



Exploring Prospective Physics Teachers' Perceptions of the Scientist-Teacher-Student Partnership (STSP) Program in Earth and Space Science Courses

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Article Info	Abstract
Article history: Received: February 13, 2026 Accepted: May 22, 2026 Published: May 25, 2026	The Scientist-Teachers-Students Partnership (STSP) Program offers a promising framework to bridge the gap between scientists and educators in fostering content knowledge for preservice physics teachers. This exploratory study investigates the perceptions of scientists, lecturers (teachers), and preservice physics teachers (students) regarding the implementation of the STSP program in an Earth-space science course. The research approach used was a mixed method, with qualitative data on prospective teachers' perceptions as the main data and quantitative data in the form of percentage calculations as supplementary data. The participants included one scientist, two lecturers, and 89 preservice physics teachers engaged over a 16-week semester. The program featured lectures, laboratory observations, and presentations by scientists, aiming to provide both breadth and depth in Earth-space science content. Data were collected through open-ended perception questionnaires and analyzed using coding and triangulation of responses across participant groups. Findings indicate that the STSP program effectively enhanced students' content knowledge through dynamic lectures and hands-on laboratory observations. Presentations by the scientist enriched the learning experience by integrating cutting-edge research and expert insights. All participants expressed positive perceptions, highlighting mutual benefits from the collaboration. These results underscore the potential of the STSP program as a valuable component in physics teacher preparation programs, offering a model for the interdisciplinary and collaborative learning framework.
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INTRODUCTION

In-depth knowledge of Earth and space sciences is essential (Jiaqi et al., 2022). The highest level of mastery in Earth science is characterized by an understanding that the Earth is a complex system due to the interconnection of the Earth system (Davidson et al., 2022; Soltis et al., 2019). Understanding the interconnection of the Earth system can be utilized to

achieve the Sustainable Development Goals (SDGs) (Orion, 2019; Vasconcelos & Orion, 2021; Zhao, 2020). Globally, one of UNESCO's agendas has also focused on Earth's sustainability (UNESCO et al., 2020). This global trend has increased the need and interest in Earth and space science knowledge (Cahyati & Liliawati, 2019; Ma et al., 2019).

From a scientist's perspective, Earth and space science is developing rapidly in line with technological developments. This development, for example, can be seen through projects by the National Aeronautics and Space Administration (NASA) in the US that continue to explore discoveries related to outer space (National Aeronautics and Space Administration, 2023); these discoveries were made through research and the scientific method.

From an educational perspective, Earth and space science is an interdisciplinary field of knowledge whose learning process involves observation activities, field lectures, and the utilization of learning tools (Aaisyah et al., 2021; Liou et al., 2018; Marra et al., 2017), and specific teaching strategies. In the context of Indonesia, at the junior high school level, it is part of the subject of natural sciences; at the senior high school level, it is explored in the subjects of geography and physics (Kemendikbudristek BSKAP RI, 2022; Permendikbud RI Nomor 37 Tahun 2018, 2018). Students studying physics in Grade X are primarily concerned with planetary motion in the solar system, as Newton's Law explains, whereas students in Grade XI are concerned with global warming (Cahyati & Liliawati, 2019). In fact, besides being related to Newton's Laws and global warming, Earth and space science in physics can also be studied concerning Kepler's Law, waves, energy, and other related physical phenomena. However, these materials have not been explicitly linked to Earth and space science in the school curriculum. This shows that teaching related to Earth and space science from a physics perspective is still limited and not in-depth.

The challenges of the school curriculum drive better teacher preparation programs. Developments that occur in the 21st century require preservice teachers to be able to adapt (Abbas et al., 2023). Research related to Earth and Space Science in physics and preservice teachers is conducted in various countries. Earth and Space Science Education's international profile in schools is a low (Greco & Almberg, 2016). In the United States, a survey of the American Association of Physics Teachers and National Earth Science Teachers Association members showed that physics teachers are very interested in learning more about the integration of Earth and space science with physics. Still, the lack of quality resources limits them (Vieyra et al., 2020). In Germany, space material is strengthened in some core curricula due to the high interest of students in learning about it (Hennig et al., 2023), as well as in Malaysia, but there are still several preservice teachers who have limited content knowledge and even misconceptions related to this material (Ibrahim et al., 2021). Therefore, future physics teachers should be prepared to teach this material (Hennig et al., 2023), because teaching readiness is important in the implementation of the learning (Sulaeman et al., 2022).

However, most Earth and space science courses in physics education study programs in Indonesia are still taught theoretically. Earth and Space Science is challenging for preservice teacher students to understand (Johan et al., 2018). The number of physics concepts related to Earth and space science makes it challenging for physics teachers and preservice teachers to have excellent and in-depth content knowledge (Hennig et al., 2023; Rosmiati et al., 2020). Content knowledge mastery is one of the basic knowledge (Cheon et al., 2022; Efwindi & Mannan, 2021; Kotoka & Kriek, 2023; Neumann et al., 2021) to become professional teachers who are adept at integrating content and pedagogical knowledge (Efwindi & Mannan, 2020; Große-Heilmann et al., 2022; Haryanto et al., 2023; Masrifah et al., 2018; Nurulsari et al., 2020). Unfortunately, preservice teachers usually have little knowledge when taking this course (Gray, 2017). The institutions of preservice teachers

need to provide support to develop preservice teachers' content knowledge skills or mastery (Leta et al., 2021; Schiering et al., 2021, 2022).

Based on the theories and research presented previously, it can be said that there is a gap between scientists and teachers in universities related to teaching Earth and space science subjects; this follows the statement by Anderson & Libarkin (2016). One program that has the potential to bridge the gap between scientists and teachers is the Scientist-Teachers-Students Partnership (STSP) program (Efwindi et al., 2025). A scientist is directly involved in discovery using the scientific method (Sharma & Honan, 2020). STSP is a collaborative program between scientists, teachers, and students that aims to improve the quality of science education and students' understanding of the science (Snitynsky et al., 2019).

The STSP program is gaining attention for its potential contribution to science education (Shanahan & Bechtel, 2020). The program has been successfully and widely used in education, for example, by Saat et al., (2021), Fadzil et al., (2019), Cavaş et al., (2021), Ismail et al., (2022), and Saat et al., (2023). The benefits of this STSP Program have also been obtained and are beneficial to all parties (Ismail et al., 2022), among others, for scientists can improve communication skills (MacFadden et al., 2022), for teachers as a reflection of learning (Nickerson et al., 2021), and improve content knowledge (Cavaş et al., 2021; Dai, 2022; Saat et al., 2021). Benefits for students can increase their interest in science (Laws et al., 2023) and their knowledge related to the material taught (Fadzil et al., 2019; Taylor et al., 2022). Through this program, students learn scientific knowledge and the scientific process (Hui et al., 2021). However, this STSP Program has never been applied to Earth and Space Science Lectures, especially in Indonesia. Therefore, this study aims to apply STSP in Earth and Space Science subjects and explore prospective teachers' perceptions of this STSP program. To guide this research, the research questions (RQ) are:
RQ1. What is the experience of prospective teachers in preparing the STSP program?
RQ2. What content knowledge about Earth and space science was acquired (includes the information obtained, the most interesting to learn more about, and the information to be taught to students in the future) through the STSP program?
RQ3. What are the perceptions of scientists, teachers, and students regarding the STSP program?

METHODS

This exploratory study aims to examine the perceptions of scientists, teachers, and students regarding the implementation of STSP in earth and science courses. The research approach used was a mixed method, with qualitative data on prospective teachers' perceptions as the main data and quantitative data in the form of percentage calculations as supplementary data. An exploration of the perceptions of invited scientists, teachers, and students is used to identify how STSP can foster students' content knowledge as preservice physics teachers (PPTs) in the Earth and Space Science Course.

This research involved a Japanese geologist as a scientist, 2 earth and space science lecturers as teachers, and 89 PPTs as students. This research was conducted in the Physics Education Study Program at a state university in Indonesia. All students who participated provided their voluntary consent for data collection and analysis.

Data on the perceptions of scientists, teachers, and students were collected using a questionnaire with several open-ended questions. The scientist questionnaire consisted of six items, and the teacher questionnaire consisted of seven items, adapted from Saat et al. (2021). The questionnaire for students consisted of 11 items, adapted from Fadzil et al. (2019). The questions in the scientist-teachers-students questionnaire were divided into three parts: 1) Collaborative activities and their relationship with the growth of content knowledge, 2) Content knowledge obtained, and 3) Opinions, difficulties, and benefits

related to the STSP program. Experts then validated the adapted open-ended questions. Validation by experts was conducted through focus group discussions with three lecturers who had backgrounds and experience in science education research. Validation was carried out by discussing the suitability of the number and questions in the groups or elements in the questionnaire sections. Validation was also carried out to ensure that no questions were repeated and that all questions were easy to understand.

After the data were collected, the data were analyzed for each perception by assigning a code to each response. In this study, co-occurrence network analysis was employed to identify trends in responses (Verma et al., 2025), to triangulate scientists' perceptions, to link relevant theories and previous studies, and to draw conclusions. The research participants' responses were analyzed qualitatively using KH Coder software. The responses, originally in Indonesian, were first translated into English because English is one of the languages well supported by this software. The data was then uploaded to KH Coder, and a co-occurrence network analysis was performed. After the data was processed, the results appeared, presenting patterns, relationships between words, and groups or themes that could be distinguished by color. Words in the same group or theme had the same color, and word frequency could be seen in the differences in the sizes of the circles containing the words.

This study modifies the research conducted by Fadzil et al., (2019) regarding collaboration with scientists. The STSP program is carried out through stages, including planning, implementation, and results. Collaboration among scientists, teachers, and students began in March 2023, starting with planning. In the planning stage, the scientist and teachers agreed on the number of meetings, the time, and the methods and lecture materials to be taught by the scientist in the Earth and Space Science course. The Earth and Space course consists of 16 meetings; the 8th meeting is the midterm exam, and the 16th meeting is the final semester exam. The implementation phase was conducted in May and June 2023 across three lecture meetings. Pre-meeting with the scientist at the 11th meeting of the course. Discussions with the scientist at the 12th and 13th meetings were held online via Zoom. The scientist delivered courses in English on two main topics: Earth Materials and Life in an Extreme Environment. Collaboration with the scientist and the scope of Earth and space lectures are presented in Figure 1.

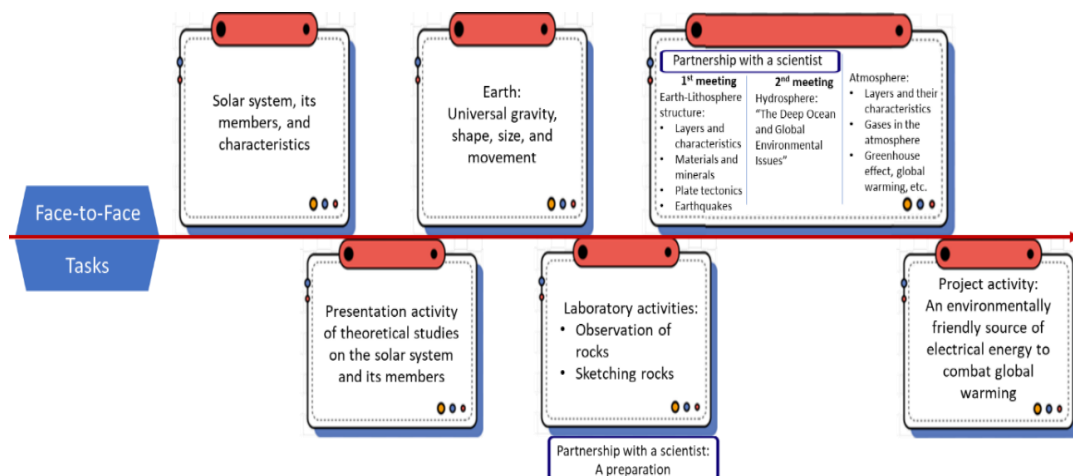


Figure 1 Collaboration and scope of Earth and Space lectures

RESULTS AND DISCUSSION

This section will present the results and discussion related to how the perceptions of scientists, lecturers (teachers), and preservice physics teachers (students) regarding the implementation of the STSP program in an earth-space science course.

Answering RQ1, all students in this study could retell their preparations for the STSP program. Some examples of student answers are presented in Table 1.

Table 1 Example of students' answers related to preparations made in the STSP program

Student-Code	Response	Code
S-87	<i>"I directly observed rocks such as granite and basalt in the geography laboratory. I also explored information about the rocks, such as their origins, characteristics, and sketches."</i>	• Observation of rocks • Sketching rocks from direct observation
S-36	<i>"The lecturer directed us to study the types of rocks in the geography laboratory. After that, we were directed to sketch the existing rocks to be able to distinguish the types. We also studied material about earthquakes, especially the 2004 Aceh Earthquake and Tsunami (West End of Sumatra Island)."</i>	• Observation of rocks • Sketching rocks from direct observation

For RQ2, the content knowledge obtained in the STSP program in this study includes the information obtained, the most interesting to learn more about, and the information to be taught to students in the future. Based on teachers' perceptions, the content knowledge that students can obtain through the STSP Program is more multidisciplinary, not only seen in physics, for example; it also connects to ecosystems, the history of the earth and its organisms, biodiversity, extinction, etc.

The results of the analysis of all answers given by students related to the content knowledge they obtained through the STSP program are presented in Figure 2.

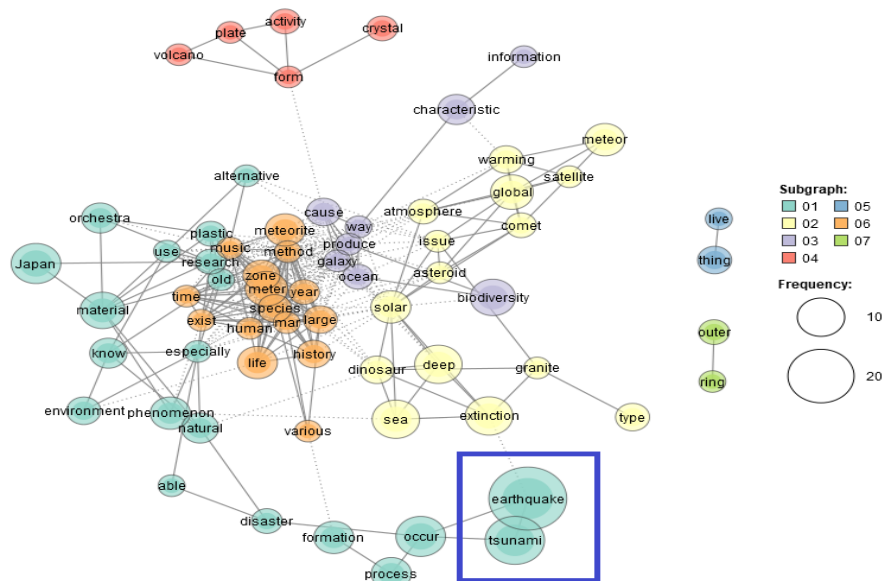


Figure 2 Content knowledge obtained by students in the STSP Program

Concerning the most exciting information, wanting to learn more is presented in Figure 3.

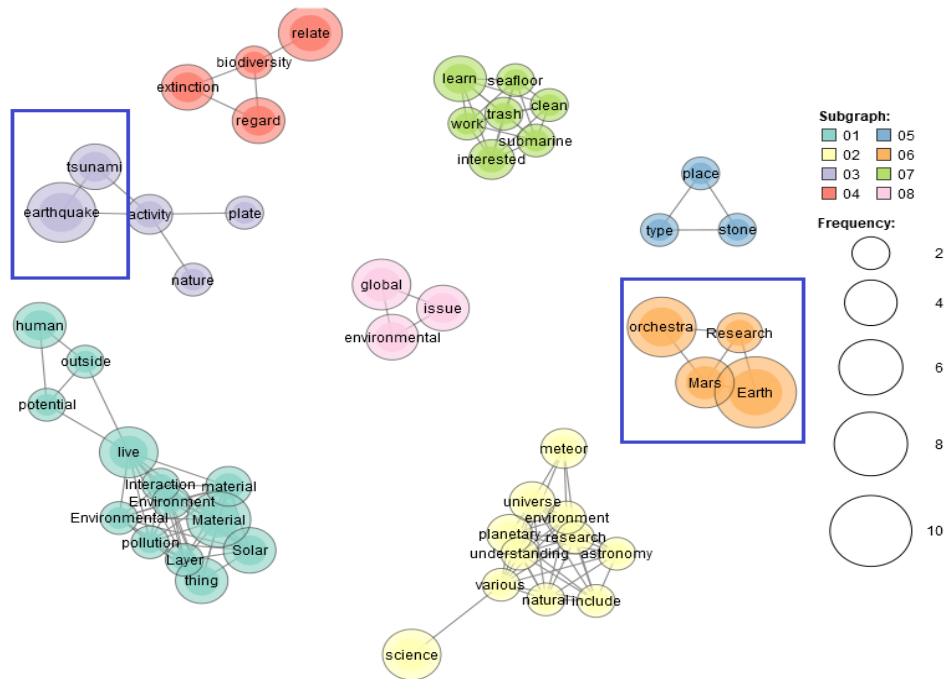


Figure 3 The most exciting content knowledge in the STSP Program

The content knowledge that preservice teachers want to teach students in the future, based on their perceptions, was analyzed using frequency and percentage calculations, and the results are presented in Figure 4.

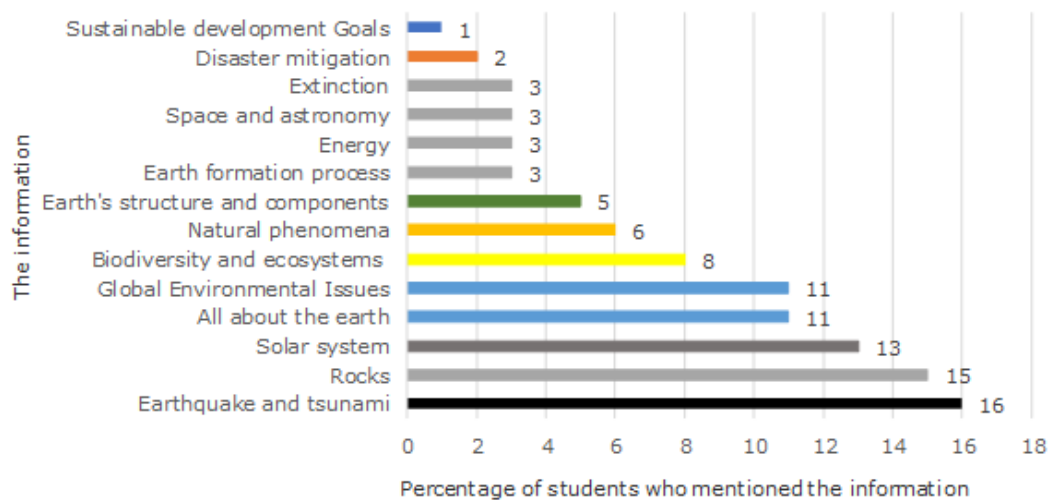


Figure 4 Content Knowledge that students chose to teach at school

Regarding RQ3, all students responded positively to this STSP program; for example, S-36 stated:

"This collaboration activity is perfect and fun; we study rocks directly, then listen to explanations from the scientist who is an expert in this field."

Students also perceive that this collaboration activity can broaden their horizons, as stated by S-14:

"In my opinion, collaboration with a scientist in lectures can increase our knowledge and broaden our horizons, especially by using English, which can hone our skills in English."

S-38:

"In addition to gaining insight from the material usually taught by lecturers, from journals and books, I can find out directly from the perspective of a scientist."

S-17:

"The benefits obtained are a lot, adding insight from the perspective of the scientist who has done research directly, which can usually only be read through websites, books, or journals; through this program, it can be explained directly by the scientist based on what has been done and researched by the scientist. This collaborative activity is very inspiring and makes me curious to dig deeper into content knowledge on natural phenomena around."

This result aligns with the statements by [Dai \(2022\)](#), [Çavaş et al., \(2021\)](#), and [Saat et al. \(2021\)](#), which state that the STSP program helps improve content knowledge. This is also following the response of scientists who gave a good response to the STSP program, such as the statement of a scientist:

"I think it is a good idea. Earth and space science research is broad in scope. Furthermore, research in earth science is constantly advancing. If students want to learn the cutting edge of earth science, the most efficient way is to talk to researchers. Invited lectures can show students photos and videos of the guest lecturer's research. Inviting experts as guests and getting to know them well can create connections with people worldwide."

Likewise, teachers also feel happy and enthusiastic about this STSP program. As stated by T-1:

"Very enthusiastic, because it enriches the lecture method, which was previously only done in the form of theories. The content knowledge provided by the scientist also presents the content in depth and globally and presents findings by the scientist so that it might motivate students to become scientists." Likewise with T-2: *"Very happy with this program; I think this program is feasible and necessary. In addition to broadening students' horizons, this collaboration activity can strengthen teachers' content knowledge in the Earth and Space course. This activity is useful both in improving mastery of content and pedagogy for me to implement in the Earth and Space Course."*

and T-2:

"Very useful in terms of improving my language skills and the literacy of the science taught in my class."

Teachers' difficulties tend to be technical; T-2 stated,

"The problem found is when it is necessary to observe rocks and make sketches because in the physics laboratory itself, there are no rocks, and in the Earth and Space course, there has never been a practicum related to rocks. The way to solve it is to collaborate with lecturers from the geography study program because the geography study program has various types of rocks and allows students to make observations."

From a scientist's perspective, the difficulties experienced stem from lecture activities conducted through distance learning, whereas the most important content of earth science is

observing and experimenting. Thus, scientists think the problem is that the most basic element was missing because of lectures or online collaborative programs.

The STSP program must be well-planned, well-attended, and flexible to be effective (MacFadden et al., 2022). Based on the data collected through questionnaires, the scientists, teachers, and students can be said to have prepared and implemented the STSP program effectively. Teachers described some of the preparations made in the STSP program in the questionnaires distributed. The description by the teacher regarding the practices made includes providing information to the scientist regarding the content knowledge commonly discussed in the Earth and Space course; discussing the material, time, and method or form of lectures that the scientist will fill; and outlining the activities that students need to do, both before the course, during the course, and after the study with the scientist. Before the STSP program, scientists had created PowerPoint slides for educational materials for 1 year and had taken inventory of rock mineral specimen photos for several years. Then, around March, after communicating with the teacher for the STSP program, the scientist adjusted the previously prepared slides, considering the number of students, class level, affiliation, and lecture time. Scientists also photograph new rock specimens and microscopically examine them. In preparation for this collaborative program, scientists also researched Indonesian geology from March to April, prepared slides in English, and translated several slides into Indonesian. To clarify lecture activities, scientists also develop student worksheets on Earth and rock materials.

Before meeting with the scientist, students are divided into groups. Each group consists of 10-15 students, with eight groups in total. This activity was conducted under the teacher's supervision in the university laboratory. Students must also learn about earthquakes and tsunamis, especially in Indonesia. During the lecture, students were given worksheets by the scientist.

Table 1 provides an overview of the preparations made by students in this STSP program, including studying, observing, and sketching rocks observed in the laboratory, as well as studying earthquakes and tsunamis. Observation in the laboratory enables students to observe rocks directly, analyze the differences in various types of rocks by looking directly at the object, and sketch rocks based on observations, like a scientist. The achievement of learning objectives in the Earth and Space course can be achieved by increasing students' practical activities and drawing conclusions from observations (Davidson et al., 2022). This activity addresses problems in science education related to students' lack of active engagement in scientific activities (Saat et al., 2021).

Meetings with the scientist were held online via Zoom. The activities include students paying attention to the scientist's presentation of material, working on provided worksheets, and participating in question-and-answer discussions. The variety of information students obtain from various perspectives (in this case, the scientist and teachers) is expected to deepen and broaden their content knowledge via PPTs. The STSP program can facilitate students' acquisition of new information and skills (Saat et al., 2021) and enrich their learning experiences (Cavas et al., 2021). The scientific material is up-to-date and accompanied by the scientist's findings. This follows the statement by Ismail et al. (2022) that the STSP program can enable all parties involved to acquire relevant new skills and knowledge.

Figure 2 shows that the content knowledge obtained in the STSP program is multidisciplinary. This also corresponds with the answers given by the teachers. Multidisciplinary delivery of Earth and space science is indeed needed. Earth and space science covers many disciplines (Soltis et al., 2019). Figure 3 shows eight groups of the most exciting content knowledge to learn further based on students' perceptions. Students consider all things about the earth to be interesting information to know more about,

especially about the analogy that the planet is an orchestra, for example, as stated by S-84, *"What I just found out is that the earth is likened to an orchestra where if one of the melodies is disturbed, the music will disappear."* Students' understanding of the interconnection of the Earth system is the highest level of mastery of the Earth science (Davidson et al., 2022; Soltis et al., 2019). The use of analogies proved to be effective in attracting students' desire to learn more (Vieira & Morais, 2025).

Figure 4 shows 14 content knowledge groups that students choose to teach in school. Content knowledge related to earthquakes and tsunamis, as well as rocks, is what student teachers most want to convey to their future students. Regarding the STSP program activities, these are two pieces of content knowledge that have been discussed since the STSP program's preparation stage. The acquisition of this content knowledge also involves students being active. The content knowledge on earthquakes and tsunamis was content that students were asked to learn before the lecture meeting with the scientist. During the lecture, this topic was also discussed in the student worksheet. Likewise, content knowledge about rocks also involves students being active through direct observation in the laboratory. The STSP program can enrich learning activities that can improve the quality of science education (Snitynsky et al., 2019). Teacher-scientist interactions can encourage teachers to engage in scientific practices (Dai, 2022) and to acquire relevant skills and knowledge (Ismail et al., 2022).

The difficulty experienced by the majority is due to the scientist's language. The participants were students from Indonesia, some of whom were less proficient in English, and they found the scientist's use of English difficult, making it hard for them to understand the material presented. Increasing English as a medium of instruction is a challenge in education (Hultgren & Wilkinson, 2022). Therefore, students' ability to speak English is also a factor that affects content knowledge. Proficiency in English makes it easier for students to obtain and understand information and content knowledge from outside sources. The ability to use English is essential because it is widely used, a popular topic, and a significant issue worldwide (Kumar & Kumar, 2018; Peng & Chen, 2022; Zhang, 2022).

In addition, students may find the material difficult to comprehend because it is too in-depth, especially regarding physics, the language used, the structure of the teaching materials, and rapid transitions between sub-materials. It is believed that this is because Indonesian students are accustomed to studying earth and space science primarily on essential topics from primary school through university. For example, at the secondary school level, the discussion of Earth and space in physics focuses only on the relationship between planetary motion in the solar system from a Newtonian perspective and global warming (Cahyati & Liliawati, 2019). These results can also be considered for stakeholders to review the depth and breadth of Earth and space science materials in primary, secondary, and tertiary school curricula.

Regarding the benefits of this STSP program for students, among others, it broadens their horizons and experiences, provides inspiration, and increases their motivation to learn Earth and space science. These findings are consistent with those of studies conducted by Fadzil et al. (2019), Hui et al. (2021), Laws et al. (2023), and Taylor et al. (2022). The STSP program benefits not only students and teachers but also scientists; involvement in this organization has increased scientists' enthusiasm for effectively communicating natural science to participants. Through this activity, scientists learn to what extent it is possible to communicate accurately with only visual and auditory information, as this program was conducted via distance learning via the Zoom application.

CONCLUSION

Implementing the STSP program in this study seeks to foster students' content knowledge of Earth and space science materials through lecture activities using different methods from previous lectures. Through STSP, courses convey theories and observation activities in the laboratory where students directly observe rocks, analyze the differences in various types of rocks by looking directly at the objects, and make sketches of stones based on observations, like a scientist. Students also got a presentation of material from a different perspective by a scientist. The scientist's presentation was broader and deeper and based on the experience and results of research conducted directly by the scientist. The scientist also tried to draw analogies that would attract preservice teachers to learn more about Earth and space science. In addition to adding insight to PPT, the STSP program also provides experience and increases students' motivation to learn science. The difficulties experienced by students are primarily due to the language factor, where materials were delivered in English. Despite this, the scientists, teachers, and students responded positively to the STSP program, gained many benefits from it, and expressed a desire to continue it in the future. The success of the STSP program in this study can serve as a recommendation to stakeholders to implement it as part of the physics teacher preparation program.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, NFS and S.E.; methodology, NFS, SE, and AN; formal analysis, SE, NFS, and AN; writing—preparation of the original draft, SE, NFS, AN, DAPRP, and TT.

AI DISCLOSURE STATEMENT

The authors used Grammarly during the preparation of this work to improve the quality of English writing. After using the tool, the authors thoroughly reviewed and edited the content as needed and took full responsibility for the publication's content.

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