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Implementation of the Investigation through Cooperative Problem-solving (ITCPS) Learning Model to Improve Students' Problem-solving and Collaboration Skills

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ABSTRACT This study aims to enhance students' problem-solving and collaboration skills by implementing the investigation through a cooperative problem-solving (ITCPS) learning model in class VIII of a Junior High School in Surakarta, Central Java, Indonesia. The type of research employed is classroom-based action research, which is conducted in two cycles, each comprising four stages: planning, implementation, observation, and reflection. The study included 32 research subjects. The data collection techniques were observation and written tests. The gathered data were analyzed using a qualitative descriptive approach. Results showed that applying the ITCPS learning model improves problem-solving and collaboration skills. Problem-solving skills, as indicated by students' average scores, increased from 73.84% in Cycle 1 to 89.41% in Cycle 2. Meanwhile, as seen from students' average scores, collaboration skills also increased from 60.09% in Cycle 1 to 86.38% in Cycle 2. The results in Cycle 2 have met the predetermined target for problem-solving and collaboration skills. This study concludes that the ITCPS learning model can enhance students' problem-solving and collaboration skills through problem formulation, investigation, discussion, data collection, group conclusion, explanation of the discussion results, and reflection on learning activities.

Keywords: ITCPS learning model, Problem-solving skills, Collaboration skills

1. INTRODUCTION

Education plays a vital role in creating intelligent individuals with superior human resources. Education is a purposeful endeavor designed to inspire students to engage in active learning. Through education, individuals can acquire the skills, insights, and competencies necessary for today's world (Care et al., 2018). Education plays a crucial role in equipping the younger generation with the skills and qualifications necessary to meet the demands of the 21st century.

Through 21st-century skills, it is hoped that students will be able to apply the knowledge they have to overcome problems and challenges in the real world. The three 21st-century skills needed are (1) learning skills that include problem-solving, critical thinking, innovation, collaboration, creativity, and communication; (2) literacy skills that include ICT, media, and information literacy; (3) life skills that include productivity and responsibility, leadership and accountability, initiative, and self-direction, flexibility and adaptability, intercultural social skills (Perez & Montoya, 2022). Natural science (IPA) education is important because it can shape students' understanding and skills regarding natural phenomena around them. IPA is about mastering various concepts, principles, or scientific facts, as well as exploration and discovery (Artinta & Fauziah, 2021). Science values encourage the development of curiosity, prioritizing evidence, flexibility towards new ideas, critical reflection, and awareness and concern for living things and the environment (Wahyuni, 2022). Science learning in the 21st century teaches students scientific concepts and essential skills, including critical thinking, creativity, problem-solving, and collaboration.

Problem-solving skills involve efforts to find solutions to problems that are not easily achieved (Polya, 1973).

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Problem-solving is a skill developed through learners' experiences, enabling them to understand concepts and solve learning problems related to everyday life. According to Polya (1973), problem-solving skills comprise four key aspects: understanding the problem, devising a plan, executing the plan, and reflecting on the outcome. In the context of learning science, problem-solving skills involve overcoming discrepancies between the expected results and the actual results achieved. Problem-solving is a thinking skill that involves analyzing a problem to understand it and going through stages to formulate a solution. The most effective method to improve students' problem-solving skills is to integrate problem-solving techniques into educational tasks and exercises, allowing them to explore a problem (Seechaliao, 2017). The expected state of science learning is that students are competent in understanding relevant problems, including logical concepts and basic and explanatory thinking skills. Conditions in the field show that most students have difficulty understanding relevant problems, including the application of science concepts in real-world situations (Wardani et al., 2024)

One of the crucial skills that students need to have is collaboration skills. (Taar & Palojoki, 2022). Collaboration skills encompass the ability to work effectively with others, respect diverse group members, make quick decisions, and have the desire to achieve common goals (Greenstein, 2012). Collaboration is a specific learning process that leads to social interaction with active and constructive groups to solve problems (Lee et al., 2015). According to Trilling and Fadel (2009), collaboration skills encompass several key aspects, including collaboration, responsibility, compromise, communication, and flexibility. Factors causing low collaboration and problem-solving skills include students are not encouraged to solve problems independently, less direct involvement of students, the lack of practice in working together and finding their concepts in analyzing a problem, learning tends to be centered on teachers resulting in a lack of activeness and independence of student learning, as well as tenacity and accuracy in solving problems that are not good, resulting in students ' ability to solve problems is still low (Jaya et al., 2022). Collaboration skills are a key competency that needs to be taught to students in schools to prepare them for the social and work realities they will face in the 21st century. Research indicates that students often learn in educational environments that lack support for peer collaboration (Liebech-Lien & Sjølie, 2021). Lien's research underscores the importance of emphasizing the social pedagogy of collaborative activities in preparing students for the social and work realities that lie ahead. Opportunities for teachers to develop their understanding of student collaboration and learn how to best structure teaching and learning to capitalize on the multiple potentials within them should be embedded in teacher education and ongoing professional development.

Meanwhile, observations and interviews with science teachers in one of the Junior High schools in Surakarta, Central Java, Indonesia, showed that students in grade VIII G have low problem-solving and collaboration skills. This can be attributed to teacher-centered learning, specifically the lecture method, and the lack of practical activities, which results in students becoming passive and less motivated to learn (Salay, 2019). This monotonous learning process has a negative impact on students' learning outcomes. According to the pretest results, students' problem-solving skills were low in the aspects of understanding the problem (45.81%), devising a plan (51.09%), carrying out the plan (56.37%), and reflecting on the outcome (51.63%). Additionally, 25% of students fall into the low category, while 75% are in the very low category, suggesting that most students continue to struggle with solving problems systematically. In addition, students collaboration skills are also not good in aspects of collaboration (37.31), responsibility (43.65), compromise (40.46), communication (43.63), and flexibility (35.18). Based on the observation, as many as 34.37% of students have collaboration skills in the good enough category, 59.37% in the bad category, and 3% in the very bad category. Students tend to work alone during group assignments, so their collaboration skills are less trained in the classroom learning process. Problem-solving and collaboration skills can be improved by applying appropriate learning strategies.

In connection with this, the role of teachers is vital in creating an interactive learning environment and providing a variety of experiences that reflect the methods scientists use to conduct experiments and obtain new knowledge, as well as solve problems. One of the learning approaches that can facilitate students' active involvement in experimental activities is the cooperative learning model (Hasanah & Himami, 2021). Creating a learning process that is not centered on the teacher requires an innovative learning model that involves students actively (student-centered). The investigation through cooperative problem-solving problem-solving (ITCPS) learning model is an innovative approach that integrates problem-solving with cooperative learning principles, where students work collaboratively in groups to enhance their problem-solving abilities and understanding of the material through various strategies, thereby increasing their critical thinking skills (Utami et al., 2023).

The ITCPS learning model requires students to play an active role in solving problems given by teachers by applying various strategies in the classroom. Students are also free to discuss the problem-solving process with their peers. Research has proven that this model effectively enhances the social and affective aspects of learning chemistry (Utami et al., 2019). ITCPS consists of five main

stages: problem identification, problem formulation, investigation, explanation, and reflection. The process is designed to enhance students' involvement in scientific activities through an interactive and fun approach. The ITCPS learning model emphasizes problem-solving in groups so that each group member is responsible for explaining the material to their group mates if it is not yet understood and solving problems together. The ITCPS learning model improves students' social interactions in the following aspects: This can be observed from the indicators of cooperation and social interaction carried out by students, namely: 1) students actively discuss solving problems, 2) learn together to understand the lesson material, 3) are independent in doing daily tests, 4) are motivated to participate in group learning, 5) care about absent friends, 6) respect other people's opinions in discussions, 7) can communicate well, 8) can discuss in solving problems, 9) can help friends who have difficulty in doing assignments, and 10) can make the right decisions (Utami et al., 2023). In addition, ITCPS can improve students ' critical thinking skills in understanding the concept of Chemical Equilibrium (Utami et al., 2021). In connection to this, Aliyah et al. (2023) found that the ITCPS model contributes to improving critical thinking skills, written communication, and learning outcomes in science subjects. Similar findings suggest that this model has a positive impact on science learning outcomes, problem-solving skills, and students' critical thinking abilities (Prasadityo et al., 2023).

Given the discussions presented, this study aims to implement an investigation through the cooperative problem-solving (ITCPS) learning model to improve the problem-solving and collaboration skills of class VIII G students in science learning.

2. METHOD

The research procedure in this study follows the model developed by Kemmis et al. (2014), known as the spiral model, where one cycle consisting of four stages—planning, action, observation, and reflection —is repeated until the expected level of improvement is achieved. The action in this study was to apply the ITCPS learning model. The spiral model chart is shown in Figure 1.

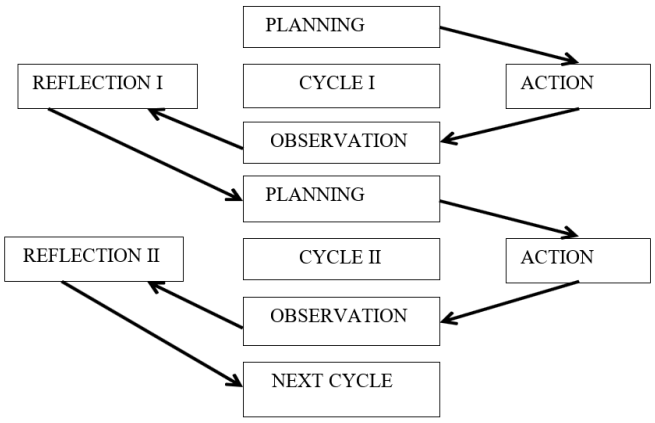

Figure 1 The Spiral model (Kemmis et al., 2014)

This research was conducted in one of the junior high schools in Surakarta, Central Java, Indonesia, from May 2024 to December 2024. The subjects of this study were 32 students of Class VIII G in the academic year 2023-2024. In implementing action learning activities, the teacher teaches while being observed by three observers

The data collection technique used was observation to measure collaboration skills and a written test to measure problem-solving skills. The instrument used to measure problem-solving skills consisted of 12 essay questions. Essay-based tests allow students to answer questions or solve problems presented, while the instrument used to measure collaboration skills is an observation sheet. Observation is a research data collection technique that involves direct observation and recording of students' behavior in classroom learning activities.

This study employed a qualitative descriptive technique to analyze the data gathered. In this study, questions were created to measure problem-solving skills based on specific aspects of problem-solving skills, and students' scores were assessed using a performance assessment rubric. An example of a problem-solving skills assessment with a performance assessment rubric is presented in Table 7.

3. RESULT AND DISCUSSION

3.1 Pre-cycle

Before Cycle 1, a pre-cycle stage was conducted to design the research, including a science process skills test with 12 questions that covered four aspects of problem-solving: understanding the problem, devising a plan, carrying out the plan, and reflecting on the outcome (Polya, 1973). Additionally, observations of students' collaboration skills were conducted using an observation sheet with 15 indicators that cover five aspects: collaboration, responsibility, compromise, communication, and flexibility (Trilling & Fadel, 2009).

School observations on March 6, 2023, and interviews with science teachers revealed several obstacles in science learning. Student participation in asking and answering questions remained low, and most students were passive during discussions. They had difficulty identifying important information, formulating problem-solving plans, and relying on teacher answers without verifying their truth. An interview with the teacher confirmed that students struggle to solve problems and collaborate in group discussions. This contributes to low student learning outcomes, with only a few achieving the Minimum Completion Criteria.

Table 1 Students' average score for each aspect of problem-solving skills

No	Problem-Solving Aspect	Average Value
1.	Understanding the problem	45.81
2.	Devising a plan	51.09
3.	Carrying out the plan	53.25
4.	Looking back	56.37
Overall average		51.63

Table 2 Criteria total score indicator of problem-solving skills

Value Range	Criteria
90-100	Very High
80-89	Height
70-79	Medium
60-69	Low
≤ 59	Very Low

(Trianto, 2009)

Problem Solving Skills

The students' average scores for each aspect of problem-solving skills are presented in Table 1, which is interpreted in conjunction with the information in Table 2. Students' problem-solving skills, along with their understanding of the problem, are categorized as very low (45.81), devising a plan is also very low (51.09), carrying out the plan is very low (53.25), and the looking back aspect is also very low (56.37). The average value of students' problem-solving skills is 51.63, categorized as very low. The pre-cycle value was used as a baseline data in the study.

Collaboration Skills

The student's average scores for each aspect of collaboration skills are presented in Table 3, which is interpreted in conjunction with the information in Table 4. Students' collaboration skills are categorized as follows: collaboration is rated as 'less good' (37.31), responsibility is 'good enough' (43.65), compromise is 'good enough' (40.63), communication is 'good enough' (43.63), and flexibility is rated as 'less good' (35.18). The average value of students' collaboration skills is 40.0, categorized as less good. The pre-cycle values for collaboration skills were used as baseline data in the study.

Table 3 Students' average score for each aspect of collaboration skills

No	Problem-Solving Aspect	Average Value
1.	Collaboration	37.31
2.	Responsibility	43.65
3.	Compromise	40.46
4.	Communication	43.65
5.	Flexibility	35.18
Average		40.0

Table 4 Criteria total score indicator of collaboration skills

Score	Description
81 – 100	Very Good
61 – 80	Good
41 – 60	Good Enough
21 – 40	Less Good
0 – 20	Very Poor

(Widoyoko, 2012: 111-115)

Based on pre-cycle data, it is necessary to conduct Cycle 1 to assess the improvement in students' problem-solving skills and collaboration. Pre-cycle Data is as helpful as Cycle 1 and Cycle 2. This research was conducted in two cycles, Cycle I and Cycle II. The determination of the next cycle depends on achieving the established indicators. The ITCPS learning Model was then applied to improve students ' problem-solving and collaboration skills.

3.2 Cycle 1

The cycle one action was carried out in three meetings. The first meeting was held for three teaching hours with the activity of working on the Earthquake and Tsunami Student Worksheet, the second meeting was held for two teaching hours with presentation and reflection activities, and the third meeting was held for two teaching hours with the activity of carrying out a written test to measure problem-solving abilities consisting of four essay questions.

Action Planning

The action planning stage is carried out with several preparations that support the actions to be taken as a solution to existing learning. This planning stage is a crucial initial step. The planning action involves compiling learning and research instruments. Learning instruments include teaching modules compiled with the syntax of the ITCPS learning model, a rubric for assessing written tests for problem-solving skills, a rubric for assessing observation of collaborative skills, and learning media in the form of Student Worksheets containing the syntax of the ITCPS learning model and aspects of problem-solving skills used as a guide during the learning process in class. Meanwhile, the research instrument consists of an observation sheet for collaborative skills and 12 descriptive test questions assessing problem-solving skills.

Action

The implementation of the first action consists of two meetings, with the first meeting 3 x 40 minutes and the second 2 x 40 minutes. The material in Cycle 1 focuses on the lithosphere layer of the Earth, related to earthquake disasters, and the hydrosphere layer, related to tsunami disasters, utilizing learning media in the form of student worksheets and PowerPoint presentations on earthquake and tsunami materials. Each stage of learning activities is adjusted to the syntax of the ITCPS learning model.

First Meeting

Learning activities begin with an introduction, where the teacher opens the session by greeting the students and then proceeds with a prayer led by the class leader. Then, the teacher takes attendance, conditions the class to be orderly, and asks about the student's readiness to learn. Next, the teacher provides apperception to students to help them recall the previous material, specifically elements,

compounds, and mixtures and relates it to the material on the structure of the Earth and its development. Furthermore, the teacher guides students to state the learning objectives. However, students cannot convey the learning objectives, so the teacher explains the learning objectives and the benefits of studying the material on the structure of the Earth and its development. Finally, the teacher conveys the activities that will be carried out, namely in the form of group discussions.

The next activity is the core activity, which consists of the syntax of the ITCPS learning model, beginning with problem identification. The teacher forms homogeneous groups of 5-6 students, distributes worksheets, and displays images of the lithosphere layers and earthquakes. Students observe, analyze, and relate the images to earthquake disasters. Next, they discuss and identify problems in the worksheets and answer questions based on the available readings. At the problem identification stage, students were informed about the earthquake and tsunami in Donggala, Palu, and Central Sulawesi and then answered questions in groups. This process helps students understand the information available and what is still needed to solve the problem (Ningsih, 2019). This stage trains collaboration skills, emphasizing collaboration and compromise, as students must discuss with group members. In problem-solving, this stage also enhances the ability to comprehend the problem and devise a solution.

In the second stage, namely formulating problems based on the reading presented in identifying problems, students and their groups discuss to determine questions based on the reading provided. Activities at this stage train students to improve their problem-solving skills and understanding of the problem, in line with the opinion of Spektor et al. (2009), who state that skimming enables students to learn how to choose sources relevant to the purpose of writing. At this stage, students provide basic explanations by focusing on questions to formulate problems that align with the goals they want to achieve (Indarwati et al., 2014). Some groups have not been able to determine the right questions based on the reading and learning materials. The questions written by some groups are still outside the material to be studied, so they are not quite right.

The next stage is the investigation stage, in which students and their groups answer five questions before investigating the earthquake and tsunami. They examine the layers of the Earth that cause disasters, the characteristics of each layer, the factors that trigger earthquakes and tsunamis, and appropriate mitigation by filling in the table in the worksheets. This stage trains problem-solving skills in understanding the problem, carrying out the plan, and reflecting on the process, encouraging active participation in formulating, planning, completing, and drawing conclusions from group investigations (Ningsih, 2019). Additionally, the investigation's syntax enhances collaboration skills in areas such as teamwork, responsibility, and adaptability. In line with Zubaidah (2018), project completion requires students to select appropriate sources of information, evaluate their quality, and consider factors such as timeliness, accuracy, and credibility. The teacher facilitates students in asking questions, although some groups have not recorded complete disaster mitigation from social, infrastructure, and environmental aspects. Research indicates that collaborative learning has a positive impact on student success (Stump et al., 2011). Stump et al. (2011) study found that female students used collaboration as a learning strategy more than their male classmates. Several studies have demonstrated that collaborative skills lead to deeper learning, where students contribute their ideas and expertise (Andrews et al., 2020; Scager et al., 2016).

The teacher concludes closing activities by providing directions and explaining the next steps at the meeting, which include continuing the syntax of the ITCPS learning model and concluding the learning activities with a joint prayer led by the class leader.

Second Meeting

The activity begins with an introduction, which includes greetings from the teacher and a prayer led by the class leader. Then, the teacher takes attendance, conditions the class, and asks the students about their learning readiness. Furthermore, the teacher provides an overview to the students, namely by recalling the previous material, including the structure of the Earth and earthquake disasters. The teacher invites students to continue the activities from the previous meeting, specifically by presenting the results of the discussions they carried out with their respective groups. This stage is the Explaining stage. At this stage, students will present the results of their discussions to the class. This stage can also help students improve their problem-solving skills by implementing the plan and reflecting on the outcome. In addition to the problem-solving aspect, this explaining stage can also train students to improve their collaboration and communication skills. This explaining stage trains students to think communicatively to convey the results of the discussion well (Sukarni, 2021). Meanwhile, in collaboration skills, communication can be influential because it is through presentations (Ulva & Fitri, 2022). However, several groups are less confident in presenting the results of their discussions and have been unable to divide tasks between group members for presentations.

The final stage is reflection, where students review the material they have studied by discussing it with their groups to draw conclusions based on the results of observations, discussions, investigations, and literature studies conducted. Activities in this phase can train students to improve their problem-solving skills in the looking back aspect and collaboration skills in the communication aspect. In line with research by Wahyuni et al. (2016), the

reflection stage can serve as a means to communicate various ideas precisely and concisely. After that, students will collect the completed worksheets and continue with the teacher and students reviewing the learning they have done. At this stage, the teacher allows students to ask questions about any material they do not understand. An example of a question asked by students is, "If an earthquake occurs, will there be a tsunami, ma'am?". The next activity involves the teacher and students determining the correct answer for each question related to the learning material.

Third Meeting

The third meeting in Cycle 1 lasted for two 40-minute sessions. At the second meeting, all students were present and in good condition to participate in the learning activities. The activity began with an introduction, including greetings from the teacher and a prayer led by the class leader. Then, the teacher took attendance, conditioned the class, and asked students about their learning readiness. Furthermore, the teacher provided an opportunity for students to reflect on the previous material, specifically the structure of the Earth and earthquake disasters. Then, the teacher invited students to continue the activities at this meeting, which included a test to measure students' problem-solving skills. The teacher distributed post-test questions to students regarding earthquakes and tsunamis, consisting of 12 essay questions.

Observation

Problem-Solving Skills

The average results of the problem-solving skill class, categorized by understanding the problem aspect, are 70.93 (medium); devising a plan aspect, 69.93 (medium); carrying out the plan aspect, 75.12 (medium); and looking back aspect, 79.12 (medium). Thus, the average value of problem-solving skills is 73.84, which falls into the medium category. The following is the average value of students in each aspect of problem-solving skills. Cycle 1 is presented in Table 5.

Table 5 Students' average score for each aspect of problem-solving skills

No	Problem-Solving Aspect	Average Value
1.	Understanding the problem	70.93
2.	Devising a plan	69.93
3.	Carrying out the plan	75.12
4.	Looking back	79.37
Overall Average		73.84

Table 5 shows that the average value of problem-solving ability is 73.84. Based on the criteria table, the total score aspects of problem-solving skills in Table 2 can be categorized as moderate. According to Polya (1973), problem-solving skill indicators include Understanding the problem, Devising a plan, Carrying out the plan, and Looking back. These indicators will be described in Table 6.

Table 6 Problem-solving skills indicators

Aspect	Definition	Indicator	Score
Understanding the problem	Students identify what is known, what is present, the quantities, relationships, and values involved, and what they are seeking to determine.	Able to identify problems based on the information presented Able to explain problems that have been understood using personal arguments Able to identify goals or questions to be answered	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Devising a plan	Students identify the strategies used to solve the given problems.	Able to prepare problem-solving plans based on the information presented Able to identify risks associated with a problem-solving action plan Be able to evaluate whether the chosen strategy makes it possible to solve the problem	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Carrying out the plan	Students maintain the chosen plan. If, for example, the plan cannot be implemented, students can choose an alternative approach or plan.	Able to solve problems based on the information presented Able to apply problem-solving steps systematically Are the troubleshooting steps in accordance with the troubleshooting plan?	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Looking back	Recheck all the important information that has been identified	Able to provide solutions to problem-solving Able to ensure that existing solutions or methods can solve existing problems Able to draw conclusions based on existing information	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met

(Polya, 1973)

In terms of understanding the problem, there was an increase from the initial pre-cycle of 45.81 to 70.93 in Cycle 1. In this aspect, some students have understood the information in the reading the teacher gave. However, some students ' answers did not match the information presented. However, some students' answers still do not match the information conveyed. Previous research shows that cooperative learning can significantly improve students' mathematical problem-solving abilities compared to conventional learning (Oktavien et al., 2012). The following examples of student answers, along with their scores on aspects of Understanding the problem, are presented in Table 7.

For the second aspect, namely devising a plan, there was an increase from the initial pre-cycle of 51.09 to 69.93 in Cycle 1. In this aspect, students can take steps or find solutions to address problems presented by the teacher. However, some students still cannot provide appropriate steps to address the problem. This aligns with research by Mardika and Hasanah (2020), which suggests that cooperative-based activities can increase students' self-confidence in learning. The following examples of student answers, along with their scores on aspects of Devising a plan, are presented in Table 8.

Upon implementing the plan, there was an increase from the pre-cycle value of $ 50.37 to $ 75.12 in Cycle I. In this aspect, students can provide solutions based on specific problems. Discussion can hone critical thinking skills and improve problem-solving, ultimately enhancing students' academic achievement (Kotsis, 2024). The following examples of student answers, along with their

Table 7 Examples of student answers with scores on aspects of understanding the problem

Question	The Meteorology, Climatology, and Geophysics Agency (BMKG) noted that there had been eight aftershocks after the earthquake centered in the Tuban region, East Java, Friday (22/3/2024). The head of the Earthquake and Tsunami Center, Daryono, said that eight aftershocks occurred this afternoon from 11.22 WIB to 13.31 WIB. The first earthquake, centered in the sea at a distance of 132 kilometers northeast of Tuban city, had a magnitude of 6.0 at coordinates 5.74° south latitude (LS) and 112.32° east longitude (BT), with a depth of 10 kilometers. Furthermore, the location of the epicenter of the aftershock was also observed by BMKG centered at 152 kilometers northeast of Rembang, Central Java, 153 kilometers northwest of Lamongan, East Java, 175 kilometers northwest of Surabaya, East Java, and 612 kilometers northeast of Jakarta. People in Central Java feel the impact of vibration with the intensity scale (Bawean, Jepara, Kudus, Semarang, Blora Pekalongan). Furthermore, East Java (Tuban, Lamongan, Bojonegoro, Surabaya, Nganjuk, Pacitan, Trenggalek, Tulungagung, Sidoarjo, Madiun, Pasuruan, Malang) and Yogyakarta. Especially the city of Tuban, which felt the aftershock vibrations for about 15 minutes until hospital patients were evacuated outside the building, including those at NU Tuban Hospital. Tectonic earthquakes are shallow earthquakes due to active fault activity in the Java Sea. The analysis of the source mechanism reveals the sliding movement that occurs during the process. He also ensured, according to the results of the earthquake analysis, that it did not have the potential to cause a tsunami. BMKG appealed to the public not to panic over such conditions, especially since the earthquake did not have the potential to cause a tsunami. "In principle, the community is still safe to move as usual on the beach and sea after this incident," he said. BMKG has also coordinated with the National Disaster Management Agency (BNPB) to monitor the affected areas and assess the impact of the earthquake's vibrations. 1. After reading the text above, identify the main problem. 2. Why do you think an earthquake can potentially occur aftershocks? 3. What is the impact of continuous earthquakes on life?		
Answer indicators and rubrics	**Indicator**		**Score**
	Able to identify problems based on the information presented Able to explain problems that have been understood using personal arguments Able to identify goals or questions to be answered		Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Example Answer	There were eight earthquakes of 5.3 m in Tuban The Return movement of the Earth's plates to a stable position after an earthquake that causes aftershocks Damage to buildings, many casualties, and other material losses.	Earthquakes occurred 8 times in Tuban, East Java. Type of shallow earthquake that occurred due to active activity in the Java Sea Damage to buildings, environmental damage, and numerous casualties result.	The community in Java feels the impact of vibration with the intensity scale. After a significant earthquake of great magnitude occurs, the Earth's plates that have moved due to colliding with each other need time to return to their original positions. Disaster Mitigation
Score	**3**	**2**	**1**

Table 8 Examples of student answers to scores on aspects of devising a plan

Question	The 2018 Palu earthquake was a harrowing natural event for the people of Indonesia, especially in Central Sulawesi. On September 28, 2018, an earthquake with a magnitude of 7.7 on the Richter Scale occurred in Central Sulawesi, causing a tsunami and liquefaction that damaged infrastructure, including roads, bridges, buildings, and other public facilities. Damage to this infrastructure can disrupt transportation, communications, and access to essential services such as clean water and electricity. At the time of the earthquake, the damage affected numerous residential buildings and several other structures, including hotels and places of worship. At the time of the earthquake, most of Palu City and Donggala Regency were affected by the tsunami and liquefaction, which caused enormous losses. Until 2018, the death toll from earthquakes, tsunamis, and liquefaction in Central Sulawesi reached 2.113 people. How do you think of a way or solution to deal with the above problems? Mention rare steps that can be taken to reduce the negative impact of earthquakes on life! Based on the answers to question b, are these measures effective to deal with existing problems? If so, please provide your reasons.		
Answer indicators and rubrics	**Indicator**		**Score**
	Able to prepare problem-solving plans based on the information presented Able to identify risks associated with a problem-solving action plan Be able to evaluate whether the chosen strategy makes it possible to solve the problem		Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Example Answer	Build a strong infrastructure, study the surrounding environment, and check the hanging objects ' Preparing safety or mitigation efforts before, during, and after a disaster Yes, because it can at least be minimized if an earthquake were to occur.	Planting mangroves, creating dikes, and installing disaster alarms Safety or mitigation efforts before, during, and after disasters and environmental recovery Yes, because it is in Japan.	Perform infrastructure development Perform Disaster Mitigation Yes, because easy to do
Score	**3**	**2**	**1**

corresponding scores on carrying out the plan, are presented in Table 9.

The last aspect is to look back and see that there was an increase in the average value from 51.63 in the pre-cycle to 79.37 in Cycle I. In this aspect, students can already provide conclusions based on specific problems. Nine students are still unable to come to the correct conclusion based on the information presented. Self-confidence is essential because it can influence the use of language when conveying ideas, opinions, and discussion results (Pratiwi et al., 2022). The following examples of student answers, along with their scores on aspects of looking back, are presented in Table 10.

Collaboration Skills

Table 11 shows that the average value of collaboration skills is 60.09, which is a fairly good category based on the total score criteria for collaboration aspects in Table 11. According to Trilling & Fadel (2009), collaboration skill indicators include collaboration, responsibility, compromise, communication, and flexibility. These

Table 9 Examples of students' answers to scores on aspects of carrying out the plan

Question	Tsunamis are large ocean waves triggered by underwater whirlpools due to plate shifts, landslides, volcanic eruptions, and meteor falls. Tsunamis can travel at extremely high speeds and reach land with wave heights of up to 30 meters. Tsunamis are potentially dangerous, although they do not cause significant damage to the coastline. Earthquakes caused by the movement of the seabed or plate shifts most often cause tsunamis. Indonesia experienced a devastating tsunami following an 8.9-magnitude earthquake in 2004, not 2006, around Aceh. In high-risk areas, if a major earthquake or landslide occurs near the coast, the first wave in the series could reach the coast within minutes, even before a warning is issued. Areas are at greater risk if located less than 25 meters above sea level and within a few meters of the coastline. If you feel a strong tremor or earthquake, this could be the first sign of a tsunami threat. How can we avoid being hit by a tsunami if we are at the seaside? Based on the answer to question a, explain the disaster mitigation measures to reduce the tsunami disaster risk. Based on Question B, are these steps appropriate to overcome the problems in the news presented? If so, please provide your reasons.

Table 9 Examples of students' answers to scores on aspects of carrying out the plan (*Continued*)

Answer indicators and rubrics	Indicator		Score
	Able to solve problems based on the information presented Able to apply problem-solving steps systematically Are the troubleshooting steps in the troubleshooting plan?		Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Example Answer	Development of a Tsunami Early Warning System, Improving Public Knowledge, and Socialization of Disaster Response Methods. Understanding Disaster Mitigation, building disaster-resistant infrastructure, and disseminating understanding of disaster mitigation to the broader community Yes, because it can overcome the above problems and reduce casualties.	Climb to a higher settlement, socialize about self-rescue, and pray Creating a solid embankment and planting mangroves around the beach Yes, because it is easy to do.	Move away from the monitor once the water has receded and report it to the appropriate authorities. Immediately run to a safe place Yes, I think that is enough.
Score	**3**	**2**	**1**

Table 10 Examples of student answers to scores on aspects of looking back

Question	Tsunamis are ocean waves that occur as a result of earthquakes, volcanic eruptions, or avalanches that occur on the seabed. Tsunami waves have a wavelength between 100-200 km and move at a speed of 800-900 km/h in open water. However, this also depends on the depth of the sea in which the waves occur. As the wave approaches the shore, its height will increase, whereas its speed will decrease. Tsunamis can cause saltwater pollution on land and clean water. This is caused by the grinding and collection of sediments and soil carried by tsunami waves, which can lead to environmental damage, including harm to ecosystems and plants, as well as fatalities. Tsunamis can cause significant environmental damage, including harm to ecosystems and plants, as well as fatalities. This pollution can cause economic, health, and environmental losses. How do we solve the above problem? Mention at least 3 Why did you choose this solution? What conclusions can you draw based on the information above?		
Answer indicators and rubrics	**Indicator**		**Score**
	Able to provide solutions to problem-solving Able to ensure that existing solutions or methods can solve existing problems Able to draw conclusions based on existing information		Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Example answer	Conduct tsunami Disaster Mitigation, increase knowledge about mitigation, and seek higher ground. Because if the solution is applied effectively, it can overcome the problems caused by the tsunami Can know about tsunami and earthquake disaster mitigation	Conduct disaster mitigation before a tsunami disaster, inform authorities of signs of a tsunami, and enhance public awareness about the tsunami. Because I think the solution is quite effective in overcoming these problems Can teach tsunami danger	Conduct Disaster Mitigation, Report to the authorities, and improve knowledge. Because it is easy Tsunami disaster
Score	**3**	**2**	**1**

Table 11 Average student score for each aspect of collaboration

No	Collaboration Aspect	Average Value
1.	Collaboration	57.34
2.	Responsibility	57.37
3.	Compromise	59.42
4.	Communication	61.59
5.	Flexibility	64.71
Overall Average		60.09

indicators are described in several sub-skills, as presented in Table 12.

In terms of collaboration, some of these students are quite capable of working effectively in groups. Students who have not experienced improvement because they are still less able to work in groups effectively. In the second aspect, namely responsibility, there was an increase, with an

Table 12 Collaboration skills aspects

Aspect	Definition	Indicator	Score
Collaboration	Students work together in/between groups to solve problems and create new ideas and products.	Students accept to enter into predetermined groups Students work together in groups to complete assignments. Students work on bills by sharing assignments in groups.	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Responsibility	Students can be responsible for tasks that have been divided into groups.	Students use time to focus on assignments. Students seek learning resources to solve problems. Students carry out tasks responsibly by completing them on time and in a prompt manner.	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Compromise	Students dare to make decisions by considering common interests.	Students discuss problems in groups to find solutions. Students provide suggestions during group discussions. Students compromise when there are differences of opinion.	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Communication	Students actively participate in group activities.	Students value the opinions of their peers when completing assignments. Students ask questions to clarify ideas or things that are not understood. Students ask for opinions or perspectives from group members on their ideas.	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met
Flexibility	Students complement each other based on their strengths and abilities, much like friends.	Students accept joint decisions. Students accept appreciation, criticism, and suggestions from other members. Students are flexible in working together.	Score 3: If three indicators are met Score 2: If two indicators are met Score 3: If one indicator is met

(Trilling dan Fadel, 2009)

average of 43.65 in the pre-cycle and 57.37 in Cycle I. In the aspect of responsibility, some of these students are quite capable of taking joint responsibility in collaboration. In line with the opinion of Yuniarti et al. (2021), students will be more responsible for completing the project and determining the schedule. Students who have not experienced improvement are less capable of taking joint responsibility in collaboration. In the third aspect, namely compromise, there was an increase in student scores from the pre-cycle, with an initial average of 40.46 to 59.43.

Regarding compromise, some of these students are quite capable of deliberating and making decisions with all group members. In the project work phase, students' collaboration skills are also developed through training in appreciating each person's strengths and talents, assuming roles, and adapting appropriately (Saenab et al., 2019). In the fourth aspect, namely communication, there was an increase in student scores with an average of 43.65 to 61.59. Some of these students were able to communicate effectively in groups. Students who have not experienced significant improvement are because they are still unable to communicate effectively in groups. In the last aspect, namely flexibility, there was an increase in scores from the previous cycle, with an average of 35.18 to 64.71. In this aspect of flexibility, some students have been able to adapt to their fellow group members and accept joint decisions. Students who have not experienced significant improvement because they are still unable to adapt to fellow group members. Students are required to interact with each other so that they have communication skills and flexibility (Ilmiyatni et al., 2019)

Based on the results of analyzing the implementation of the learning process cycle I in Class VIII G, using the material structure of the Earth and its development, it is evident that the use of learning models ITCPS can enhance problem-solving skills and student collaboration. This is indicated by the increase in the average score of students on the problem-solving and collaboration skills test from the previous cycle. This aligns with the research results of Zengin et al. (2022), which demonstrated that student-centered learning models can enhance problem-solving skills more effectively than the control group. However, there are still aspects that have not reached the target that has been determined for the ability to solve problems and

critical thinking students 75% of students from a total of all students in Class VIII G meet the criteria for problem-solving skills, and 75% of students from a total of all students in Class VIII G meet the criteria both on the aspect of collaboration.

Reflection

After completing the learning activities in Cycle 1, the teacher reflects on the learning process that has been undertaken. Learning reflection is a teacher's action in reviewing the learning process, encompassing planning, implementation, and management of learning achievements (Ismayanti et al., 2020). The results of this reflection aim to identify existing deficiencies, allowing for the development of an improvement plan that can be applied in Cycle 2. Based on the analysis of the implementation of Learning Process Cycle 1 in Class VIII G using the material on the Earth's structure and its development, it is evident that the use of the ITCPS learning model can enhance students' problem-solving and collaboration skills. This is indicated by the increase in students' average scores on the problem-solving skills test and observation of collaboration skills from the previous cycle or before the application of the ITCPS learning model. However, some aspects still have not reached the previously determined target. The mastery of problem-solving and collaboration skills, which have been targeted, has increased by 20% for each aspect, with 75% of the total number of VII G students participating. To achieve the target achievements determined in each aspect, actions are taken for Cycle 2. The following are the results of the Cycle I action, as shown in Table 13.

Table 13 Analysis result action Cycle 1

No	Aspect	Percentage of Cycle Action Result 1 (%)	Target research success (%)
1.	Problem-Solving	73.84	75
2.	Collaboration	60.09	75

3.3 Cycle 2

Cycle 2 was conducted in three meetings and continued with the material on Earth Structure and Its Development using the ITCPS learning model. The first meeting lasted two teaching hours, the second meeting lasted three teaching hours, and the third meeting lasted two teaching hours. Cycle 2 was conducted as a reflection on learning from Cycle 1, serving as an evaluation of learning. Learning in cycle two runs smoothly, and all syntax of the ITCPS learning model can be implemented optimally in the wave material. Based on the results of interviews with teachers and students, it is shown that after Cycle 2, learning activities become more interactive and engaging. The teacher-centered approach is no longer dominant in learning, having shifted to a student-centered approach. Student-centered activities can increase student activity (Putri, 2023). Student-centered activities in implementing this research are practicum activities and group discussions. Practicum methods in learning have been proven to train students' science process skills (Putri et al., 2022). Through practical experience, students can observe, measure, and conduct experiments that ultimately enrich their understanding of science rules. This process involves developing practical skills, enhancing students' motivation and interest in learning, facilitating an understanding of concepts, and strengthening the connection between theory and practice (Nuai & Nurkamiden, 2022). Students seemed enthusiastic during the practical activities. The improvement in students' science process skills in Cycle 2, compared to pre-Cycle and Cycle 1, showed significant progress. This may be due to students' habits and experiences in carrying out practical activities in class that were previously introduced in Cycle 1.

Action Planning

The reflection results from cycle one show that there are still aspects that have not improved, and learning activities remain suboptimal. Therefore, the teacher plans corrective actions so that in Cycle 2, all learning activities can run optimally to produce satisfactory and optimal results. Learning tools and research instruments are adjusted to aspects and indicators of problem-solving and collaboration skills.

Action

First Meeting

Learning activities begin with an introduction. The teacher opens the learning activities by greeting the students and then continues with a prayer led by the class leader. Furthermore, the teacher takes attendance, conditions the class to be orderly, and asks for students' readiness to participate in learning. The teacher provides an opportunity for students to recall previous material, specifically the layers of the Earth, including the lithosphere and hydrosphere, and relate it to the material on the layers of the Earth and the atmosphere. Furthermore, the teacher guides students to convey learning objectives, and students answer them.

In the problem identification syntax, the activities carried out by the teacher involve forming groups of 5-6 people homogeneously and distributing worksheets to each student. Furthermore, the teacher will distribute worksheets on the problem of volcanic eruptions. The teacher asks students to observe and analyze the problems in the news. The results of observations made by students will foster problem-solving skills, specifically understanding the problem. Problem identification is an important first step in research (Nasution, 2021). Problem identification can guide the research process because it can provide clear focus and direction. Problem identification focuses on arousing interest and curiosity regarding existing problems (Pedaste et al., 2015).

After reading and observing the news presented, students are asked to formulate the problem and identify the hypotheses that might arise. This syntax will bring up problem-solving skills in understanding the problem. The problem formulation is obtained from the results of student observations. Based on the facts found in the news by students, they formulate the problem in the form of questions. Furthermore, each group is asked to write down the answers to the problem formulation in front of the class, and then the teacher checks the answers individually. After all the answers are written, the teacher determines the problem formulation used in this first meeting so that each student has the same point of view on the answer and produces the same conclusion in the volcanic eruption disaster discussion activity. The hypothesis must be based on a research problem that has been identified and formulated (Lund, 2022).

The next stage is an investigation through a series of experimental activities. Experiments can enhance students' academic achievement by providing practical experiences that strengthen their understanding of theoretical concepts and also improve their critical thinking and problem-solving skills, ultimately leading to improved overall academic performance (Kotsis, 2024). After that, students answer questions related to the practicum, reflecting on problem-solving skills in making a plan. Furthermore, students read the work steps and carry out the experiment according to the instructions, developing skills in implementing the plan and collaborating on aspects of responsibility and compromise. After the experiment, students answer questions in the worksheets and eleven discussion questions based on the experiment's results, which include implementing the plan, making compromises, and developing communication skills. Finally, students answer questions about disaster mitigation in the context of volcanic eruptions.

Second Meeting

The second meeting lasted for three 40-minute sessions. At the third meeting, all students were present and in good condition to follow the learning series. The activity began with an introduction, including greetings from the teacher and a prayer led by the class leader. Then, the teacher took attendance, introduced the class, and inquired about the student's readiness to learn. Furthermore, the teacher allowed the students to recall the previous material, namely volcanoes. Then, the teacher invited students to continue the activities from the previous meeting by presenting the results of the experiments they had carried out with their respective groups. The core activity began with two groups presenting the results of their experiments to the entire class. Students explained the process and results of the experiments they had carried out.

The ability to speak has an important value and must be possessed by students because it allows students to express desires, convey information, share thoughts and ideas, as well as influence, convince, ask questions, and entertain others, and reflects a person's ability to think (Patongai et al., 2023). Afterward, the teacher facilitated a question-and-answer discussion session between students, providing input and suggestions to those who may not have fully understood the material. Groups not selected to make a presentation must pay attention, take notes, and ask questions to the group making the presentation. At this explanation stage, collaborative communication skills are seen when presenting the results of their experiments in front of the class. The teacher serves as a facilitator, ensuring the discussion proceeds smoothly and providing clarification as needed. At the end of the lesson, the teacher allows all students to reflect by asking several questions that can prompt their thinking on the material just learned. These questions help students reflect on their understanding during the learning process. After that, the teacher provides further clarification and explanation to students regarding the learning outcomes that have been passed to ensure that no concepts are still confusing or poorly understood by students. Furthermore, the teacher guides students in formulating conclusions from the material studied together, which students then answer or convey.

Observation

Problem-Solving Skills

Table 14 shows the average value of problem-solving skills at 89.41, based on the total score criteria for the problem-solving ability aspect. This value can be categorized as high. In terms of understanding the problem, students have been able to comprehend the issues in the questions because they are accustomed to working on problem-solving questions from previous learning. Students' scores in this aspect have increased from cycle I, which initially was 70.3 to 90.68. In the second aspect, namely creating a plan, students developed a problem-solving plan based on the given material and readings, with an increase from 69.93 in Cycle I to 85.53 in Cycle II. In the third aspect, namely implementing the plan, there was an increase in the average score from cycle I, which initially stood at 75.12 to 88.66. In this aspect, students were able to provide solutions to problems based on the readings provided. Looking back, there was an increase in the average score of Cycle 1, which initially stood at 79.37, to 92.78. In this aspect, students can provide solutions to specific problems and draw conclusions based on the

Table 14 Students' average score for each aspect of problem-solving

No	Problem-Solving Aspect	Average Value
1.	Understanding the problem	90.68
2.	Devising a plan	85.53
3.	Carrying out the plan	88.66
4.	Looking back	92.78
Overall Average		89.41

information presented in the news. Problem-solving skills help students understand that the learning process can shape their participatory personalities and lead to meaningful learning (Anita & Bentri, 2023).

Collaboration Skills

Table 15 shows that the average critical thinking skills score is 86.38, which falls within the very good category based on the total score criteria for collaboration aspects in Table 15. Regarding the collaboration aspect, Cycle 2 shows an increase in the average value of students, from 57.34 to 84.53. Regarding collaboration, these few students are already quite capable of working effectively in groups. Regarding responsibility, Cycle 2 shows an increase in the average value of students, from 57.37 to 86.59. Regarding responsibility, these few students are already quite capable of being jointly responsible for collaborative work. Regarding the aspect of compromise, Cycle 2 shows that the average value of students increased from 59.43 to 85.56.

Table 15 Students' average score for each aspect of collaboration

No	Collaboration Aspect	Average Value
1.	Collaboration	84.53
2.	Responsibility	86.59
3.	Compromise	85.56
4.	Communication	86.59
5.	Flexibility	88.65
Overall Average		86.38

Regarding compromise, these few students are already quite capable of making decisions with all group members. Investigation-based learning enables students to learn collaboratively, develop their listening skills, and appreciate diverse opinions (Korkman & Metin, 2021). Regarding the communication aspect, Cycle 2 shows an increase in the average value of students, from 61.59 to 86.59. In terms of communication, these students can communicate effectively in groups. In terms of flexibility, Cycle 2 can be seen as the average number of students increased from 64.71 to 88.65. In terms of flexibility, these few students can adapt to fellow group members. Collaborative learning requires cooperation, respect for others' opinions, self-control, patience, and adequate emotional intelligence from students (Fitriyani et al., 2019).

Reflection

After completing Cycle 2, the teacher conducted an in-depth reflection on the entire learning process that had been carried out, with the primary focus on evaluating the implementation of the previously prepared improvement plan. This reflection aims to analyze the results from the actions taken, including recording problems during the learning process, interpretation, analysis, and drawing conclusions based on observation results (Wibowo, 2021). At this stage, the teacher thoroughly analyzes the implementation of each planned improvement step and evaluates the extent to which the plan has been successfully implemented in the classroom. The results of the reflection indicate that all improvements planned by the teacher were successfully implemented. All syntax of the ITCPS learning model in Cycle 2 ran perfectly 100%. All aspects of problem-solving skills, including understanding the problem, devising a plan, carrying out the plan, reflecting on the outcome, and collaboration skills, such as collaboration, responsibility, compromise, communication, and flexibility, have met the learning achievement indicators. In addition, more than 75% of students have achieved the minimum high category and met the requirements. The learning model that involves investigating a problem can enhance students' skills in the 21st century, including problem-solving, critical thinking, and collaborative work (Wardani et al., 2024). The research was halted in cycle two because all learning achievement indicators had been met, demonstrating that the ITCPS learning model effectively improved the problem-solving skills and collaboration of students in class VIII G at SMP N 18 Surakarta. This success reflects teachers' commitment and hard work in designing and implementing effective learning strategies to improve the quality of student learning (Sulaeha, 2022).

4. CONCLUSION

Based on the results of the implementation of two cycles of class action research that have been done, it can be concluded that the application of the investigation through cooperative problem-solving (ITCPS) learning model improves problem-solving skills and collaboration skills as follows: problem-solving skills as seen from the average students' score increasing from 73.84% in Cycle 1 to 89.41% in Cycle 2; Collaboration skills also increased as seen from the average students' score increasing from 60.09% in Cycle 1 to 86.38% in Cycle 2. The results in cycle two have met the predetermined target. This study concludes that the ITCPS learning model can enhance students' problem-solving and collaboration skills through problem formulation, investigation, discussion, data collection, group conclusion, explanation of the discussion results, and reflection on learning activities. To improve students' problem-solving and collaboration skills, an effective learning model is needed that provides students with opportunities to hone their problem-solving and collaboration skills and apply them in various situations. By implementing the ITCPS learning model, it has been proven to improve students' problem-solving and collaboration skills in grade 8. In solving problems, students still struggle and are not effective in discussing with groups. Therefore, this study recommends the application of the ITCPS learning model in science education to enhance problem-solving and collaboration skills as 21st-century skills. This study recommends

implementing the ITCPS learning model in science learning to improve other 21st-century skills.

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