



## **PROBLEM-BASED LEARNING-COLLABORATION (PBL-C) MODEL IN ELEMENTARY SCHOOL SCIENCE LEARNING IN THE INDUSTRIAL REVOLUTION ERA 4.0 AND INDONESIA SOCIETY 5.0**

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### **ABSTRACT**

This study aims to describe the problem-based learning and collaboration model on science learning in elementary schools in the Industrial Revolution era 4.0 and Indonesia Society 5.0. This research is qualitative and descriptive. Data collection activities at the preliminary stage are carried out by exploring elementary school teachers' perceptions of problem-based learning and its application in science learning in schools in Surakarta, Indonesia. Focus group discussions (FGD) were conducted on 20 elementary school teachers employing the open inquiry method. The discussion reviewed several topics related to the teachers' perception of the problem-based learning application, the advantages and disadvantages of problem-based learning as the basis for modifying the learning model, and the importance of collaboration skills for elementary school students. The problem-based learning-collaboration (PBL-C) model is a development of the problem-based learning model, which is equipped with collaborative skill indicators from the Industrial Revolution 4.0 aspects and coordination indicators with various parties from Indonesia Society 5.0 aspects. The result of this research is the problem-based learning-collaboration (PBL-C) model design with six steps: (1) orientation of students to problems, (2) organizing students for learning and division of tasks, (3) guiding investigations on local community leaders, (4) proving the results of the investigation, (5) developing and presenting the work, and (6) analyzing and evaluating the problem-solving process.

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### **INTRODUCTION**

The purpose of education in the twenty-first century is to equip students with the knowledge and skills to learn and invent, to use technology and information media, to work, and to survive by employing life skills (Kemdikbud, 2013). Education today needs to prepare quality students who can go through the process of science education so that they have scientific skills, attitudes, and higher-order thinking skills (Liliasari in Pratiwi, 2015). In addition, Zubaidah (2016) mentioned the demands for particular skills that need to be empowered in learning activities that

students must possess, including critical thinking skills, problem-solving, collaboration, and various other skills. These skills are some of the skills needed in the Industrial Revolution era 4.0. In formal schools, learning has been oriented to 21st-century learning, which is the application of 4C skills (critical thinking, communication, collaboration, creativity) (NEA, 2017; Sugiyarti et al., 2018; Oktariani et al., 2020), problem-solving skills, collaboration and leadership, adaptability, entrepreneurial spirit, communication skills, ability to access and analyze information, and high curiosity and imagination (Wagner, 2010)

Collaboration is frequently mistaken for cooperation. These phrases do differ, though. Collaboration refers to a "personal philosophy"

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centered on creating (Hernández, 2012; Roselli, 2016). Based on Dillenbourg (in Hernández, 2012), a collaboration is when two or more individuals share responsibilities, decide on actions together, and work together to achieve a goal. Nevertheless, one of the problems in implementing 4C skills in schools is the low collaboration skills possessed by students. It is supported by Julita's (2016) research on the students' cooperative attitude and social interaction. The results showed that both attitudes were still low, so students must be trained in cooperative attitudes.

The interview results from teachers in elementary schools, students, on average, had low collaboration skills. It was due to the increasing individualistic attitude of students, one of which was caused by the utilization of mobile phones at home. Playing mobile phones made students ignore the surrounding environment since they were already preoccupied with their world. In the life of elementary school students, collaboration skills were still limited to completing group assignments instructed by the teacher. The rest of the students did not have the awareness to create a thing or solve problems by collaborating with other students.

Currently, collaboration skills make cooperation an interaction structure designed in such a way to facilitate collective efforts to achieve common goals. Through collaborating, students can work together and socially to achieve learning goals (NEA, 2007). Greater awareness and control over the learning process will result from the collaboration, which will also foster a favorable connection of interdependence and accountability (Mateos & Echeverría, 2006). Communication between team members is also necessary to coordinate interdependence and achieve success in many other aspects of collaboration (Clark & Brennan, 2004; Fiore et al., 2010).

On the other hand, the living conditions of the Society 5.0 era significantly affect all areas of human life, including education. The implications of the society 5.0 concept for education include demands for renewal of competencies taught to students, adapting to the needs of life in the Society 5.0 era 0, and including the learning model in schools. The learning model based on the paradigm that students are immature individuals, passive individuals as objects in the teaching and learning interaction process, and placing the teacher as the center of teaching and learning activities (Zamroni, 2000) is no longer adequate to prepare human resources for the Society 5.0 era. Learning models that emphasize the deducti-

on process and the process of transferring knowledge from teachers to students also cannot reach the acceleration of changes.

Therefore, quality students can be prepared through student-centered learning implementation, making educators innovative in designing learning. According to Heuvelen and Lippmann (in Wiyanto et al., 2006), the recommended science learning model for student-centered learning is to provide opportunities for students to learn to discover and not to accept. However, the learning implementation and processes in schools tend to ignore the elements of education, and education seems to be replaced with activities that emphasize more on brain training aspects. In addition, the ways educators teach students are simply by transferring knowledge without providing broad opportunities for students to observe their learning experiences. Educators also place themselves as the only primary source of learning. Learning methods that only transmit knowledge do not provide opportunities for students to interact and transact, causing them to lose time to articulate their experiences in the learning process.

An effort to deal with this problem is to use an effective learning model to improve the students' low 21st century skills by applying active learning that is student-centered and based on constructivism. Industrial Revolution 4.0-inspired education also calls for different approaches that force educational institutions to mix active and cutting-edge learning models in order to enhance the processes of teaching and learning (Halili, 2019).

One of the innovative learning models that can be applied in the current era is problem-based learning (PBL). This method of learning enables students to recollect what they have learned, pinpoint what they want to know, and find out how they can pick up problem-solving skills. Additionally, it boosts students' self-confidence, fosters group work in a safe setting, enhances interpersonal communication and critical thinking abilities, and creates self-awareness. However, previous research found that the average learning planning and implementation using PBL was still low (Dwi et al., 2018). PBL is an innovative model which steps lead to active learning (Balim et al., 2014). Employing PBL model in science learning provides benefits, including increasing environmental literacy (Sueb & Damayanti, 2021), enhancing problem-solving skills (López-Jiménez, 2021), and boosting scientific literacy (Savitri et al., 2021).

For this reason, PBL is very appropriate to be applied because some characteristics of science learning need to use the scientific method. In science learning, there are two interrelated things: science in the form of conceptual knowledge as a product and science as a process (Bybee et al., 2014). Science as a scientific process or method includes the methods used to investigate problems, scientific products in the form of facts, principles, laws, and theories, and scientific attitudes that refer to specific values that accompany the scientific process (Sund & Carin, 2010). It can develop thinking skills, how to investigate a problem, collect all knowledge, and its relation to technology and society (Koballa & Chiapeta, 2010). Furthermore, science learning should connect situations and actual conditions directly because science focuses on studying everything in nature (Gita et al., 2018).

According to Sutarto's research in 2022, "The Effect of Problem-Based Learning on Metacognitive Ability in the Conjecturing Process of Junior High School Students," compared to using traditional learning models, problem-based learning (PBL) has a considerable impact on students' metacognitive skills and conjecturing process. Every PBL stage can inspire students to engage in metacognitive tasks, particularly when they participate in group discussions.

Utamingingsih (2022), in her research entitled, "The Effect of Problem-Based Learning Assisted by Peer Tutoring on Student's Critical Thinking Ability," explained that fifth-grade elementary school students' critical thinking skills are significantly improved by the problem-based learning model with peer tutoring. Based on the t-count calculation, the result is -9.0339, and the t-table is 1.6725 with a significant level of  $\alpha = 5\%$  (0.05), so t-table is greater than t-count. Average critical thinking skills of experimental class students who learnt utilizing the problem-based learning model with peer tutoring and the control class students are significantly different;  $H_a$  is accepted, and  $H_0$  is rejected.

More specifically, the 2013 Indonesian curriculum states that science learning is contextual, which links the science concepts with events in the context of students' real lives. For this reason, the science learning model in elementary school classes must contribute to shaping the students' creativity as a reliable generation in the future. Furthermore, students are also expected to become a superior, innovative, productive, and creative generation in the Industrial Revolution era 4.0 and Indonesian Society 5.0. Therefore, this study aimed to explore the elementary school te-

achers' knowledge regarding the problem-based learning application, which became the basis for modifying the problem-based learning-collaboration (PBL-C) model in the Industrial Revolution 4.0 era and Indonesia Society 5.0.

For this reason, this study aims to describe the framework of the PBL-Collaboration model in the era of the industrial revolution 4.0 and Indonesia Society 5.0. This research result is crucial to apply to elementary school learning because students study individually and rarely interact with friends or teachers during the COVID-19 pandemic. In addition, learning has focused more on completing material without paying attention to skills that support the 21st century. This learning impacts decreasing collaboration skills since teachers rarely facilitate it. This study has a novelty from previous research, which focuses on developing a learning framework that develops the collaboration skills of elementary school students. This collaboration skill needs to be trained early, so students have a solid foundation to interact in solving problems and creating innovations in the future.

## METHODS

This case study explored the perspective of elementary school teachers on problem-based learning and its application in elementary school science learning in Surakarta City, Indonesia. The method used was descriptive qualitative. It aims to provide an overview of the existing learning models used so far and analyze the need for the learning models to be developed.

Data sources comprised research subjects, events, and Focus Group Discussion (FGD) data. Data were collected using open interviews through FGD activities. FGD was conducted using the open inquiry method on 20 elementary school teachers. The discussion discussed several topics related to the teacher's perspective on the application of problem-based learning, the advantages and disadvantages of problem-based learning, which became the basis for modifying the learning model, and the importance of collaboration skills for elementary school students.

The study was conducted in ten elementary schools in Surakarta, Indonesia, from January-April 2021. As the study subjects, the data sources in this study were elementary school teachers and relevant documents. Data validity was measured through triangulation of sources and peer review through discussion. The data were then analyzed employing interactive analysis techniques: data reduction, data presentation, and concluding (Miles & Huberman, 2014). The following

are data analysis steps: Data reduction summarizes data by taking essential points, focusing on themes, and sorting out unnecessary data (Sugiyono, 2015). Data reduction provides a clearer picture to researchers if they want to collect additional data. The summarized data helps them analyze the data more deeply. The data obtained were sorted to obtain the primary data containing essential points related to the implementation of PBL, the teacher's perception of the PBL model, and the collaborative ability of students.

Data presentation is done in tables, diagrams, charts, schematics, and the like to make the pattern of relationships and data easier to understand (Sugiyono, 2015). This study uses descriptive narrative data presentation by presenting data in summary tables and systematic translation of sentences according to the indicators and sub-discussions. The data from the FGD

results were reduced to taking important points and were then described in descriptive narrative form according to each indicator of PBL implementation, shortcomings, and students' collaborative abilities.

Concluding means testing conclusions by comparing theories from experts related to similar research, checking the FGD implementation, and making conclusions based on the findings with the hope that these conclusions can become new ideas from a brand new research subject (Sugiyono, 2015).

## RESULTS AND DISCUSSION

The research results regarding exploring 20 elementary school teachers in science learning through FGD with the open inquiry method were reduced, as in Table 1.

**Table 1.** Results of Focus Group Discussion (FGD) with Open Inquiry Method

Aspect	S1	S2	S3	S4	S5
Perceptions of PBL	"PBL comes interesting for students because it presents contextual learning problems."	"PBL is an alternative learning to provide provisions in line with the increasingly complex development of life so that it requires students provide solution and become adaptive."	"It is a learning model that involves students to be active in learning, both active in thinking and physical activity to solve problems through reading, listening, or kinesthetic activities."	"Learning that applies the PBL model provides opportunities for students to find concepts in groups; this activity makes students more active, critical, and motivated to participate in learning."	"Students who learn to use PBL are happier because learning is more challenging and develops critical thinking skills, and all individuals are actively involved in every activity, such as discussions, finding references, and completing assignments in groups."
Lack of PBL that had been implemented so far	"There are different responsibilities in completing tasks; there are active students in solving problems, but there are also passive ones."	"Students cannot yet organize, especially in the division of tasks in groups, so that the role of students in each group is still not optimal."	"Solving the problems given needs to involve students in investigations, involving several figures other than teachers to facilitate students to be independent in learning."	"The PBL implementation has not involved students optimally to think critically by proving the results of the investigation as proof of problem-solving."	"In solving problems, it is necessary to involve other parties so that co-operation can be established and add insight for students."
Perception of the importance of collaboration skills	"Collaboration skills can provide an opportunity for each individual to share goals in the group."	"It becomes an essential skill for students in the Industrial Revolution era 4.0 and Society 5.0 to work together with various parties."	"Students equipped with collaboration skills will have a responsibility in completing their tasks in groups."	"The existence of collaboration skills will provide opportunities for students to work together in solving problems."	"There is a positive relationship in problem-solving because each individual is involved in interactive communication."

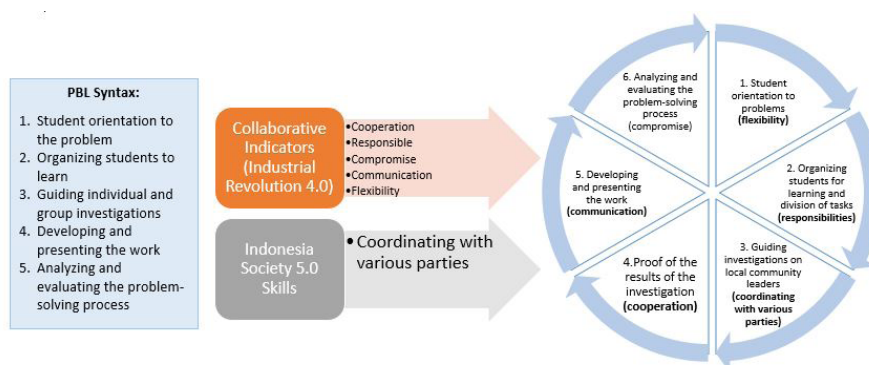
(The detailed instrument can be seen in the following link: <https://drive.google.com/drive/u/0/folders/1PI0XxlnKgJF3uNjJsGrSKDOL0TIuHzBv>)

These results indicate that teachers supported the problem-based learning model implementation because it has many advantages and facilitates students to learn actively. However, based on the evaluation of the PBL implementation, it was still not optimal. For example, PBL that had been implemented still did not facilitate students to have the responsibility for solving problems; there were still some passive students in each group. In addition, the group had not provided individual opportunities to have the ability to organize tasks in groups and conduct investigations that involved collaboration with various parties to solve problems given by the teacher.

This study's results became the basis for further studies related to the problem-based learning (PBL) model framework based on collaboration skills in the Industrial Revolution 4.0 era and Indonesia Society 5.0

The following table shows the analysis results between PBL syntax and skills in the Industrial Revolution 4.0 and Indonesia Society 5.0.

Based on the analysis results above, there were deficiencies in the problem-based learning (PBL) syntax in developing collaboration skills in the Industrial Revolution 4.0 aspects and skills in coordinating with other parties in the Indonesia Society 5.0 aspects. Therefore, this study developed a problem-based learning (PBL) syntax with indicators of collaboration skills to bring up collaboration and coordination skills from the Industrial Revolution 4.0 and Indonesia Society 5.0. In the model design development in this study, the third syntax in PBL was developed with the addition of one syntax to apply collaboration skills. The following is a design for the development of problem-based learning-collaboration (PBL-C) syntax.



**Figure 1.** Modified PBL-C Model Framework

The problem-based learning-collaboration (PBL-C) model design has six learning steps to improve the collaboration skills needed in the Industrial Revolution era 4.0 and Indonesia Society 5.0. The six learning steps include (1) orientation of students to problems, (2) organizing students for learning and division of tasks, (3) guiding

investigations on local community leaders, (4) proving the results of investigations, (5) developing and presenting the results of the work, and (6) analyzing and evaluating the problem-solving process. In more detail, Table 2 presents teacher and student activities in PBL-C syntax.

**Table 2.** Modified PBL-C Syntax

No	PBL-C Syntax	Teacher Activities	Student Activities
1	Orientation to the problem	The teacher explains the learning objectives and the necessary logistics, poses problems, and motivates students to participate in their chosen problem-solving activities.	Students form groups and determine the topic of the problem to be discussed.
2	Organizing students for learning and division of tasks	The teacher assists students in defining and planning problem-related learning projects.	Students make a schedule of task implementation plans and divide each member's tasks, so they have sufficient time to solve problems.
3	Guiding research on local community leaders	The teacher encourages students to collect information through community leaders following the topic of students' problems.	Students make a list of questions asked of community leaders to find out the causes and solutions of the selected problem topics.

4	Proof of investigation results	The teacher encourages students to look for evidence from investigations through books or carry out experiments to explain problem-solving.	Students look for sources from books/the internet or conduct experiments to prove the truth of the investigation results of public figures.
5	Developing and presenting the work	The teacher assists students with various assignments with their groups, helping them plan and develop acceptable works, such as reports, videos, and models.	Students make written reports and present the results of their discussions.
6	Analyzing and evaluating the problem-solving process	Teachers support their students' reflection on or evaluation of their investigation methods.	Students complete the report by adding input, suggestions, or responses from the teacher or other friends.

The problem-based learning-collaboration (PBL-C) model develops the problem-based learning model equipped with indicators of collaborative skills from the Industrial Revolution 4.0 aspects and indicators of coordinating with various parties from the Indonesia Society 5.0 aspects. Information technology is outpacing and influencing every aspect of human life in the fourth industrial revolution era. The emergence of the internet of things, which has permeated many areas of people's life today, including in education, is what defines the fourth industrial revolution. Therefore, initiatives like curriculum renewal and appropriate information technology use must be made.

Based on the PBL implementation in science learning in elementary schools, there were still shortcomings; for example, students did not have group responsibilities because there were still passive students in groups. PBL had not allowed students to collaborate with other parties in solving problems, so problem-solving was not optimal. When students solved the problem, it was not supported by evidence of the investigation, which impacted the results' accuracy. Moreover, it is necessary to involve the scientific process in science learning.

The lack of the PBL model implementation became the basis for modifications in the PBL model by integrating collaboration in PBL syntax so that the PBL model becomes better and facilitates students to develop skills in the Industrial Revolution 4.0 era and Indonesian Society 5.0. Collaborative skills, in this case, are one of the 21st-century skills that students must have in the Industrial Revolution 4.0 era (Council, 2011; OECD, 2013; Griffin & Care, 2015; Graesser et al., 2017; Sanabria & Arámburo-Lizárraga, 2017; Gauvain, 2018; Sottolare et al., 2018; Andrews-Todd & Kerr, 2019; Dewi et al., 2020; England et al., 2020).

Besides, collaboration consists of several skills that must be honed to become permanently embedded in students. Interpersonal, group management, questioning, resolving conflicts, and

presentation skills are all components of collaboration skills (Bosworth, 1994). Collaboration allows individuals to solve the problems they face to achieve the desired goals (Sahin et al., 2014). Furthermore, learning activities carried out in collaboration will make individuals observe and be aware of social processes and see the consequences of joint efforts in setting targets in learning.

The following explains the modified problem-based learning-collaboration model syntax that can be applied in learning science in elementary schools to accelerate skills in the Industrial Revolution 4.0 era and Indonesian Society 5.0. (a) Orientation to the problem. At this stage, the teacher's activities are to explain the learning objectives and necessary logistics, pose problems, and motivate students to participate in the problem-solving activities of their choice. Meanwhile, students form groups and determine the topic of the problem to be discussed. This stage is vital because it solves problems. They must understand the problem, see it from various perspectives, and not think rigidly with one method of solving it (Rahayuningsih et al., 2020).

This problem-oriented activity facilitates the process of cognitive flexibility. Cognitive flexibility in neuropsychology is the capacity to change between modes of thought and adjust to novel or shifting situations (Zmigrod et al., 2019). When dealing with a dynamically changing environment, a person's actions to solve a problem result in cognitive conflict (Hommel, 2015). However, solutions remain flexible and open to alternatives when the external or internal environment changes (Zmigrod et al., 2019). It aligns with the Industrial Revolution 4.0 era and Indonesian Society 5.0, where many changes and complex problems exist. Therefore, given the growing quick pace of technological advancement, flexible thinking skills are required to overcome potential challenges (Rahayuningsih et al., 2020). Thus, in a world that is changing quickly, thinking flexibly is crucial (Deliyanni et al., 2016).

The problem orientation stage allows students to develop their critical skills. In problem-solving, students use problem analysis and synthesis skills and apply previously learned concepts (McCormick et al., 2015). Students must actively participate in conceptualizing, applying, analyzing, synthesizing, evaluating, and communicating information in order to practice critical thinking (Kim et al., 2012). By understanding thinking skills, one can explain new ideas and insights during interaction (Heong et al., 2020). In solving problems, students must think simply and critically (Yuwono et al., 2019). This syntax allows them to develop critical thinking skills as skills in the 4.0 industrial revolution era and develop solutions as skills in society 5.0 era.

(b) Organizing students for learning and division of tasks. At this stage, the teacher helps students define and organize learning tasks related to the problem. Meanwhile, students make a schedule of task implementation plans and divide each member's tasks to have sufficient time to solve problems. Modification of the PBL-C model was carried out by emphasizing the ability of students to have responsibility for the tasks given as skills needed in the Industrial Revolution 4.0 era. Based on the analysis of teachers who had implemented PBL, many students still had not been actively involved in groups for problem-solving. Thus, collaboratively, giving assignments will provide awareness of each member's responsibility to achieve group goals.

In addition, PBL-C provides opportunities for students to take responsibility for solving problems in groups. One of the key stages in collaborative learning is group formation since having enough participants in a learning group fosters positive collaborative interaction and serves as the foundation for ensuring excellent performance (Chen & Kuo, 2019). Students get the chance to participate in discussions and accept responsibility of their ongoing education through collaborative learning. (Gokhale, 1995). With groups, problem-solving solutions are sometimes better than the solutions given by each member because there is a mutual agreement (Schwartz, 1995; Aronson & Patnoe, 1997; Slavin, 2015)

Collaboration also can create positive interdependence and mutual responsibility relationships, encouraging greater awareness beyond just the learning process (Mateos & Pérez Echeverría, 2006). It is consistent with the opinion (Cramer, 1998; Crowther, 1998; Proctor et al., 1998; Robbins & Finley, 1998) that each individual must be aware of the responsibility within a group to improve outcomes. The collaborative indicators

allow students to give and receive knowledge among the participants and to see this exchange as a responsibility to create a collaborative culture (Kim, 2008).

Learning that incorporates collaboration can systematically add cognitive and social components to each major activity. Collaborative problem-solving, knowledge sharing, group engagement, and peer review processes are all necessary for these major activities (Herrera-Pavo, 2021). Students are more likely to exchange information and accept help from others when they understand that collaboration rather than competition can spark mutual interests. Due to the peaceful setting, they frequently experience happy feelings, and they may also exhibit favorable social behaviors (Ingrid, 2019).

On the other hand, the growth of the internet, which has permeated many aspects of our lives today, including education, is a defining feature of the Industrial Revolution 4.0 era and Indonesian Society 5.0. Therefore, several efforts need to be made to use appropriate information technology. For example, in the Industrial Revolution 4.0 and Indonesian Society 5.0, previous face-to-face learning between teachers can now be done with online classes using social media or other media supporting the online learning process. In this case, PBL-C can be applied in online learning by considering several things, such as the type of task relevant to collaborative learning.

Kopp et al. (2012) described E-tutors should facilitate the following three basic categories of cooperative activities in virtual learning environments: (1) cognitive activities, such as knowledge exchange, online discussion, argumentation, collaborative problem solving, and considering different perspectives, (2) social activities, such as motivation, interpersonal interaction, social influence processes, and information processing, (3) metacognitive activities to plan, monitor, and organize collaborative learning. However, it is crucial to remember that not every task fits together collaboratively, and not all learning objectives can be achieved better collaboratively. It agrees with the theory that there are various ways to characterize the nature of collaborative learning tasks, including structured versus authentic, clear versus ambiguous, individual versus group, and divergent versus convergent (Kirschner et al., 2004). In collaborative learning, students work on assignments until all group members understand and complete them. The tasks given will facilitate students to develop responsibility as a skill needed in the Industrial Revolution 4.0 and Indonesian Society 5.0 era.

(c) Guiding research on local community leaders. At this stage, there is a modification of activities, where the previous teacher only guided individual and group investigations. PBL-C extends the investigation to local community leaders. Students make a list of questions asked of community leaders to find out the causes and solutions of the selected problem topics. The skills developed at this stage are coordinating with various parties per the Indonesian Society 5.0 era. Students gain broader insight and improve their ability to socialize with the community. Coordination also provides opportunities for students to organize, lead, and utilize human resources in a targeted and effective manner. Based on the results study, the science content has been successfully developed by utilizing the indigenous knowledge (Parmin et al., 2019)

It is in line with the statement that collaboration takes place not only with other students but also with outside parties and the environment (Dewi et al., 2020). It aligns with the statement that learning that can practice 21st-century skills must be student-centered, teamwork, and learning related to the context of students' daily lives (Mayasari et al., 2015). It also aligns with the 2013 curriculum, which is anticipated to be implemented in 21st-century learning and reflect four concepts: communication, collaboration, creativity and innovation (Makhrus et al., 2019). To increase students' creativity, it is necessary to make changes through active learning that will help them construct their knowledge (Reigeluth & Carr-Chellman, 2009), involve students actively in class discussions (Singh & Yaduvanshi, 2015), and establish student-student collaboration, which indirectly affects their creativity (Romero et al., 2012). Through group discussions, students are encouraged to express unique ideas (Breslin, 2017).

(d) Proof of investigation results. At this stage, the activities carried out by the teacher encourage students to look for evidence from investigations through books or carry out experiments to get an explanation of problem-solving. Students look for sources from books/the internet or conduct experiments to prove the truth of the investigation results of public figures. These activities can lead to an attitude of cooperation between individuals. It is under the theory that, to solve problems, students will begin to develop cooperative skills (Dupri et al., 2020). Doing good cooperation can motivate other teammates to be directly involved in solving problems, providing opportunities for discussion, and finding solutions. This process is a factor in improving stu-

dents' cooperative skills in learning. The teacher can also invite students to interact, be active, and collaborate to solve problems so that learning outcomes increase.

As a result of the investigation, the developed content attracts learners to study the provided information related to daily life (Eratay, 2017). Investigation can improve students' cooperative skills (Pramasta et al., 2021). In groups, there is little emphasis on group rewards to ensure teamwork or group competition to motivate students (Blumenfeld, 1996).

(e) Developing and presenting the work. At this stage, the teacher assists students with various assignments with their groups, helping them plan and develop acceptable works, such as reports, videos, and models. Meanwhile, students make written reports and present the results of their discussions. Planning, discovery, investigation, and knowledge gathering from a variety of information sources can all be used to develop scientific work independence (Parmin et al., 2017). Activities at this stage can facilitate students to develop communication skills. It agrees with the opinion, suggesting that communication skills can be built with activities, such as discussion, problem-solving (Oradee, 2013), models, multimedia, posters, and oral presentations (Spektor-Levy et al., 2009). One of the activities at this stage is presenting the work with a presentation. These presentation skills are essential for success in all daily life (Harper, 2004). The presentation should, however, include the following four fundamental components: (a) clearly stating the idea; (b) elaborating on the idea; (c) reinforcing the view with proof from additional sources; and (d) concluding/restating the idea.

In the Industrial Revolution 4.0 and Indonesian Society 5.0 era, learning activities that integrate technology can be carried out in various ways, such as using easily accessible technology (such as video hosting services) to help students develop their professional speaking and presentation skills (Kenkel, 2011). This study's results support previous research that problem-based presentation activities can improve communication skills.

(f) Analyzing and evaluating the problem-solving process. At this stage, teachers support their students' reflection on or evaluation of their investigation methods. On the other hand, students complete their reports by adding input, suggestions, or responses from the teacher or other friends. This activity is vital because it will impact team performance. It reinforces the opinion that the effectiveness of an individual's knowledge



articulation on team performance is high when the individual has good self-reflection (Rachtham & Srisamran, 2018). This self-reflection benefits individuals and the team to improve team performance and effectiveness (Loo & Thorpe, 2002). Therefore, students must be trained to self-reflect on their presentations to prepare to compete in a competitive environment, especially in communication skills (Shauki & Benzie, 2014). This activity can also foster student compromise, an essential skill in the Industrial Revolution 4.0 and Indonesian Society 5.0 era.

This study's results support the previous studies' results that due to its emphasis on collaboration, respect for others' perspectives, and listening to others when they speak, problem-based learning (PBL) can strengthen collaboration skills. In group work, PBL prioritizes cooperation, empathy, and active participation in analyzing the material provided (Dewi et al., 2020). PBL also allows students to hone their collaborative skills, critical to making learning outcomes traceable (Bell et al., 2010).

This study's results also reinforce previous research, stating that with the inherent 21st-century skills assessment, it is challenging to assess utilizing a traditional approach. That study employed technology-based Tangible User Interfaces (TUI) to assess individuals' complex problem-solving and collaboration skills (Ras et al., 2014). In addition, there are also results of research on evaluation using the in-task assessment framework (I-TAF) technique for collaborative problem-solving assessments (Andrews-Todd & Kerr, 2019).

Teachers must therefore create a learning system that includes a learning discovery model into 21st-century learning (Raya et al., 2019). For this reason, 21st-century skills must be incorporated into the core curriculum by the educational system. Additionally, the educational system should help students acquire knowledge, abilities, and traits that will help them become successful individuals, productive members of society, and engaged citizens (Anagün, 2018). In addition, the local Education Office should encourage all schools to conduct in-house training focused on 4C integration to ensure that all teachers have experienced in-depth training and contextual practice of 4C integrated science teaching (Harryani et al., 2021). Moreover, the competence of 21st-century teachers demands that professional teachers are no longer merely those who can instruct effectively; they are also those who can learn from their students, act as leading change in their schools, build relationships with other educators, and create effective lesson plans (Makhrus et al., 2018).

## CONCLUSION

The study concludes that the problem-based learning-collaboration (PBL-C) model is a development of the problem-based learning model equipped with indicators of collaborative skills from the Industrial Revolution 4.0 aspects and indicators of coordinating with various parties from the Indonesia Society 5.0 aspects. The problem-based learning-collaboration (PBL-C) model design has six steps: (1) orientation to problems, (2) organizing students for learning and division of tasks, (3) guiding investigations on local community leaders, (4) proving the results of the investigation, (5) developing and presenting the work, and (6) analyzing and evaluating the problem-solving process. The development of this learning model is expected to grow the collaborative skills needed in the Industrial Revolution 4.0 and Indonesia Society 5.0 era. Besides, it is hoped that this research can bring up other models that follow the 21st century.

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