A. A., Maas, A. J. J., Bert, C., Byrne, B., Colgan, N., Essers, M., Isidoro, J., Koniarova, I., Makridou, A., Pesznyak, C., Rønde, H. S., & Winiecki, J. (2021). A generic curriculum development model for the biomedical physics component of the educational and training programmes of the non-physics healthcare professions. *Physica Medica*, *85*(January), 32–41. https://doi.org/10.1016/j.ejmp.2021.04.015

Çavaş, B., Çapar, S., Çavaş, L., & Yahşi, Ö. (2021). Turkish STEM Teachers' Opinions about the Scientist-Teacher-Student Partnership. *Journal of Turkish Science Education*, *18*(4), 622–637. https://doi.org/10.36681/tused.2021.94

Cook-Sather, A., Salmeron, D., & Smith, T. (2023). Humanizing STEM education through student-faculty pedagogical partnerships. *Frontiers in Education*, *8*(June), 1–16. https://doi.org/10.3389/feduc.2023.1153087

Efwinda, S., & Mannan, M. N. (2020). Pedagogical Content Knowledge Ability in Reflecting Project-Based Learning on Physics Concepts. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*.

https://doi.org/10.4108/eai.12-10-2019.2296475

Eltanahy, M., & Forawi, S. (2019). Science Teachers' and Students' Perceptions of Implementing Inquiry-Based Learning Instruction in a Middle School in Dubai. *Journal of Education*, *199*(1), 13–23. https://doi.org/10.1177/0022057419835791

Endo, M. (2021). History of medical physics. *Radiological Physics and Technology*, *14*, 345–357.

Fadzil, H. M., Saat, R. M., Awang, K., & Adli, D. S. H. (2019). Students' perception of learning STEM-related subjects through scientist-teacher-student partnership (STSP). *Journal of Baltic Science Education*, *18*(4), 537–548. https://doi.org/10.33225/jbse/19.18.537

Fagerstrom, J. M. (2023). Medical Physics Topics as an Anchor for Physics Learning. *International Journal of Innovation in Science and Mathematics Education*, *31*(4), 74210. https://doi.org/10.30722/ijisme.31.04.004

Fagerstrom, J. M., Gao, W., & Robertson, G. E. (2019). A hands-on introduction to medical physics and radiation therapy for middle school students. *Journal of Applied Clinical Medical Physics*, *20*(4), 148–153. https://doi.org/10.1002/acm2.12569

Fraser, L., Parkar, N., Adamson, K., Fletcher, A., Julyan, P., Kalirai, C., McGowan, D., & McKiddie, F. (2022). GUIDELINES & RECOMMENDATIONS Guidance on medical physics expert support for nuclear medicine. *British Journal of Radiology*, *95*(1135). https://doi.org/10.1259/bjr.20211393

Goolsby, J. B., Cravens, A. E., & Rozance, M. A. (2023). Becoming an Actionable Scientist: Challenges, Competency, and the Development of Expertise. *Environmental Management*, *72*(6), 1128–1145. https://doi.org/10.1007/s00267-023-01863-4

Haryanto, Z., Efwinda, S., & Sulaeman, N. F. (2024). Factors of Shaping Pedagogical Content Knowledge Self-efficacy for Preservice Physics Teachers Throughout Microteaching Course. *Pegem Journal of Education and Instruction*, *14*(4), 351–358. https://doi.org/10.47750/pegegog.14.04.32

Haryanto, Z., Efwinda, S., Sulaeman, N. F., & Sholeh, M. (2023). Changes in the Pedagogical Content Knowledge (PCK) Self-Efficacy of Pre-Service Physics Teachers : Redefining the Role of Influencing Factors. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 109–116. https://doi.org/10.29303/jppipa.v9i1.2268

Hermann, R. S., Kisiel, J., Muzikar, D., Dapretto, M., & Bookchin, M. (2016). Effective Teacher Professional Development in the evolution of human and non-human animals. *Learning Policy Institute*, *June*.

Houseal, A. K., Abd-El-Khalick, F., & Destefano, L. (2014). Impact of a student-teacher-scientist partnership on students' and teachers' content knowledge, attitudes toward science, and pedagogical practices. *Journal of Research in Science Teaching*, *51*(1), 84–115. https://doi.org/10.1002/tea.21126

Ismail, M. H., Fadzil, H. M., Saat, R. M., & Salleh, M. F. M. (2022). A Needs Analysis Study for the Preparation of Integrated STEM Instructional Practices through Scientist-Teacher-Student Partnership (STSP). *ASM Science Journal*, *17*(August). https://doi.org/10.32802/ASMSCJ.2022.1112

Kemendikbudristek BSKAP RI. (2022). *Capaian Pembelajaran Mata Pelajaran Fisika Fase E – Fase F*. Kemendikbudristek BSKAP RI.

Kurniati, E., Suwono, H., Ibrohim, I., Suryadi, A., & Saefi, M. (2022). International Scientific Collaboration and Research Topics on STEM Education: A Systematic Review. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(4). https://doi.org/10.29333/ejmste/11903

Kurniawan, B. R., Rahmawati, I., & Fawaiz, S. (2023). E-Module Implementation by Using Feature-Lesson-Based Moodle in Physics Learning Multimedia Practices for Students of Prospective Physics Teachers. *Jurnal Pendidikan Fisika Indonesia*, *19*(1), 76–88. https://doi.org/10.15294/jpfi.v19i1.37176

Luo, T., Zhao, J., Wing, W., & So, M. (2022). *Issn 1648-3898 Issn 2538-7138 Students ' Reflections on Their Scientist- or Engineer-Like Practices in Stem Project-Based*. 119–130.

Maas, A. J. J., Lammertsma, A. A., Agius, S., Bert, C., Byrne, B., Caruana, C. J., Gilligan, P., Koutsouveli, E., Pace, E., & Brambilla, M. (2021). Education, training, and registration of Medical Physics Experts across Europe. *Physica Medica*, *85*(May), 129–136. https://doi.org/10.1016/j.ejmp.2021.03.034

Marlina, L., Dariyani, N., Sriyanti, I., Sudirman, S., & Meilinda, M. (2022). Development of Differentiated Physics Teaching Modules Based on Kurikulum Merdeka. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2286–2292. https://doi.org/10.29303/jppipa.v8i5.2061

Nyssan, G. (2023). Improvement of the Professional and Methodical Training of

Future Physics Teachers. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 514–525. https://doi.org/10.15294/jpii.v12i4.45415

Ozkan, G., & Topsakal, U. U. (2023). Identifying Middle School Students' Perceptions of STEAM Careers. *Jurnal Pendidikan Fisika Indonesia*, *19*(1), 1–15. https://doi.org/10.15294/jpfi.v19i1.35912

Paul, J. (2022). What Do Medical Physicists Do? Leadership and Challenges in Administration and Various Business Functions. *Advances in Radiation Oncology*, *7*(6), 100947. https://doi.org/10.1016/j.adro.2022.100947

Pelobillo, G. (2023). Conceptions of Learning Physics among University of Mindanao Students: A Validation Study. *International Journal of Instruction*, *16*(4), 921–938. https://doi.org/10.29333/iji.2023.16451a

Saat, R. M., Fadzil, H. M., Adli, D. S. H., & Awang, K. (2021). Stem teachers' professional development through scientist-teacher-student partnership (STSP). *Jurnal Pendidikan IPA Indonesia*, *10*(3), 357–367. https://doi.org/10.15294/JPII.V10I3.27845

Saat, R. M., Piaw, C. Y., & Fadzil, H. M. (2023). Creating a Grounded Model of Performance Quality of Scientist-Teacher-Student Partnership (STSP) for STEM Education. *International Journal of Science and Mathematics Education*, *21*(1), 325–345. https://doi.org/10.1007/s10763-021-10236-4

Santoso, A. P., Jupitz, S., & Lin, C. (2021). A framework for developing community-focused medical physics outreach programs. *Journal of Applied Clinical Medical Physics*, *22*(10), 305–314. https://doi.org/10.1002/acm2.13413

Sotero, M. C., Alves, Â. G. C., Arandas, J. K. G., & Medeiros, M. F. T. (2020). Local and scientific knowledge in the school context: Characterization and content of published works. *Journal of Ethnobiology and Ethnomedicine*, *16*(1), 1–28. https://doi.org/10.1186/s13002-020-00373-5

Sudirman, S., Kennedy, D., & Soeharto, S. (2023). The teaching of physics at upper secondary school level: A comparative study between Indonesia and Ireland. *Frontiers in Education*, *8*(March), 1–9. https://doi.org/10.3389/feduc.2023.1118873

Sukmayadi, V., & Halim Yahya, A. (2020). Indonesian Education Landscape and the 21st Century Challenges. *Journal of Social Studies Education Research*, *11*(4), 219–234. www.jsser.org

Sulaeman, N. F., Efwinda, S., & Putra, P. D. A. (2022). Teacher readiness in STEM education: Voices of Indonesian physics teachers. *Journal of Technology and Science Education*, *12*(1), 68–82. https://doi.org/10.3926/jotse.1191

Sulaeman, N. F., Nuryadin, A., Efwinda, S., Subagiyo, L., Dinurrohmah, S., Tandra, T. F. R., & Takebayashi, T. (2024). Preservice Physics Teacher Views on Scientists' Role in Physics Teaching and Learning. *Berkala Ilmiah Pendidikan Fisika*, *12*(1), 84. https://doi.org/10.20527/bipf.v12i1.16961

Tabakova, V. (2020). E-learning – from first experiences in medical physics and engineering to its role in times of crisis. *Health and Technology*, *10*(6), 1385–1390. https://doi.org/10.1007/s12553-020-00474-x

Tsapaki, V. (2020). Radiation dose optimization in diagnostic and interventional radiology: Current issues and future perspectives. *Physica Medica*, *79*(October), 16–21. https://doi.org/10.1016/j.ejmp.2020.09.015

Ufnar, J. A., & Shepherd, V. L. (2019). The Scientist in the Classroom Partnership program: an innovative teacher professional development model. *Professional Development in Education*, *45*(4), 642–658. https://doi.org/10.1080/19415257.2018.1474487

Westbrook, A. L., Adams, C. T., & Taylor, J. A. (2023). Digging Deeper into Student-Teacher-Scientist Partnerships for Improving Students' Achievement and Attitudes about Scientists. *American Biology Teacher*, *85*(7), 379–389. https://doi.org/10.1525/abt.2023.85.7.379