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THE EFFECT OF EXPERIENTIAL LEARNING-BASED SCIENCE INTEGRATED LEARNING ON STUDENTS' INTERPERSONAL COMMUNICATION ON HEAT AND TEMPERATURE MATERIALS

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Abstract :

This study aims to analyze the effect of a Science Integrated Learning model based on Experiential Learning on students' interpersonal communication skills in the context of heat and temperature material. A mixed methods approach with a sequential explanatory design was employed. In the quantitative phase, an experimental design was used involving both control and experimental groups. The sample consisted of 66 high school students selected through purposive sampling. Instruments included a student questionnaire and interview guidelines. Quantitative data analysis were analyzed using an independent t-test. The results showed that students who participated in the Science Integrated Learning model based on Experiential Learning a significantly greater improvement in interpersonal communication compared to students who just with the Science Integrated Learning method (p <0.05). In the qualitative phase, in-depth interviews were conducted to explore factors that supported the effectiveness of the model. The qualitative findings revealed that students experienced notable improvements in communication, particularlyin the aspects of openness, empathy and supportiveness. These findings indicate that the experience-based learning positively influences students' interpersonal communication skills. This research offers a novel integration of the Science Integrated Learning model with the Experiential Learning approach to enhance students' interpersonal skills while learning physics. Unlike previous studies that focused primarily on cognitive outcomes or applied these models independently, this study uniquely combines both to address students' conceptual understanding and social communication skills simultaneously.

Keywords:, Experiential learning, Heat and temperature, Interpersonal communication, Science integrated learning

INTRODUCTION

Communication skills are essential for 2st-century students to acquire practical and in-depth knowledge of the subjects they study at school. This practical knowledge can be developed through various processes, one of which is effective interpersonal communication (Dwi Ariyani et al., 2020). Interpersonal communication refers to the process of conveying messages from the communicator to the a communicant or a group of communicants, with the potential for various impacts and the opportunities for immediate feedback. In this context, the communicator serves as the source of the message, while the communicant functions as the recipient who can provide direct reponses to the communicator (DeVito, 2016). Furthermore, interpersonal communication can also be viewed as the art of speaking-essentially the act of expressing one thoughts and feelings to others in a manner that aligns with the communicator's intentions (Burhanudin, 2016).

Physics, as a scientific discipline, involves activities such as observation, hypothesizing, experimentation, and drawing conclusions processes that rely heavily on scientific methods and process skills. As such, physics learning is not only about acquiring conceptual knowledge, but also about engaging in communication during the process of inquiry. In this context, students are encouraged to express their understanding of concepts using their own words, which helps them internalize and interpret the knowledge they construct (Kurniawati et al., 2021). Effective communication skills are therefore essential in supporting students' learning process and improving academic outcomes, particularly through interpersonal communication (Wantu et al., 2020). Students who develop strong interpersonal communication skills are better able to optimize their potential and perform effectively at each stage of the learning process (Mulyani et al., 2021). However, in practice, these fundamental communication skills are often overlooked by educators, contributing to the persistently low level of students' interpersonal communication abilities. This deficiency is largely attributed to students' difficulties in articulating their ideas to teachers or peers, as well as a lack of self-confidence (Bolu Eoh, 2023; Caryono et al., 2024; Kurniawati et al., 2021).

In high school physics curricula, the topic of heat and temperature is typically introduces to second-year science students. This topic explores changes in objects resulting from variations in heat energy. Subtopics include temperature, heat, phase changes due to heat, expansion, and heat transfer (Zohdi & Kafrawi, 2023). However, heat and temperature are often considered abstract and conceptually challenging components of physics (Risqa et al., 2021). The abstract nature of these concepts can lead to varied interpretations among students, contributing to confusion and misconceptions. As the result, heat and temperature are frequently identified as difficult topics within science education (Roon, 1994). Many students struggle to grasp these concepts, which is reflected in their relatively low academic performance and conceptual mastery in this (Cantika, 2021; Nurhalimah et al., 2023; Risqa et al., 2021).

In addition to the challenges related to conceptual understanding, the low level of students' interpersonal communication skills highlights the need for educators to identify effective learning strategies. One such strategy is Experiential learning (EL). According to Kolb (1984), EL is defined as "a process in which knowledge is created through the transformation of experience." When students acquire new knowledge based on their experiences, the modify their cognitive structures to integrate this expanded understanding, enabling them to apply the knowledge in future contexts (Kolb, 1984; Mezirow, 1997). Experiential learning is considered an appropriate approach for addressing both communication challenges and abstract nature of physics topics such as heat and temperature. By engaging directly in meaningful learning experiences, students are more likely to contruct their own understanding and assign greater meaning to the material. This hands-on engagement promotes active participation, increases student motivation, and has been shown to improve cognitive learning outcomes (Fortunela et al., 2022). Moreover, EL is widely regarded as an effective tool for developing both skills and competencies (Leal-Rodríguez & Albort-Morant, 2019). When students process strong interpersonal communication skills, they are better equipped to balance knowledge, attitudes and self-confidence, key attributes that serve as valuable assets for pursuing higher levels of education (Nurbani et al., 2023).

Therefore, a learning strategy that incorporates the EL approach can be considered effective in enhancing students' interpersonal communication skills, particularly in the context of learning heat and temperature. However, the EL approach alone may not be sufficient. There is a need for a structured learning model with a clear instructional syntax that can be integrated with EL to further support the development of students' interpersonal communication skills. The implementation of the science integrated learning model based on experience (EL-based SIL) is considered a promising approach. Science learning demands more than theoretical understanding; it also requires providing students with authentic learning experiences to deepen their grasp of the scientific concepts. The integration of EL into science learning is crucial, as it allows students not only to learn theoretical content but also to directly experience how scientific concepts operate in real life. Additionally, this model fosters students' curiousity and encourages exploration of natural phenomena and scientific processes, making them more engaged and self-directed in constructing knowledge. Moreover, the integrated nature of the SIL model facilities students' active participation in the learning process. It enables them to better understand scientific concepts through direct, meaningful experiences and connect those concepts to real-world contexts, ultimately supporting the development of both cognitive and interpersonal competencies.

Furthermore, this integrated approach offers a holistic learning experience, where students not only understand the concepts of heat and temperature theoretically but can also discussion, collaboration, and effective presentation of their experimental results in groups. According to Budihal et al (2020), integration in learning through the EL approach is effective in improving student learning outcomes. This study also aims to provide new insights into the importance of developing communication skills within the context of science education, and how to simultaneously integrate both technical and social skills in the learning process. Based on the aforementioned issues, this research seeks to investigate the integration of the EL-based SIL and its influence on students' interpersonal communication skills, particularly in the topic of heat and temperature. The purpose of this study is to examine the effects of EL-based SIL on students' interpersonal communication skills. The findings of this research are expected to serve as a reference for the integration of the SIL with EL in physics education, in order to enhance the effectiveness of the learning process and support students in mastering interpersonal communication skills.

1.1 Experiential Learning (EL)

David Kolb introduced the concept of Experiential Learning in 1984, defining it as "a process in which knowledge is created through the transformation of experience". This theory presents a fundamentally different perspective from behaviorist learning theories, emphasizing the central role of life experiences in learning process, where meaningful knowledge emerges through reflective interaction with those experiences (Yustiqvar et al., 2019). Kolb outlined four keys stages in the Experiential Learning cycle that are particularly relevant to science education, namely: concrete experience; 2) reflective observation; 3) abstract conceptualization; and 4) active experimentation (Kolb, 1984). This sequence allow students to actively engage with scientific phenomena, reflect on their observations, conceptualize abstract ideas, and test those ideas through experimentation. Experiential Learning, when linked to students' own experiences, fosters increased motivation, deeper engagement, and has been shown to improve learning outcomesm particularly in the cognitive domain (Fortunela et al., 2022).

Concrete experience (feeling) means learning through direct and specific experiences, with a strong emphasis on intuition and personal involvement. Learners become actively engaged by experiencing and feeling the situation. Learning activities that support this stage include small group discussions, simulations, games, role plays, drama techniques, videos or films, giving examples, chatting and stories. These experiences help learners become more sensitive and responsive to their learning environment. Reflective observation (watching), in this phase learners reflect on their experiences from multiple perspectives before forming judgments or making decision. This stage emphasizes careful observation and the development of understanding through perception. Learners attempt to interpret events by considering both their own thoughts and feelings, as well as those of others, to gain deeper insights into the situation. Abstract conceptualization (thinking) involves logical analysis and theoretical understanding of experiences. Learners use systematic thinking to create new ideas or refine existing concepts, forming generalizations that can explain their observations. The learning here is structured, analytical, and often supported by frameworks, models, or theories that help make sense of complex phenomena. Active experimentation (doing), learners apply their newly acquired knowledge in practical, real-world situations. This stage emphasizes action, decision-making, and risk-taking, enabling students to test hypotheses, implement solutions, and refine their understanding through hands-on application. It is at this point that learning becomes internalized through meaningful practice (Morris, 2020).

1.2 Science Integrated Learning (SIL)

The Integrated Learning Model is an instructional approach that applies a cross-curricular strategy, aiming to connect multiple subject areas into a cohesive learning experience. In the context of Science Integrated Learning (SIL), students do not solely rely on the teacher's direct instruction; instead, they are given opportunities for reinforcement and exploration, enabling them to actively identify, gather, evaluate, and utilize information from their environment in a meaningful way. This process allows students to apply their understanding to new and increasingly complex contexts (Akib et al., 2020). As a broader concept, integrated learning merges content from various disciplines to create holistic and meaningful learning experiences. By integrating several subject areas, this model encourages students to make connections across concepts, thus supporting deeper understanding and real-world application of knowledge (Akib et al., 2020).

The syntax of science integrated learning are: (1) Exploration; (2) Concept Integration; (3) Experimentation; (4) Analysis; (5) Taking Action; (6) Reflection. Exploration is the stage in which teachers encourage students to recall and explain social events or phenomena related to the topic being studied. This process is guided by information obtained from observations, often facilitated through electronic media. At this stage, the teacher introduces a problem topic and prompts students to construct problems by identifying relevant information and formulating hypotheses (Parmin et al., 2017). Concept Integration involves students mapping out scientific concepts using keywords derived from written descriptions. These keywords help students explore information sourced from societal contexts, utilizing electronic and integrated technological media (Azarpira et al., 2012). Experimentation follows, where students apply the results of conceptual integration to design experiments focused on solving the identified problems. During this process, students collect data objectively using worksheets as a means to guide their investigations (Parmin et al., 2017). Analysis is conducted by examining the experimental data in order to test the proposed hypotheses. This involves integrating findings with supporting facts, scientific theories, and relevant literature or journal references, and is typically carried out through collaborative group discussions (Afandi, 2017). Taking Action refers to the stage where students engage in discussions to develop and propose alternative solutions to the problems based on their experimental findings (Afandi, 2017). Reflection is the final stage, where students transform their social understanding into scientific knowledge through experimental activities. These reflections are documented in a reflection journal, which encapsulates the entire learning journey from exploration to conclusion (Parmin et al., 2017).

1.3 Interpersonal Communication Skills

Interpersonal communication can be understood as the art of expressing an individual's thoughts and feelings to others in a manner that aligns with the individual's intent and context (Burhanudin, 2016). Meanwhile, according to DeVito (2019) himself, interpersonal communication refers to the process of exchanging information, ideas, and emotions between two or more individuals through both verbal and nonverbal channels. This ability encompasses various essential skills, including speaking, active listening, interpreting messages, and responding effectively in diverse social interactions. Furthermore, interpersonal communication not only facilitates the process of social interaction but also plays a significant role in shaping an individual's personality and social identity (Savina, 2020).

Aspects of interpersonal communication skills include openness, empathy, supportiveness, positiveness, and equality (DeVito, 2019). Openness refers to an individual's willingness to receive and respond positively to information shared within an interpersonal relationship. Empathy involves the ability to understand and share the feelings of another person by sensing their emotional state and responding in a way that demonstrates genuine understanding and sensitivity. Supportiveness reflects an individual's capacity to create an open and accepting environment that fosters effective communication, thereby reducing defensive attitudes during interactions. Positiveness pertains to the ability to maintain a positive self-image, encourage others to participate actively, and cultivate a communication climate conducive to constructive dialogue. Lastly, equality emphasizes mutual respect and recognition of the value each participant brings to the interaction, ensuring that all individuals are seen as equal contributors in the communication process.

1.4 Heat and Temperature

Heat and temperature are fundamental concepts in physics, dealing with the energy possessed by an object and the mechanisms through which this energy is transferred (Serway,2009). Temperature, in physics, originates from the qualitative perception of hot and cold based on the sense of touch—an object that feels hotter typically has a higher temperature than one that feels cooler (Young, 2016). The instrument used to quantitatively measure an object's temperature is the thermometer (Giancoli, 2014). Temperature is commonly measured using four main scales: Celsius, Reamur, Fahrenheit, and Kelvin (Giancoli, 2014). The interaction underlying temperature change involves the transfer of energy between substances. When this energy transfer occurs solely due to a temperature difference, it is referred to as heat transfer, and the energy being transferred is known as heat (Young, 2016).

RESEARCH METHOD

Research Design

This study employed a mixed methods approach and was conducted at SMAN 8 Malang. The quantitative phase of the research was carried out over four meetings, from September 30 to October 10, 2024. Subsequently, the qualitative phase was conducted on November 6, 2024, following the analysis of the quantitative data.

Target/Research Subject

The subjects of this study were 66 grade XI high school students consisting of two classes: 33 students in the control class and 33 students in the experimental class. Quantitative samples were selected using purposive sampling techniques based on the students' communication abilities, as informed by the class teacher. Two classes were selected, with one class assigned as the experimental group using EL-based SIL, and the other as the control group using SIL methods without EL. Qualitative samples consisted of students from the experimental group who obtained the highest and lowest post-test scores, selected purposively to represent students with the most significant and least improvement. This selection aimed to investigate the effect of EL-based SIL on students' interpersonal communication skills.

Research Procedures

This study employed an explanatory sequential design, which was implemented in two stages. The first stage involved the collection and analysis of quantitative data to measure the effect of the Science Integrated Learning (SIL) model based on Experiential Learning (EL) on students' interpersonal communication skills. The second stage consisted of the collection and analysis of qualitative data to gain a deeper understanding of the quantitative results. A non-test method was used throughout the study to analyze the impact of the EL-based SIL model on students' interpersonal communication skills in the heat and temperature topic. The participants were eleventh-grade students from a high school in Malang City, selected through purposive sampling.

The research procedure began with the preparation stage, which involved developing a questionnaire instrument based on indicators of interpersonal communication skills, along with interview guidelines to support qualitative data collection. Additionally, an experience-based learning design was developed to be implemented during the instructional process. In the implementation stage, students participated in learning activities based on the pre-designed scenarios. During these activities, students were encouraged to freely communicate with peers across groups, thereby constructing their own learning experiences. Furthermore, structured interviews were conducted with selected students to serve as data triangulation, confirming and enriching the findings obtained through observation.

Once the data has been collected, the next stage is data analysis. The questionnaire data are analyzed to identify patterns in the development of students' interpersonal communication skills, while the interview data are examined to gain deeper insights into students' understanding and experiences during the learning process. The results from both methods are then compared to provide a more comprehensive understanding of the impact of Experiential Learning (EL) on students' interpersonal communication skills.

Data Collection Instruments and Techniques

The instruments utilized in this study included both measurement instruments and learning guideline instruments. The measurement instruments comprised a questionnaire and an interview guideline designed to assess interpersonal communication skills. The questionnaire aimed to gather detailed insights into students' experiences during the learning process. It contained 40 items, addressing various aspects of interpersonal communication skills, including openness, empathy, supportiveness, positiveness, and equality. Additionally, the extreme case interview guideline was used to conduct in-depth interviews, exploring the impact of the Science Integrated Learning (SIL) model based on Experiential Learning (EL) on students' interpersonal communication skills. The interview questions were structured around the key indicators and aspects of interpersonal communication skills, focusing on students' experiences and learning outcomes. The learning guideline instruments consisted of teaching modules and student worksheets. Prior to data collection, all research instruments underwent validation and feasibility testing by subject matter experts to ensure their reliability and appropriateness for the study.

To collect data on interpersonal communication skills, self-assessment was conducted using a questionnaire. Students completed the questionnaire based on their learning experiences related to interpersonal communication skills. The questionnaire utilized a Likert scale, where students indicated their level of agreement with each statement, ranging from strongly disagree to strongly agree. The questionnaire was administered to two classes: one experimental group that received the Science Integrated Learning (SIL) intervention based on Experiential Learning (EL) and one control group that did not receive the EL-based intervention. The questionnaire was completed at the conclusion of each learning session, or post-class. For qualitative data collection, structured interviews were conducted to explore the enhancements and barriers in each aspect of interpersonal communication skills that students experienced during the learning process. Interviews were conducted with two students representing extreme cases: one with the highest score and one with the lowest score.

Data analysis techniques

1. Quantitative Analysis of Interpersonal Communication Skills

   The data obtained from the questionnaire responses were initially analyzed descriptively, with the results categorized and scored based on the following criteria.

   Strongly agree category : 5

   Agree category : 4

   Neutral category : 3

   Neither disagree category : 2

   Strongly disagree category : 1

   (Riduwan, 2014).

   This categorization is then processed to see the score of respondents' answers using score analysis in the following equation.

$$\mathbf{Score} = \frac{\mathbf{total\ student's\ outcome\ score}}{\mathbf{maximum\ score}} \times \mathbf{100}$$

The data that has been calculated is then summarized and given the following criteria.

Table 1. Student Interpersonal Communication Category

Value Limit	**Category**
> 95	Good
66 – 95	Average

< 66	Poor

Additionally, an independent t-test was performed to assess the impact and differences in learning outcomes between the control and experimental groups for each variable. Based on Masyhud (2015), if the significance value of t <0.05, it indicates a significant difference between the results of the control and experimental groups. Therefore, it can be concluded that SIL based on EL has an effect on students' interpersonal communication skills.

2. Qualitative Analysis of Interpersonal Communication Skills

Qualitative data is collected to provide a deeper understanding of the quantitative data analysis results. The qualitative data from extreme case interviews (those with the highest and lowest improvements) are analyzed using thematic analysis to identify themes that are relevant to the quantitative findings.

According to Braun & Clarke (2006), thematic analysis consists of six main stages:

1. Familiarization with data
2. Coding
3. Initial theme search
4. Reviewing themes
5. Naming and definition of themes
6. Writing the analysis results report

RESULTS AND DISCUSSION

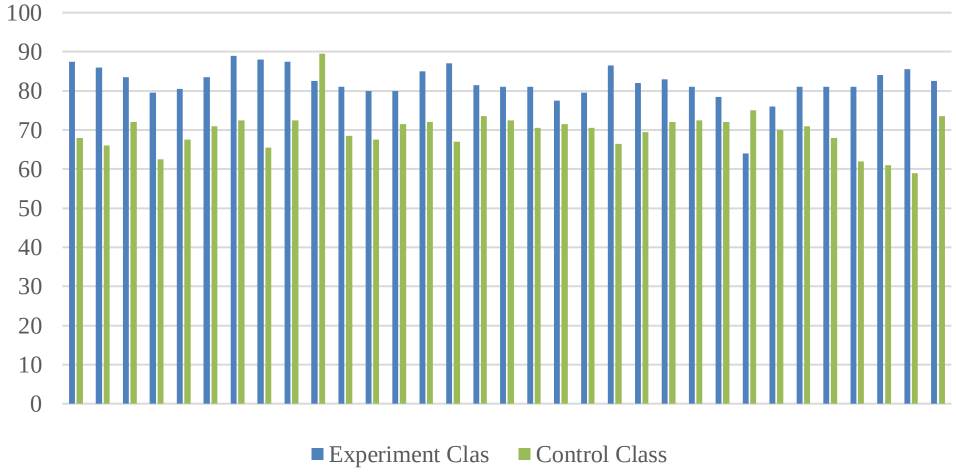
This chapter presents the findings of the research, aligned with the objectives and problem formulation. Data analysis was conducted to assess the effect of integrated Experiential Learning (EL) on students' interpersonal communication skills in the context of heat and temperature materials. The results are presented in a quantitative descriptive format and are supplemented with qualitative data, where relevant, to offer a more comprehensive understanding.The following is a table of the results of interpersonal communication ability scores.

Table 2. Student's Interpersonal Outcome

Student	Outcome Score	Category	Outcome Score	Category
	Experimental Class		Control Class	
1	87.5	Average	68.0	Average
2	86.0	Average	66.0	Average
3	83.5	Average	72.0	Average
4	79.5	Average	62.5	Poor
5	80.5	Average	67.5	Average
6	83.5	Average	71.0	Average
7	89.0	Average	72.5	Average
8	88.0	Average	65.5	Poor
9	87.5	Average	72.5	Average
10	82.5	Average	89.5	Average
11	81.0	Average	68.5	Average
12	80.0	Average	67.5	Average
13	80.0	Average	71.5	Average
14	85.0	Average	72.0	Average
15	87.0	Average	67.0	Average
16	81.5	Average	73.5	Average
17	81.0	Average	72.5	Average

18	81.0	Average	70.5	Average
19	77.5	Average	71.5	Average
20	79.5	Average	70.5	Average
21	86.5	Average	66.5	Poor
22	82.0	Average	69.5	Average
23	83.0	Average	72.0	Average
24	81.0	Average	72.5	Average
25	78.5	Average	72.0	Average
26	64.0	Poor	75.0	Average
27	76.0	Average	70.0	Average
28	81.0	Average	71.0	Average
29	81.0	Average	68.0	Average
30	81.0	Average	62.0	Poor
31	84.0	Average	61.0	Poor
32	85.5	Average	59.0	Poor
33	82.5	Average	73.5	Average
Mean	82.0		69.8	

The table below presents the interpersonal communication scores of students in both the experimental and control classes. In the experimental class, the scores ranged from 64.0 to 89.0, with 3% of students categorized as "Poor" and 97% as "Average," yielding an average score of 82.0. In contrast, the control class scores ranged from 59.0 to 89.5, with 18% of students in the "Poor" category and 82% in the "Average" category, resulting in an average score of 69.8. The experimental class exhibited a higher average score than the control class, and the percentage of students in the "Poor" category was lower in the experimental class. The 12.2-point difference in average scores between the two classes suggests that the learning method implemented in the experimental class was more effective in improving students' interpersonal communication skills compared to the method used in the control class. Additionally, while most students in both classes fell within the "Average" category, this indicates potential for further improvement to enable more students to achieve higher levels. The following graph illustrates the difference in interpersonal communication outcomes between the experimental and control classes.



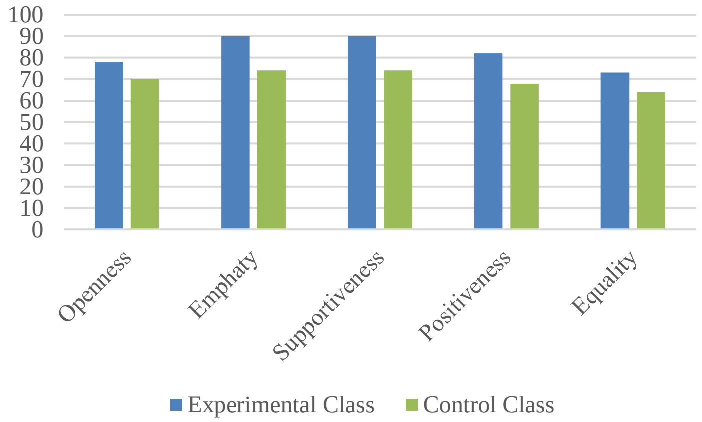
Picture 1. Graph of the Difference Student's Interpersonal Outcome

To gain a deeper understanding of the influence of integrated experiential science learning, a detailed description of the results for each aspect of interpersonal communication skills is provided to highlight the differences between the two classes. The table below presents the differences in the average scores for each aspect of interpersonal communication skills between the experimental and control classes.

Table 3. Student's Average Scores of Each Aspects of Interpersonal Communication

Aspect	Experimental Class	Control Class	Different
Openness	78	70	8
Empathy	90	74	16
Supportiveness	90	74	16
Positiveness	82	68	14
Equality	73	64	9

The table above presents a comparison of interpersonal communication skills between the experimental and control classes across five key aspects: openness, empathy, supportiveness, positiveness, and equality. Overall, the experimental class outperformed the control class in all aspects. The most significant difference was observed in the empathy and supportiveness aspects (a 16-point difference), while the smallest difference was found in the openness aspect (8 points). These findings suggest that the integrated experiential science learning method has a positive effect on enhancing students' interpersonal communication skills. The graph below illustrates these differences between the two classes in terms of students' interpersonal communication skills.



Picture 2. Graph of Differences Interpersonal Aspects Between Classes

After performing the descriptive analysis, a statistical analysis was conducted to obtain more in-depth and meaningful results. A normality test was first performed to verify that the data from both the experimental and control classes were normally distributed. The Kolmogorov-Smirnov test was used, and the resulting data showed normal distribution with a significance value of 0.116 ($p > 0.05$). Following this, statistical tests using independent sample t-tests were conducted to determine whether there were significant differences between the experimental and control classes.

Table 4. T-Test results differences between the experimental and control classes

Group	N	Mean	Standard Deviation	t-score	t-table	Sig. (p)	Conclusion
Experiment	33	83.0	4.54309	10.113	64	.000	Significant
Control	33	69.8	5.24228				

The t-test results revealed a significant difference in the interpersonal communication ability scores between the control class and the experimental class ($p = 0.000 < 0.05$). This indicates that the learning method applied in the experimental class had a significant effect on improving students' interpersonal communication skills.

Based on the interview with one of the students who scored the highest in interpersonal communication (score = 89), the most developed interpersonal communication skills were in the aspects of openness, empathy, and supportiveness. In terms of openness, the student expressed comfort in speaking with both teachers and peers, being proactive in asking questions when facing difficulties and helping others by explaining concepts they understood. This openness created a positive communication environment in the classroom. Regarding empathy, the student demonstrated a strong sense of understanding and care in group work settings. They actively engaged in group discussions, offering support to peers, and showed genuine concern for others' learning. Empathy played a key role in fostering a cooperative and supportive group dynamic. Lastly, the student exhibited supportiveness by encouraging classmates, offering praise for their successes, and actively participating in discussions to enhance the collective understanding of the material. This supportive attitude not only strengthened relationships within the group but also contributed to a collaborative and motivating learning environment. These findings highlight how the integration of experiential learning-based science education positively influenced the development of interpersonal communication skills in the student, particularly in the areas of openness, empathy, and supportiveness.

Based on the interview with a student who scored the lowest in interpersonal communication (score = 64), several aspects of interpersonal communication experienced significant barriers, particularly in openness, supportiveness, equality, and participation in group activities. Through thematic analysis, it was revealed that the student faced challenges in being open, providing social support, and actively participating in group work, which affected their overall interpersonal communication skills. The student expressed fear and hesitation when it came to openness, particularly in public speaking. They were worried about not being able to explain concepts clearly, which prevented them from engaging in open communication with their peers. In terms of supportiveness, the student showed a lack of awareness about the importance of offering encouragement or help to others, as they did not see it as a critical part of communication. Equality and participation in groups were also problematic, with the student preferring to study alone and not actively contributing to group discussions. They did not take the initiative to share their understanding of the material with others, assuming that their peers already understood. These barriers highlight the need for further development in these areas, particularly in terms of fostering openness, supportiveness, and group collaboration to improve interpersonal communication skills.

Before discussing further, it's important to understand how the learning method influenced students' interpersonal communication skills in each aspect. In the openness aspect, students are expected to respond positively to information received in interpersonal relationships. The analysis showed that the experimental class had an average score of 78 in this aspect, placing them in the moderate/sufficient category. This indicates that students were able to respond adequately, though there is room for improvement in their openness in communication. In the empathy aspect, which involves the ability to understand and communicate the feelings of others with sensitivity, the experimental class scored an average of 90. This score suggests that students were quite capable of perceiving and expressing empathy, as they were able to understand and respond to others' emotions effectively, falling within the moderate/sufficient category. The supportiveness aspect, which refers to creating an open environment that fosters effective communication, also showed positive results, with an average score of 90. This score indicates that students were able to provide supportive communication and minimize defensive behaviors during interactions, again falling within the moderate/sufficient category. In the positiveness aspect, where students are expected to foster positive feelings toward themselves and encourage others to participate more actively, the experimental class achieved an average score of 82. This result shows that students generally exhibited a positive attitude and encouraged active participation in communication, creating conducive environments for effective interaction. Finally, in the equality aspect, where communication should reflect mutual respect and acknowledgment of each other's contributions, the experimental class scored an average of 73. This indicates that students were somewhat effective in recognizing and respecting each other’s contributions, though there is potential for further improvement in fostering equality in their interactions.

In summary, while students in the experimental class showed moderate-to-sufficient performance in each aspect of interpersonal communication, there is still room for improvement in all categories. The integrated experiential learning model appears to have had a positive influence, but further enhancement in these areas could lead to stronger interpersonal communication skills. Next, the discussion of interpersonal communication is carried out by integrating quantitative and qualitative data to gain a comprehensive understanding of the aspects that contribute to improving students' interpersonal skills. Quantitative data shows that the largest difference in value between the experimental class and the control class is in the empathy and supportiveness aspects. The empathy aspect is related to students' ability to understand and feel the experiences of others, in this case according to (Handayani & Aminatun, 2020) students in the experimental class are more able to share experiences which involve them telling their experiences directly to others in a structured and clear manner. And the aspect of supportiveness is related to the ability of students to show support for something. According to (Chien et al., 2020) it can be said that students in the experimental class are more capable of expressing opinions clearly, providing useful suggestions, and motivating others to improve their performance.

On the other hand, the ability to provide support involves the ability to receive feedback with an open attitude, consider it carefully, and use the feedback to improve communication skills. Thus, as stated by Suleman (2024) that experiential learning can be an effective way to improve students' communication skills. Learning that involves direct experience can help students gain a better understanding of communication skills and how they can be applied in everyday situations. Meanwhile, the results of interviews with students who had the highest interpersonal scores in the experimental class revealed that during experiential learning, the aspects that most influenced the increase were openness, empathy, and supportiveness. Both data show that the empathy and supportiveness aspects experienced a significant increase in EL. This difference indicates that EL creates a learning environment that supports social interaction, where students are more open to discussion, show empathy, and provide support to each other during the learning process (Nicols, 2022). In the aspect of openness, although not specifically identified in the quantitative data, the qualitative results emphasize the importance of openness as a factor that supports the improvement of interpersonal communication skills. This shows that students feel the benefits of an environment that encourages openness in communication where openness and honesty in communication help reduce misunderstandings, conflicts, and tensions in interpersonal relationships (Nurrachmah, 2024).

In addition to analyzing the aspects with the greatest differences, it is also important to look at the aspects that experienced the smallest differences in interpersonal communication skills between the experimental and control classes. This aims to understand the obstacles that students may face in developing their communication skills during EL. The results of the quantitative data analysis showed that the smallest difference in scores between the experimental and control classes was in the openness aspect, followed by equality. This shows that although EL has a positive impact on this aspect, the increase is not as large as other aspects. According to Rakhmaniar (2024), culture and social environment play an important role in shaping communication behavior. If the school or community culture already emphasizes the importance of openness and equality, students from both groups are likely to have internalized these values before the intervention, so the intervention does not produce significant differences. From the results of the integration of quantitative and qualitative data, it was found that the aspects of openness and equality did indeed experience a small increase in EL.

Interviews with students who had low interpersonal scores reinforced this finding, stating that openness, supportiveness, and equality were the main factors that hindered their communication skills. Difficulty in expressing oneself (openness) led to low participation in interpersonal communication, which contributed to the small difference in scores between the experimental and control classes (Rahman, 2024). Feelings of not being on the same level as their friends (equality) make students reluctant to speak and interact actively (Ahmad, 2021). This is in line with quantitative findings that show that this aspect experienced the smallest increase after openness. The aspect of supportiveness, this factor did not explicitly appear in the quantitative data as an aspect with the smallest difference, but the interview results showed that feelings of lack of support contributed to the low interpersonal communication of students. However, based on the analysis above, it was also conveyed by Hakima & Hidayati (2021) that EL has an influence on students' self-confidence, planning, problem solving and especially communication skills. Suleman (2024) stated that learning with EL can improve students' communication skills, including speaking in public or in groups. These small differences in openness and equality aspects suggest that although EL provides benefits in improving interpersonal communication, there are still challenges in creating an environment that truly encourages openness and equality in communication between students.

The integration of quantitative and qualitative data reveals that EL not only improves the understanding of material concepts but also encourages the creation of positive social interactions in the classroom. This is in line with the theory of interpersonal communication which states that openness, empathy, and supportiveness are important aspects in building productive relationships in the context of learning (Sapphine, 2024). This finding confirms that interpersonal communication skills are an inseparable aspect of experiential science learning. In addition to improving scientific skills, this approach also strengthens interpersonal relationships that contribute to collaborative learning. As conveyed by Suleman (2024) that through direct experience and reflection, students can develop better communication skills, which in turn strengthen interpersonal relationships and support collaborative learning. Thus, experiential learning can continue to be utilized to support the formation of an interactive and inclusive learning environment. The integration of quantitative and qualitative results indicates that EL provides a holistic learning experience. Theory Kolb (1984) support these findings, emphasizing that the learning cycle involving concrete experiences, reflection, and discussion not only develops technical skills, but also social aspects that support learning. Thus, the results of this study indicate that EL not only improves mastery of science concepts, but also prepares students to work collaboratively and communicate effectively in scientific contexts.

The results of this study have several important implications for science learning practices, especially in the application of EL models. The improvement of students' interpersonal communication skills, especially in the aspects of openness, empathy, and supportiveness, shows that EL can also be used to build a collaborative learning environment and support positive social interactions. This implication is important for teachers to not only focus on academic achievement, but also pay attention to the development of students' social skills through group discussions, teamwork, and providing constructive feedback. This is in line with the demands of 21st century learning, where interpersonal skills are one of the important competencies that students must have to collaborate in the real world. Previous studies have shown that many students face difficulties in understanding the concept of heat and temperature, as reflected in low learning outcomes on this topic (Cantika, 2021; Nurhalimah et al., 2023; Risqa et al., 2021). While these studies addressed conceptual understanding, they did not consider how affective and social aspects particularly interpersonal communication skills might influence science learning outcomes. Research also indicates that students' low communication skills are often due to difficulties in expressing ideas to teachers or peers and a lack of self-confidence (Bolu Eoh, 2023; Caryono et al., 2024; Kurniawati et al., 2021). Despite its importance, interpersonal communication has not been a central focus in science education studies, especially those related to physics learning on heat and temperature. Moreover, there is a lack of research integrating Science Integrated Learning (SIL) with Experiential Learning (EL) as a combined model to address both conceptual mastery and interpersonal communication. Therefore, this study aims to fill that gap by implementing SIL based on EL to enhance students' understanding of heat and temperature concepts while simultaneously fostering their interpersonal communication skills. This approach offers a novel contribution to science education by connecting cognitive and social dimensions of learning in a high school context.

Based on the results of the study and discussion, it can be concluded that the implementation of EL significantly contributes to developing students' interpersonal communication skills, with the greatest increase seen in the aspects of empathy and supportiveness. The integration of quantitative and qualitative data shows that EL not only improves cognitive learning outcomes but also builds positive social interactions in the classroom. These results confirm that experiential science learning can provide a more meaningful learning experience, where students not only understand concepts in depth but also develop collaborative skills that are relevant to the demands of the 21st century. In addition, the difference between quantitative and qualitative results shows the importance of a mixed methods approach in understanding learning holistically. Thus, this study not only contributes to the development of science learning models, but also opens up opportunities for further exploration of the application of EL to other materials or in cross-disciplinary contexts. This reinforces the importance of EL as an innovative strategy in improving the quality of education.

This study has several limitations that need to be considered for the interpretation of the results and further research development. First, this study was conducted on subjects of certain grade students in one school only, so generalization of the research results to a wider population needs to be done carefully. Demographic conditions, learning environments, and characteristics of students in other schools may differ and may affect the effectiveness of experiential learning. Second, the duration of experiential learning implemented was relatively limited to only a few meetings. This may not be enough to develop science process skills and interpersonal communication skills in depth on all indicators. Improvements in certain indicators may take longer to achieve optimal results. Third, the qualitative data in this study were only based on student interviews which may be influenced by perception bias or students' ability to express their experiences verbally. The use of additional qualitative data collection methods, such as direct observation or document analysis, can provide a more comprehensive picture. Fourth, this study has not explored further the long-term impact of experiential learning on students' science process skills and interpersonal communication. Further studies involving evaluations over a longer period of time or on various other materials in the field of science are needed to determine the sustainability of the impact of this learning. By understanding these limitations, it is hoped that the results of this study can still provide valuable insights for the development of science learning models and become a basis for more comprehensive further research.

CONCLUSION

Experiential Learning has been proven to be effective in influencing students' interpersonal communication skills, especially in the aspects of empathy and supportiveness. Quantitative data showed significant differences between the experimental and control classes in these aspects, while interview results confirmed that openness, empathy, and support contributed to the improvement of interpersonal skills. The aspects of openness and equality experienced the smallest increase, possibly influenced by cultural and social environmental factors. Students who feel less supported or unequal to their peers tend to have difficulty in communicating. However, experiential learning is still able to create a more interactive learning environment and encourage positive social interactions. The integration of quantitative and qualitative data confirms that experiential learning not only improves the understanding of science concepts but also strengthens interpersonal communication skills that support collaborative learning.

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