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Enhancing Scientific Communication Skills of Pre-Service Science Teacher Through Guided Inquiry Learning on Basic Physics Laboratory Activities

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Abstract: This study aims to describe the enhancement of students' science communication skills through the application of guided inquiry learning models in laboratory activities. The method used to describe science communication skills is to use pre-experiment research. The samples used in this study were 60 physics education students in the odd semester 2023/2024 who took basic physics practicum courses. The implementation of the guided inquiry learning model in the four meetings. The results of improving science communication skills were based on three indicators that researchers have limited. The result analysis used non-test instruments like observation sheets. The sub-scientific communication skills are: 1) searching information, 2) scientific writing, and 3) representing information. Based on the observation results, it was found that the application of the guided inquiry learning model can train students' science communication skills in sub-skills of seeking information with a percentage increase of 74%, sub-skills of scientific writing with a rise of 67% and sub-skills of representing information at an increase in percentage of 76%. Each average score on the third and fourth meetings shows that science communication skills are in the very skilled category.

Keywords: Basic Physics Laboratory; Guided Inquiry Learning; Scientific Communication Skills

Introduction

In the 21st century, human resources are emphasized to improve their quality in facing global challenges in the world of work. The National Education Association has identified 21st-century skills as "The 4Cs." "The 4Cs" include critical thinking and problem-solving, creative thinking, communication, and collaboration skills. The preparation of human resources who master 21st-century competencies and skills will be adequate if pursued through education. Educational institutions are seen as the most likely institutions to prepare students to become superior human beings who can collaborate in the global order. In the intense uncertainties and challenges everyone faces, a paradigm shift in the education system is urgently needed to provide a set of 21st-century skills learners need to meet every aspect of global life (Syamsuddin, 2019; Van Laar et al., 2020; Jalinus et al., 2023).

In line with this, the 21st century demands various skills that a person must master, so it is hoped that education can prepare students to master these multiple skills to become successful. Essential skills in the 21st century are still relevant to life's four pillars: learning to know, learning to do, learning to be and living together. Akpan & Kennedy (2020) told that the four principles each contain specific skills that need to be empowered in learning activities, such as critical thinking, problem-

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solving, metacognition, communication skills, collaboration, innovation and creation, information literacy, and various other skills.

Communication skills are a necessary competency to convey ideas and thoughts in various life contexts. The task and role of the teacher is no longer as a provider of information (transfer of knowledge) but as a stimulation of learning so that students can construct their understanding through various activities, including aspects of communication. Education today prepares students to have good hard skills and soft skills. The Indonesian government has responded to this by developing the 2013 curriculum in which three things are demanded: attitude, knowledge and skills. In this case, communication skills fall into the realm of skills in the demands of the 2013 curriculum (Patriot et al., 2018; Patriot & Jannah, 2022).

Communication skills are one of the skills that students must have in 21st-century education. This skill is indispensable in the world of work because it is one of the 21st-century skills that must be empowered in learning. Success is not only related to the ability of technical knowledge, commonly called hard skills, but also to soft skills, namely the ability to manage yourself and others. This is reinforced based on the results of a survey conducted by NACE in the journal Hariyanto, Yamtinah, Sukarmin, Saputro, and Mahardiani, which states that "important things that are often compared to the cumulative grade point average (GPA) are soft skills". Soft skills include communication, honesty, motivation, adaptation, cooperation, and good interpersonal skills (Hariyanto et al., 2019).

Based on the results of observations made by researchers during one semester, student skills in laboratory activities are science communication skills. This skill is reviewed based on communication, both verbal and non-verbal. This also certainly affects students' level of understanding in the learning process of concepts in physics. Communication skills also indicate how students interpret knowledge in various forms of representation. This is supported by previous research that shows that learners can share their ideas and opinions through communication, involve cooperative skills, and collaborate with other group members (Mukaromah & Wusqo, 2020; Patriot & Jannah, 2022).

The physics content competency also requires scientific communication skills, namely in presenting experimental results in tables and graphs and reporting the results orally and in writing. Based on this, communication skills are essential to learning science, especially physics. Bunawan et al., (2023) told that educators must be able to design a learning process that can motivate and improve student communication skills because this will impact students' success in understanding the concepts they learn. Applying an appropriate learning model will result in an effective learning process.

Therefore, a student-oriented learning model is needed. Student-oriented learning can allow students to play an active role and centre learning activities. It can improve understanding by linking old knowledge with new, trained skills. After all, students are asked to be involved in learning activities and foster high motivation in students because they feel that the learning carried out is meaningful to students.

One of the learning models that is an alternative to the implementation of physics learning is Guided Inquiry Learning. Guided inquiry learning promotes acquiring new knowledge, abilities and attitudes by investigating questions, problem-solving strategies and standard questions in the discipline. This is consistent with a range of contemporary learning theories, collectively called constructivism. Inquiry guided learning means a learning model carried out by the teacher by guiding students to find their understanding of the material through systematic, logical, and analytical investigation activities (Zuhra et al., 2021; Saputri et al., 2023).

There are several characteristics of guided inquiry that need to be considered. For example, students can develop thinking skills to make inferences or generalizations through specific observations. The goal is to learn how to observe events or objects and then make appropriate generalizations. The teacher controls certain parts of the learning, such as events, data, and materials and acts as a class leader. Kuhlthau et al., (2015) support that each student attempts to build meaningful patterns based on classroom observations. The classroom is expected to function as a learning laboratory. Usually, a certain number of generalizations will be obtained from students. The teacher motivates all students to communicate their abstractions so that all students can utilize them (Wahyuni et al., 2019).

One of the compulsory courses followed by students is Basic Physics. The Basic Physics course serves as a vehicle for developing scientific attitudes and fostering ways of learning in college. Introductory Physics is given to provide a physics foundation that departs from physics knowledge in high school. Students are actively involved in solving problems, and lecturers motivate students to gain experience that allows them to find and solve problems (Sari et al., 2017; Putri et al., 2023). In fact, students have done the Basic Physics practicum in the physics education laboratory.

From the beginning of practicum to the final stage of practicum activities, students are trained to possess various skills that students in the 21st century should have. One of the skills focused on in this study is communication skills. Through the background

described above, the researcher intends to present the research results on applying guided inquiry learning models to optimize student communication skills in physics matters.

Method

This research employs a pre-experimental design. This method was chosen because it is based on the research objectives, which only want to see the impact of treatment on the dependent variable (Creswell, 2015). The study focuses on students as pre-service teachers in the Physics education department at Sriwijaya University. The study involved a total of 60 students as the research sample.

Scientific communication skills are students' skills in communicating their thinking process in physics learning both orally and in writing. The sub-skills of scientific communication that will be measured are searching information, listening and observing, scientific writing, representing information, and presenting knowledge. Enhancing scientific communication skills is the process of improving students' skill achievements in communicating their knowledge at each meeting.

Table 1. The indicator of scientific communication skills assessment format

Component of Scientific Communication skills	Indicator
Searching information	•Use of library resources (printed books, teaching modules, articles and the internet) •Selection of Library source quality
Scientific writing (Compiling the report)	• Quality of exposure (citation) of literature review • Discussion of content in report
Communicate the report orally (presentation)	• Fluency of speech in expressing opinions • Delivery of the content of the opinion • Active in expressing ideas, respecting other students' opinions • Ability to present material (focused, systematic) and display quality • Use of language

A performance test or performance assessment is a non-test to measure students' scientific communication skills. The performance test or performance assessment is used to see how the development of scientific communication skills takes place during the learning process. This performance test contains indicators adapted to Spektor-Levy et al., (2008) has developed. In this research, we limited the scientific communication skill in: 1) seeking information, 2) scientific writing, and 3) representing information. The indicator of scientific communication represented from Table 1.

The analysis used to describe students' science communication skills during learning using guided inquiry model is by measuring science communication skills as Equation 1.

$$P_p = \frac{P}{N} \times 100\ \% \quad (1)$$

The criteria for science communication skills used as a guideline in this study, science communication skills data were analyzed statistically. The indicators of science communication skills assessment range are listed in Table 2.

Table 2. The rubric of science communication skills

The range (%)	Category
81 ≤ score ≤ 100	Very skilled
61 ≤ score ≤ 80	Skilled
40 ≤ score ≤ 60	Enough Skilled
<40	Less Skilled

Result and Discussion

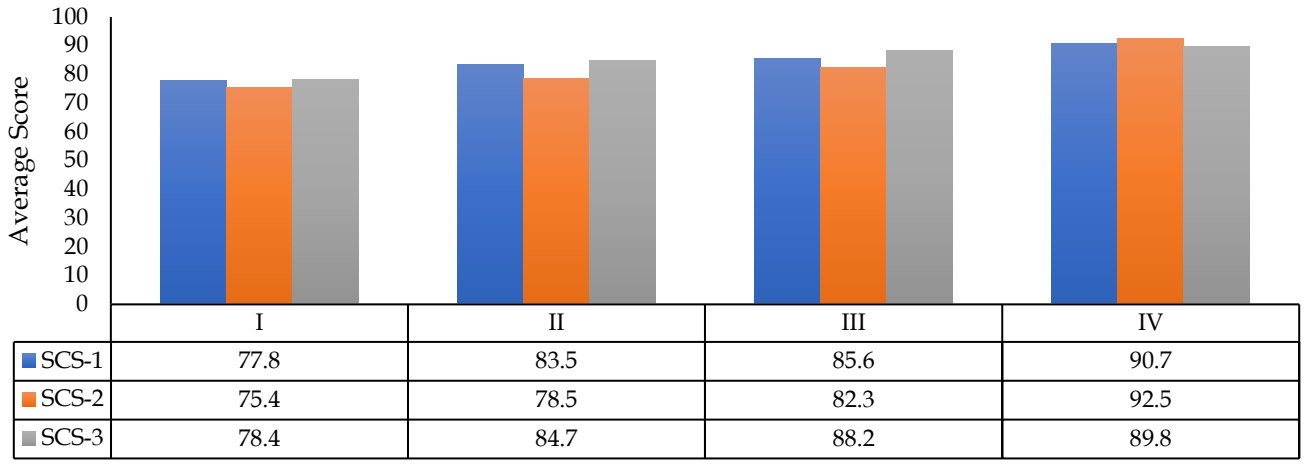
This study describes enhancing students' science communication skills in introductory physics practicum courses. The application of the guided inquiry learning model in the learning process took place four times so that the results of improving science communication skills were based on three indicators that researchers have limited.

The purpose of this research activity is to observe three essential things: the application of the guided inquiry learning model, the improvement of communication skills, and student responses to the learning model used in lectures. Students who take introductory physics practicum courses are prospective teacher students in physics education study programs with 60 students.

In general, lecture activities have three stages of implementation, namely introductory, core and closing activities. In this activity, the guided inquiry learning model consists of 6 steps, which are explained in the Table 3.

Table 3. Stages of learning through guided inquiry learning model

Syntax	Description
Orientation	This stage is critical and required to create a conducive and pleasant atmosphere for learning.
Formulate the problem	At this stage, students are directed to a problem that requires solving. The problem can be presented interestingly, such as a unique demonstration, so that students are challenged to find out what is happening and formulate it in a question or statement they must answer themselves later.
Formulate a hypothesis	At this stage, students are trained to make a hypothesis or temporary answer to the problem they have witnessed. Ideas are not necessarily correct, so encourage children not to be afraid to express their views.
Data Collecting	At this stage, students conduct activities to collect the information needed to test their hypothesis. In inquiry learning, this stage is a critical process to develop students' intellectual abilities because, at this stage, students are trained to use all their thinking potential.
Testing a hypothesis	This stage is a step that trains students' rational abilities, where the hypothesis that has been created is then tested by comparing it with existing data and then showing it. At this stage, students are also trained to be honest and confident to test their hypotheses based on data and facts.
Communicate results	In this step, students must describe the findings obtained based on the results of hypothesis testing to reach accurate conclusions.



	I	II	III	IV
SCS-1	77.8	83.5	85.6	90.7
SCS-2	75.4	78.5	82.3	92.5
SCS-3	78.4	84.7	88.2	89.8

Figure 1. Histogram the percentage of observation result

The experimental class applied the guided inquiry learning model assisted by student worksheets. Student worksheets become student activity sheets to express ideas and opinions and describe the results of data collection through practical laboratory activities. Students' science communication skills are measured through observation sheets categorized as assessments through non-test instruments with adjusted rubrics. There are several science communication sub-skills measured in this lecture are searching information, scientific writing, and representing information (Spektor-Levy et al., 2008). One of the results of science communication skills is taken through data from individual student practicum reports and group presentations. The results of science communication skills analyzed through observation sheets are represented through a diagram, which is the data from the processing results as figure 1.

Based on Figure 1 above, the observation data of scientific communication skills has increased at each meeting. The first scientific communication skill (SCS-1) is finding information, which is one of the skills in sorting and selecting information as a reference for the reports and presentation materials they will make. The skill is observed through indicators developed and seen in determining their reading sources, written in the information and student worksheet (LKM). In the first lecture meeting, students conducted a practicum on GLB (Straight Line Motion) material. This activity is carried out in groups, but each student has an individual worksheet so that skills in finding and selecting the sources of information used can be seen. The improvement in SCS-1 is shown through an average increase from the skilled category to the very skilled category, an increase of 74% from the first meeting to the second meeting.

In the second meeting, practicum activities were carried out on the material of straight-line motion (GLBB). The increase in SCS-2 also occurred from the second to the third meeting. The percentage increase of 67% shows a decrease in the percentage increase from the previous session. This is due to several factors, such as some students still using confidential information from blogs, websites, and previous reports that are only

necessarily reliable with filtering first. Evaluation at the second meeting was carried out to all students so that they could be more careful in choosing the sources of information they would use. Further research shows that students can find the correct reference and use it to train literacy in the learning process (Husnaini & Chen, 2019).

Lectures at the third meeting carried out simple harmonic oscillation practicum activities. At this meeting, the skills in the first indicator were included in the very skilled category. This figure shows that students have done citations and found sources of information better than in the previous meeting. In addition, the improvement of science communication skills occurred in SCS-2. An increase of 82.4% shows that students' skills in writing practicum reports are included in the very skilled category. This is shown in the suitability of the predetermined report format and also the strength in using reference sources in the discussion chapter so that it can answer the hypothesis they have compiled at the beginning before the core practicum activities begin (Eroglu, 2019; Algiani et al., 2023). After writing the practicum report, students in groups are also trained to communicate the practicum results orally to students in other groups. This is shown in the increase in SCS-3 from the second meeting to the third meeting. The rise of 86.4% indicates that the quality of the presentation delivered by each student is included in the very skilled category. Some of the SCS-3 indicators that stand out in improving this skill are students' fluency in delivering their presentation, being able to convey opinions well and straightforwardly, better presentation display through PPT, and using standardized language in presentation activities.

The lecture at the fourth meeting carried out practicum activities on series and parallel circuit material. In this practicum activity, the increase in SCS-1 from the third meeting to the fourth meeting was 85%. The average value category at the fourth meeting was 90.7, included in the very skilled category. In the SCS-2 class, the average value obtained at the fourth meeting was 92.5, which is also included in the very professional category. Another improvement is shown in SCS-3, where the average value obtained is 89.8, including in the very skilled category.

The impact of this increase in science communication skills can be attributed to applying the guided inquiry learning model. In practicum activities, students are presented with problems and an equation to prove the correlation through a practicum activity. This problem is offered through the Student Worksheet . The appearance of the LKM used is shown in the Figure 2.

Figure 2. Activity sheets of student for basic physics laboratory activities

When formulating problems, students are directed to a problem that requires solving. Problems can be presented interestingly through student worksheets or learning videos so that students are challenged to find out what is happening and formulate it in a question or statement they must answer later. This statement in line with researched by Nafsih, et.al. (2022) that formulating problems make students can solve the problem and make a hypothesis. The next stage is developing a hypothesis. In this activity, students are trained to make a hypothesis or temporary answer to the problem presented at the beginning. In this activity, students begin to search and use renewable references as their theoretical basis in determining the practicum activities that will be carried out to test the hypothesis that has been formulated.

The references used by students as supporting reference sources for practicum activities start from basic physics books, websites, practicum guidebooks, and recent articles (2018-2023) to the use of blogs that contain some information on practicum activities that can support the implementation of practicum activities in the laboratory.

At the data collection stage, students carry out activities to collect information needed to test the hypothesis they have made. In inquiry learning, this stage is a critical process to develop students' intellectual abilities because, at this stage, students are trained to use all their thinking potential. Data collection starts with determining the practicum tools and materials used. One practicum that can be used as an example is series and parallel circuit material through Figure 3.

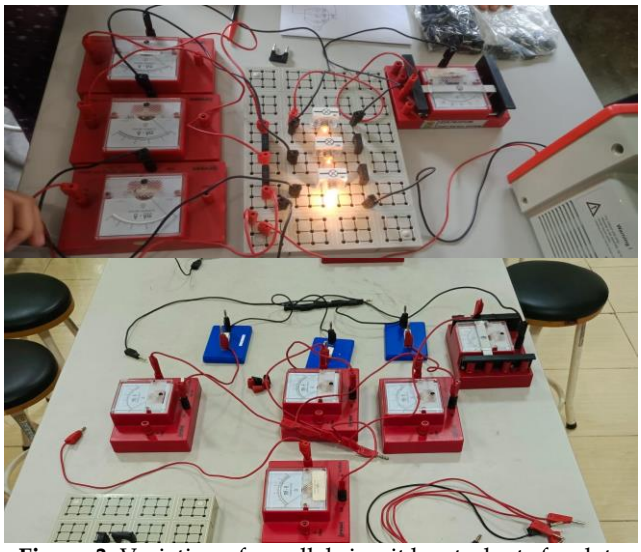


Figure 3. Variation of parallel circuit by students for data collection stage

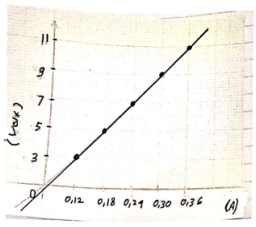
At this stage, students collaborate with friends in one group to carry out various practicum activities to answer the formulation of the problem that has been prepared. After obtaining the required data, students enter a process to test the hypothesis.

The next stage is testing the hypothesis. This step trains students' rational abilities, where the idea that has been made is then tested by comparing it with existing data and then showing it. At this stage, students are also trained to be honest and confident so that students can test their hypotheses based on data and facts.

The last stage is communicating the results. At this stage, students must describe the findings obtained based on the results of hypothesis testing to reach an accurate conclusion. At this stage, the indicators of science communication skills observed are students' skills in writing and reporting the results of data testing both orally and in writing. The hands seen are the use of reference sources and citations and the strength in the discussion chapter to link the theory obtained with the practical results achieved through laboratory activities. The following are the results of student reports written individually in Figure 4.

In the final stage, students write the results of their reports using references that have been cited and write data in various forms of representation. The representations used are verbal, tables, diagrams, and mathematical equations. Skills in communicating data orally through different representations are supported in research, which states that individuals can express thoughts, tackle challenges, and gain insights into the evolving world through engaging in writing activities. Additionally, writing serves as a mode of self-expression (Lambirth & Goouch, 2006; Eroglu, 2019). It acts as a conduit for understanding future scenarios, enabling students to prepare themselves for academic endeavors (Sulak, 2018; Radyk et al., 2023)

DISCUSSIONS



This experiment is a basic physics experiment with the title series and parallel resistor circuits, with the aim that students can understand the effect of large values of series or parallel resistance on current and voltage and can understand the nature of series and parallel resistor circuits. The procedure for this experiment is to first make sure the internet connection is good to be able to access the simulator page smoothly, secondly enter the web simulator page, then drag the icons used in the experiment. The icon is a cable whose function is to connect or media the course of electric current, battery as a source of electricity, resistor as resistance, then there is a switch whose function is to connect and disconnect the electricity, then there is a voltmeter used to measure voltage, and an ammeter used to measure the strength of electric current.

The first activity in observation is series circuit gets the results at the time R1, R2, R3 each have amount 10 Ω , so V1, V2, V3 and each have amount 3V, dan I1, I2, I3 each have amount 0,3 A. Saat R1, R2, R3 each have amount 50 Ω , so V1, V2, V3 each have amount 3V, and I1, I2, I3 each have amount 0,06 A. When R1, R2, R3 each have amount 100 Ω, so V_1, V_2, V_3 each have 3V, dan I1, I2, I3 each have amount 0,03 A. So R1, R2, R3 each have amount 10 Ω, 50 Ω, 100 Ω , so V1, V2, V3 each have amount 0,56 V, 2,81 V, 5,62 V, and I_1, I_2, I_3 each have amount 0,06 A.

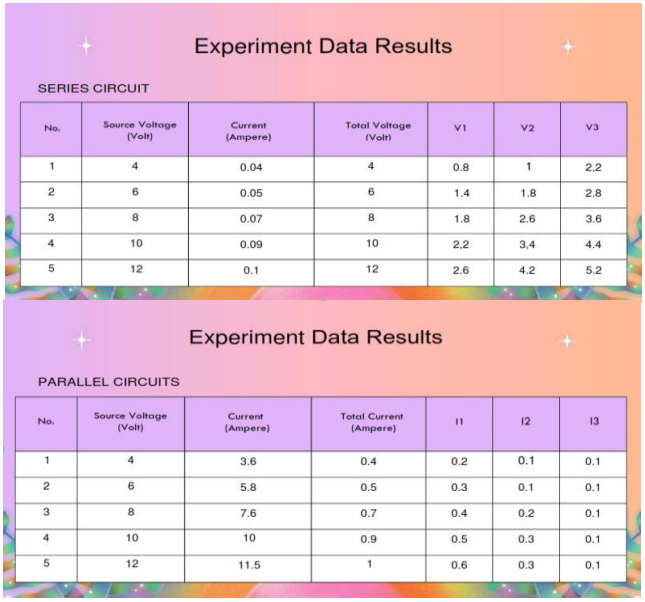
Figure 4. Basic physics practicum report

The other research conducted by Radyk, M. D., et al. (2023) using a writing intensive course in improving the perceptions and beliefs of biology students at Stanford University, California, about students' ability to read scientific literature and communicate science provides a clear picture in scientific writing skills. The study's results on understanding scientific papers showed good gains in the perception of student understanding and the ability to communicate science in writing. Lee et al., (2011) found that using laboratory reports improves students' communication skills. Additionally, they highlighted that the enhancement in communication skills was attributed to incorporating basic writing activities into the classroom learning process.

In addition, students also present in groups to communicate the results of data collection and hypothesis testing orally. At this stage, students are trained to communicate well with other groups. The problem that often causes low oral communication skills is the need for more opportunities for students to optimize their potential. Therefore, one of the most appropriate ways to overcome communication problems is to provide various opportunities for students to practice public speaking skills. There are several options for students to practice public speaking skills (Khan et al., 2017; Eroglu, 2019). Supported with other research Yulianti, et. al. (2021) that the voice clarity indicator relates to a clear voice with stable intonation and intonation, stable voice speed, and the habit of avoiding reading presentation slides. The material clarity indicator relates to delivering material in a structured and organized manner. At the same time, the

indicator of response to the audience relates to the presence of eye contact and attitudes that show awareness of the audience's view and presence.

This activity was carried out in the week after the practicum was completed. The following are the results of student presentations assembled in the form of PowerPoint through Figure 5 .



No.	Source Voltage (Volt)	Current (Ampere)	Total Voltage (Volt)	V1	V2	V3
1	4	0.04	4	0.8	1	2,2
2	6	0.05	6	1.4	1.8	2.8
3	8	0.07	8	1.8	2.6	3.6
4	10	0.09	10	2,2	3,4	4.4
5	12	0.1	12	2.6	4.2	5.2

No.	Source Voltage (Volt)	Current (Ampere)	Total Current (Ampere)	I1	I2	I3
1	4	3.6	0.4	0.2	0.1	0.1
2	6	5.8	0.5	0.3	0.1	0.1
3	8	7.6	0.7	0.4	0.2	0.1
4	10	10	0.9	0.5	0.3	0.1
5	12	11.5	1	0.6	0.3	0.1

Figure 5. Presentation of basic physics practicum in groups by students

The indicators that become points to be observed each week are student skills in presenting smoothly and not stammering, skills in explaining through standardized language, and presentation displays that attract other student participants to listen during the presentation process. However, in general, some students need to be more constrained in making presentations optimally, including fluency in speaking and calmness in making presentations. This aligns with previous research that indicates calmness can be seen from the calm attitude and focus on the material presented by prospective teacher students (Asih & Ellianawati, 2019; Suparlan, 2021). These things must be formed through more intense efforts and over time. Durdukoca & Atalay (2019) explain in detail that uncertainty or anxiety in oral communication can be caused by the fear of being wrong and the habit of comparing themselves with other students.

Engaging in a guided inquiry learning model entails students discovering and utilizing diverse information sources to enhance their comprehension of the taught concepts. This approach goes beyond question-and-answer sessions, encouraging students to connect their experiences with the inquiry process and fostering interest and challenges (Kuhlthau et al., 2015; Artayasa et al., 2021). In this method, students seek concepts under the guidance of teachers, who act as mentors in the learning process, providing essential support for students with lower abilities to ensure effective learning. Beside that this method, which aims for profound comprehension, knowledge acquisition occurs through engaging activities such as examination, design, modelling, interviews, research, and other active exploration, ultimately guiding students towards fresh insights. Teachers facilitate the learning journey by providing guidance and organizing the learning environment (Li et al., 2010; Simonson, 2023).

Through a series of laboratory activities that have been carried out through introductory physics practicum by applying the guided inquiry learning model, proving that the stages in the model can improve students' science communication skills on indicators: 1) seeking information, 2) scientific writing, and 3) representing information, this research certainly has implications for further research for researchers, both lecturers and students. Some of the shortcomings of this study are expected to be input for other researchers to be able to examine science communication skills with other indicators based on different references and the use of a broader sample in order to compare the experimental class and control class so that it can be seen the percentage comparison of the effectiveness of using the guided inquiry learning model.

Conclusion

The implementation of the guided inquiry learning model can train students' science communication skills in the seeking information sub-skill with a percentage increase of 74%, scientific writing sub-skill with an increase of 67%, and representing information sub-skill with at an increase in percentage of 76%. Each average score on the third and fourth meetings shows that science communication skills are very skilled.

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A.P., E.A.P, A.P.B, writing-original draft preparation, result, discussion, methodology, analysis and conclusion; A.F.R, S., M.A. proofreading, review, and editing.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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