

Preliminary Study: Development of a Physics Learning Assessment Instrument using the PjBL Model to Improve 4C Skills

Nurul Azmi^{1*}, Festiyed², Desnita², Yulkifli²

¹ Masters Study Program of Physics Education, Universitas Negeri Padang, West Sumatera, Indonesia.

² Department of Physics, Universitas Negeri Padang, West Sumatera, Indonesia

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Correspondence

Email:
nurul.azmi257@gmail.com
Phone: 082372490353

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ABSTRACT

This research aims to determine the 4C skills of Padang City High School students. The research design uses the R & D method and the ADDIE development model, which includes five development stages, namely analysis, design (develop), implementation (implement) and evaluation (evaluate). The research instruments used were validation sheets, communication and collaboration skills questionnaires and critical thinking and creative thinking skills test sheets. From the results of initial research at three schools in Padang City, it was found that critical thinking skills (45.65%), creative thinking skills (40.46%), communication skills (61.77%) and collaboration skills (61.46%). This shows that students' 4C skills are still lacking. To overcome this, researchers proposed a solution by developing a PjBL model physics learning assessment instrument to improve 4C skills learners.



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INTRODUCTION

The development of education in the era of Industrial Revolution 4.0 demands changes in the quality of student learning. Learning is getting grades and expanding knowledge into other disciplines to solve everyday problems. Schools play an essential role in realizing this by implementing a curriculum to improve and develop students' cognitive skills and affective domains. Skills and attitudes are expected to foster students' higher-order thinking skills (HOTS), including communication, collaboration, critical thinking, creative thinking, and responsibility (Jenderal et al., 2020). In the Assessment and Teaching of 21st Century Skills article (2018), Lolanessa et al. (2020) divide 21st-century skills into three skills, namely: (1) creative, innovative, critical thinking skills, being able to solve problems, and being able to take (1) decision wisely; (2) collaboration and communication skills; and (3) forward thinking skills in society and the environment.

Critical thinking is a structured problem-solving process that includes analyzing problems, providing critical responses, drawing conclusions and induction, evaluating and making decisions and finding solutions when facing a problem (Wati, 2014). Critical thinking

abilities are not obtained through physical growth but through continuous practice (Fakhriyah, 2014). In education, critical thinking is defined as the formation of abilities in logical aspects, such as the ability to give arguments, syllogisms and propositional statements (Andriani, 2022). According to Emzir (2014), the ability to think creatively produces new methods, concepts, understandings, discoveries, and works. The ability to think creatively is an essential thinking skill characterized by high curiosity and formulating various solutions to the problems encountered (Kardoyo et al., 2020).

Collaborative skills are needed in work and education as a critical factor for effective learning (Saenab et al., 2019). Collaboration skills help individuals or groups to achieve goals and shape students to be tolerant and open-minded towards ideas, attitudes, and behaviours (Pratiwi et al., 2018). Communication skills are creating relationships between people or through the media so that messages or information are correctly conveyed. Communication skills are the abilities of someone, both non-verbally and verbally, to convey messages to audiences or vice versa (receive messages) and then convey them. There is no miscommunication (Dewi & Kustiarini, 2022).

With 4C skills, students are expected to be able to think critically to solve problems in their environment. Creativity, innovation, collaboration and good communication make work more effective and efficient so that misunderstandings with others can be minimized. These skills are essential in the twenty-first century. The ability to acquire, evaluate and integrate knowledge that can be taught, limited and acquired is the meaning of critical thinking skills (Zubaidah, 2017). Critical thinking skills include communication and information skills and the ability to assess, analyze and evaluate evidence. Creative thinking skills (creative thinking skills) are skills related to innovations in solving a problem. Communication skills include explaining concepts effectively and persuasively both vocally and in writing, expressing opinions with precise phrases, conveying orders clearly, and motivating others through speaking skills.

A problem that often occurs in physics learning is the application of learning models that are less than optimal. Using the same learning model makes lessons dull. This limits students' opportunities to try and discover new things. Educators often equate learning models for all core competencies, even though each core competency is different. The solution to this problem is that educators must look at the competencies students need to achieve in each new material to determine an appropriate learning model. The objective conditions in the field do not match the expected ideal conditions. Based on initial observations made in three schools in the city of Padang, the results of the analysis of the educator's questionnaire sheet regarding the application of the learning model were obtained. The discovery and problem-based learning models obtained an average score of 80% and 83.33% with good criteria.

Applying the project-based learning model resulted in 33.33% with poor criteria. This states that educators only apply discovery and problem-based learning models in the learning process, rarely using other learning models. So, there are no variations in the application of learning models during the physics learning process. Based on the results of several studies, a learning model that can improve critical and creative thinking skills in the 21st century is the application of Project Based Learning (PjBL). Project Based Learning emphasizes solving authentic problems that occur daily through practical learning experiences directly in the community (John, 2008). The advantages of PjBL include: (1) encouraging students to be challenged to solve real problems in the field through project activities, (2) students become active in learning, (3) student performance in completing projects is more organized, (4) participants students have more freedom in completing projects, (5) students are motivated to compete to produce the best products, and (6) students become more independent and have responsibility for the projects they are working on (Baidowi, A., Sumarmi. & A. Amirudin, 2015).

Physics is a part of science that studies various natural phenomena and plays an important role in developing science and technology (Nurlina, 2020). The essence of Physics is physics as a product, attitude, and process. Physics as a product is a collection of knowledge in the form of facts, concepts and principles. Understanding physics as a process is how we get knowledge. Physics knowledge is obtained through various scientific processes such as measurements, experiments, and discussions, as well as involving students directly in activities to help them understand existing concepts (Gunawan, 2015). Knowledge in the learning process must assist students in achieving goals, namely (1) building meaningful knowledge and knowledge; (2) providing freedom in developing thinking, creative, and critical abilities; and (3) applying the knowledge that is already owned for learning. Students are also encouraged to produce active, interactive and fun products. Physics is a subject that is considered complicated by students. Educators still teach physics in theory without practice. Students memorize formulas, laws, and physics concepts. This reduces the enthusiasm of students to learn physics. The ability of students to ask questions and talk with educators is still not optimal. Students have been unable to think critically to find concepts and solutions to their physics problems. The lack of students' interest in learning causes a weakening of the mastery of physics concepts and skills.

The role of educators is a determinant of success in the world of education. Educators are one component of the education system. Educators' ability determines the quality of existing education, so there is a need for learning that suits the needs of students (Wicaksono, 2016). Educators try various ways to improve students' learning abilities in physics subjects. For example, educators hold discussions, training, workshops, seminars and MGMP meetings to discuss appropriate ways to improve learning methods that suit the material and characteristics of students. Although various efforts have been made to improve the curriculum, there are still gaps. If allowed to continue without an appropriate strategy, it will not increase the quality of learning processes and outcomes (Festiyed, 2018). As a result, education goals in the 21st century are not achieved.

The solution to the above problems is the use of a project-based learning model, namely learning that focuses on students and positions educators as motivators and facilitators, provides opportunities for students to think creatively and innovatively, and works independently or in groups to build learning (Yance et al. al., 2013). Educators can direct students to real-world problems whose solutions require group work, critical thinking, or action. Following research conducted by Condliffe concluded that the project-based learning model can instil collaborative skills (Birgili, 2015). This learning gives freedom to students to build knowledge and develop skills independently.

PjBL also helps students develop group work, problem-solving, and communication skills, strengthens social-emotional learning (SEL), and positively correlates with student achievement (Didin & Zubaedah Wiji, 2020). In its implementation, several steps must be implemented. One of the first steps is fundamental questions; the result is the creation of student projects (Ismuwardani et al., 2019). The projects created are projects from one educator or joint projects from several educators teaching different subjects. Learners are trained to analyze problems, research, collect information, and interpret and evaluate projects related to the problems studied. This learning allows students to develop their creativity by designing and creating projects that can be used to solve problems. Project-based learning is based on constructivism theory and is active student learning (student-centred learning). The learning process through PjBL allows educators to "learn from students" and "learn with students" (Sani, 2014).

In the PjBL model, educators give assignments to students. Students find solutions to the tasks given in groups or independently so that educators can stimulate students to improve their abilities. The strategy is a learning tool to achieve student competency attitudes,

knowledge, and skills (Triningsih & Mawardi, 2020). The PjBL method includes problem-solving, decision-making, investigative, and creative skills. Learners should focus on solving problems or questions that guide them to understand the concepts and principles associated with the project.

The learning models mentioned above encourage students to collaborate. Students can create challenging projects to find solutions to real-world problems while interacting with their environment. This learning model is very effective in teaching students to carry out complex processes of planning, communication, problem-solving, and decision-making (Suranti & Sahidu, 2016). The project-based learning model makes students active so that they meet the demands of the 2013 curriculum. PjBL allows students to carry out scientific learning activities in the form of 1) asking questions, 2) making observations, 3) carrying out investigations or experiments, 4) reasoning, and 5) establishing relationships with other people to obtain information or data. For example, the learning project being carried out is investigating how to deal with waste problems around schools; students must observe conditions in the school environment, conduct investigations about the sources and types of waste that exist, communicate with the community around the school, and other activities relevant to the learning process. Based on the explanation above, it can be concluded that the 4C skills of students are still low. To overcome this problem, the researcher proposed a solution: developing an assessment instrument for learning physics in the PjBL model to improve 4C skills. This research aims to determine the 4C skills of Padang City High School students.

METHODS

The development model used in this research is the ADDIE model (Branch, 2009). The ADDIE model consists of five main stages, namely the analysis stage, initial design stage, development stage, implementation stage and evaluation stage. The analysis phase is the foundation of the steps to be carried out. At this stage, the researcher analyzed the gap between the learning conditions and the desired results (Ariani, 2018). This stage is also used to dig up as much information as possible in the form of needs analysis, curriculum analysis, student analysis, and giving questions in the form of essays to measure critical thinking skills and creative thinking skills as well as questionnaires to look at students' collaboration skills and communication skills.

The design stage aims to design the product and the product design to be made. The assessment instrument product design will be created by selecting tasks, determining criteria, creating a rubric, and creating an initial product design. At the development stage, an assessment instrument can measure students' knowledge and skills competencies during the learning process. The implementation stage is the product trial stage, which aims to apply the assessment product in the form of an assessment activity sheet that has been made. Evaluation is a process carried out to give value to the assessment activity sheet in learning.

The variables used in this study are the validity of the assessment instrument, practicality, and effectiveness of assessment instruments (critical thinking skills, creative thinking, collaboration and communication). The research instruments used were validation sheets, communication and collaboration skills questionnaires, and critical and creative thinking test sheets. The validation sheet is used to obtain information regarding the validity of the assessment instrument. Four examining lecturers filled in this sheet. Questionnaire sheet to measure communication skills and collaboration skills. The test sheet measures students' abilities using critical and creative thinking indicators. The test sheet is in the form of a description test.

RESULTS AND DISCUSSION

Results

Based on initial observations through asking questions and distributing questionnaires carried out in three schools in the city of Padang to measure students' 4C abilities, it was found that students' 4C abilities were still lacking. These results are described in several aspects, namely aspects of critical thinking skills, creative thinking, collaboration skills and communication skills. Critical thinking and creative thinking skills are measured using essay questions, while collaboration and communication skills are measured using a questionnaire.

Critical thinking skills are the process of judging correct statements to reduce misunderstandings. Critical thinking is also rational, reflective thinking about deciding what to believe or do. Analysis of critical thinking skills consists of five indicators of critical thinking. This can be seen in Figure 1.

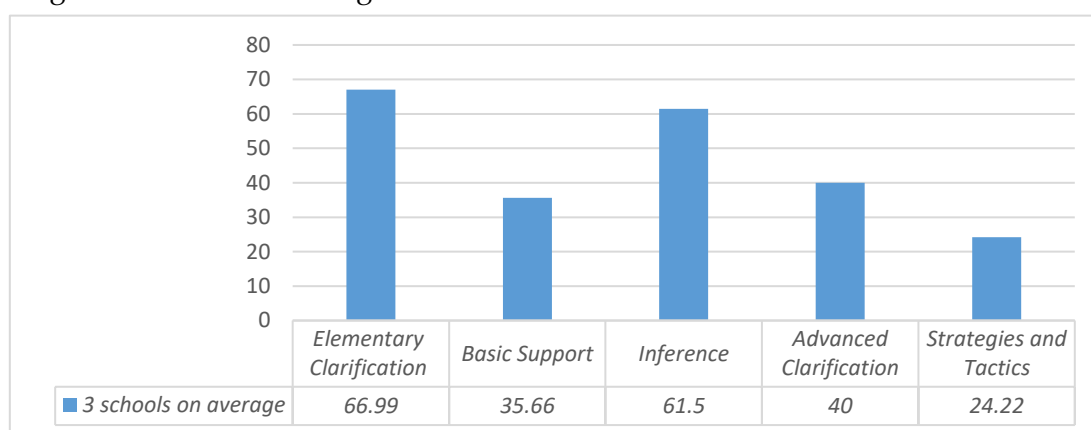


Figure 1. Aspects of Critical Thinking Skills

Overall, critical thinking skills are 45.65%. Critical thinking skills consist of five indicators: basic clarification, basic support, inference, further clarification, and strategies and tactics (Ennis, 1991). Figure 1 also shows that the analysis of aspects of critical thinking skills is in the less criteria because the P value ≤ 70 . The lowest percentage values are obtained in the five aspects: strategy and tactics. The highest aspect was obtained in the basic classification aspect, 66.99%. The second lowest aspect is obtained from the basic aspects of making decisions.

The basic classification indicators consist of three sub-indicators, which focus on questions, argument analysis and question and answer. The basic indicators for decision-making or support consist of two sub-indicators: assessing the credibility of sources and evaluating observation reports. The conclusion consists of three sub-indicators: concluding and evaluating conclusions, inducing and considering the results of induction, and making and determining the results of reasoning. Further classification consists of two sub-indicators, namely definition assessment and assumption identification. The determination of strategy and tactics consists of two sub-indicators: the determination of actions and interactions with other people.

Critical thinking skills are needed in the process of solving a problem. When someone solves a problem or decides, they do so critically. Students accustomed to critical thinking will be able to solve a problem in their lives. Ennis (1991) states that critical thinking skills are reflective patterns that focus on deciding what to believe or do. The purpose of critical thinking is to prevent someone from making wrong and hasty decisions

that cannot be accounted for. The characteristics of critical thinking are evaluating when thinking, always thinking reflectively, using logic, and systematically.

Yalcin et al. (2009) suggested that project-based learning can affect attitudes, motivation to learn physics and developing thinking skills. A. Sudewi I.G. et al. (2013) also stated that through a project-based learning model, students can practice to continue learning to think critically, work in groups, learn to solve problems in society, learn to present and account for their learning outcomes, feel the challenges of learning, learn from experience. Everyday life is not only learning in theory from books, learning to think at a higher level, learning to appreciate group work, learning democracy, learning to solve problems scientifically, and learning to participate in making public policies for the common good. The ability to think critically can be observed from various opinions of other people, which may be different or the same; by knowing conflicting opinions, a person can assess and decide which opinion is more inclined to scientific truth so that he never hesitates in making decisions. (Hasruddin, 2009).

Indicators of critical thinking skills, according to (Sagala, 2017), include acceptance, readiness, mechanical, complex work, adaptation, and advanced skills. These indicators follow the critical thinking indicators expressed by Ennis (1991), so it can be concluded that the two indicators are very closely related, so the development of physics learning assessment instruments in the PjBL model influences students' critical thinking skills.

The creative thinking skills aspect consists of four indicators. First, fluency in expressing ideas (fluency); second, openness in receiving information (flexibility); third, the ability to find innovations (originality); and fourth, the willingness to share ideas with others (elaboration) is an indicator of achieving creative thinking skills for students. The average results obtained in the initial research can be seen in Figure 2.

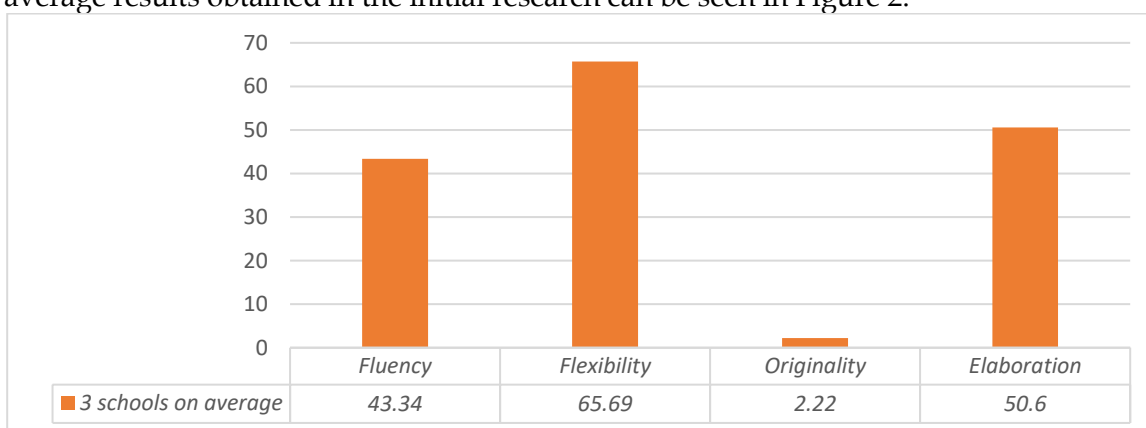


Figure 2. Aspects of Creative Thinking Skills

Overall, the ability to think creatively is 40.46%. Fluency refers to multiple ideas when responding to a particular stimulus. Flexibility refers to various categories of responses or the ability to change one's mental view of something. Authenticity refers to the statistical rarity of a response (Mohamed, 2008). Perkins (1984) states that in the process of creative thinking skills, students communicate through internal actions in making decisions and conclusions as well as external actions that must have results (output). To think creatively, student learning outcomes must be the primary goal.

Thinking creatively is forming new ideas when meeting needs (Marzano, 1988). Creative thinking is a process for realizing communication that connects integration and effusion, convergence and divergence, and thesis and antithesis by combining ideas with critical thinking skills (Montuori, 2003). The ability to think creatively is limited by a combination of aspects that combine processes (imagination, thinking), properties (fluency, flexibility, originality) and products (technical products, scientific knowledge, scientific phenomena, scientific problems).

Marzano (1988) also argues that in American schools, students in the classroom are rarely asked to express original ideas, let alone provide opinions or evidence in any form. If schools want to develop more skilled thinkers, more active interactions must occur in the classroom, from significant discussions of controversial issues to small groups and problem-solving.

According to (David, 1973), developing creativity needs to consider three factors: the individual's attitude, the basic abilities (convergent and divergent thinking) required, and the techniques used. Referring to individual students' different attitudes and actions, one way to foster creative thinking in the classroom is to make students aware of their characteristics. This can be told to students directly or help them find it themselves. The final approach educators can take is to ask students to study the lives of critical and creative figures or interview local people known for their thinking qualities.

Selection of assessments and models that have a positive influence on students' creative thinking abilities. As stated by (Wartika et al., 2014), the physics learning outcomes of students who follow the PjBL learning model are significantly different from those of students who follow the conventional learning model. This was then confirmed by the opinion of Widyastuti (2017) that the ability to solve physics problems among groups of students who were treated with authentic assessments was higher than the ability to solve physics problems that used authentic portfolio assessments. The results of this research also follow what was stated by (Fauziah, 2015), who said there are several characteristics of creative thinking, namely fluency, flexibility, originality and elaboration. It can be concluded that these two indicators are closely related. Hence, developing physics learning assessment instruments using the PjBL model influences students' creative thinking skills.

Communication skills are needed to convey various ideas so that others and the environment can receive them well. Communication skills include the ability to explain concepts effectively and persuasively both vocally and in writing, convey opinions with clear phrases, convey orders clearly, and motivate others through speaking skills (Zubaidah, 2017). The research results obtained can be seen in Figure 3.

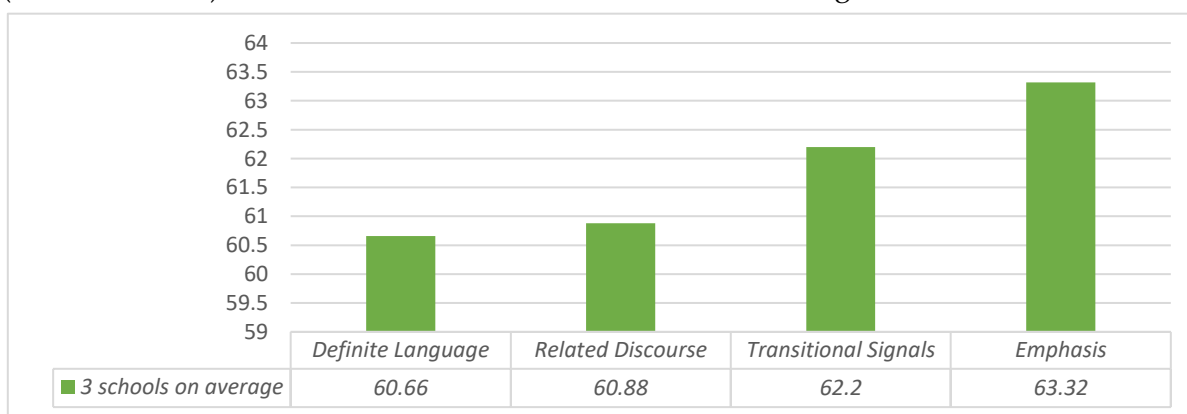


Figure 3. Aspects of Communication Skills

Overall communication ability is 61.77%. The communication ability indicator consists of four indicators: definite language, related discourse, transitional signals and emphasis.

In language indicators, three sub-indicators are used: correct punctuation, correct hyphens and making sentences according to EYD. The related discourse indicators consist of two sub-indicators, namely referring to thematic delivery and aiming at a purpose by students. The transition signal indicator consists of two sub-indicators, namely, conveying the main idea in the paragraph and conveying sentences that support the main idea. The

emphasis indicator consists of one sub-indicator, namely, being able to convey the paragraph's main point well (Eggen & Kauchak, 2016).

The assessment instrument contains indicators of student communication skills. The instrument is in the form of an assessment sheet equipped with a rubric. The assessment instrument rubric contains the communication indicators being assessed, statement items and assessment scores. The assessment instrument scale developed uses a Likert Scale with five alternative scores, namely 5, 4, 3, 2, and 1. Then, the calculation of scores or grades for each assessment stage is based on a formula to obtain a final score conclusion and the criteria for assessing students' communication skills.

Implementing a project-based learning model can improve students' communication skills (Elisa et al., 2020). This is reinforced by the research results of Lestari et al. (2015), which show that providing a project-based learning model can improve students' communication skills. (Zulfa, 2020) also states that assessment instruments can improve students' communication skills. This reinforces that assessment instruments in the project-based learning model can improve students' communication skills (Aristiadi & Putra, 2018). Collaboration skills consist of five indicators. This can be seen in Figure 4.

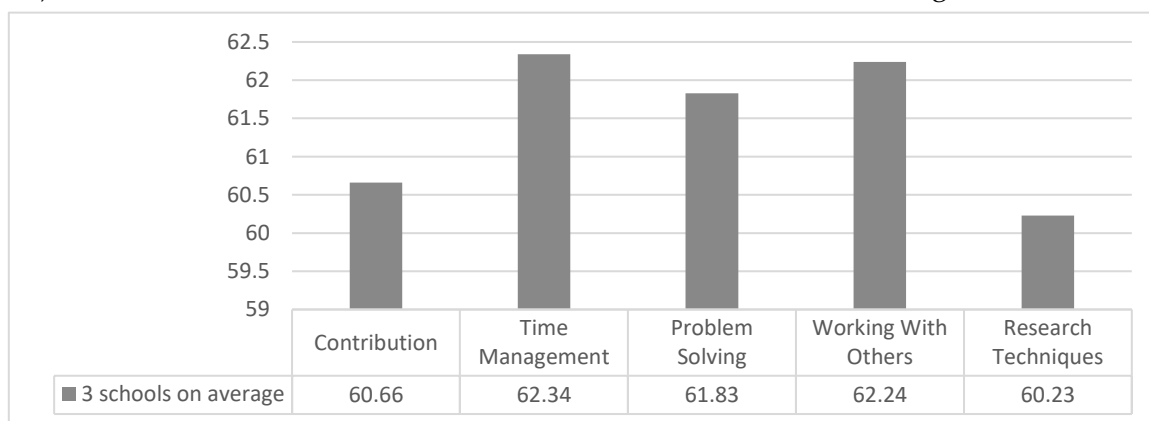


Figure 4. Aspects of Collaboration Skills

Overall, students' collaboration skills were 61.46%. Indicators of collaboration skills consist of five aspects: contribution, time management, problem-solving, working with other people and investigative techniques. In collaboration skills, through student involvement in teamwork, students have the opportunity to express ideas, share ideas and knowledge, help each other among team members and respect each other's opinions to find solutions and achieve goals.

Discussion

Several factors cause the low level of each skill. First, regarding critical thinking skills, learning still applies a teacher centre so that students' skills in critical thinking are not well trained. Second, regarding creative thinking skills, students still tend to be unable to create new ideas or innovate in solving physics problems (Mihardi et al., 2013). Students also have not fully learned to apply physics concepts in creating work (Wibowo & Suhandi, 2013). Third, educators are more active in communication skills, and students appear passive in learning (teacher centre) (Kulsum & Nugroho, 2014). As a result, there is no two-way communication in the learning process. Fourth, students' collaboration abilities are low because students are passive when doing group work. This is caused by their lack of understanding of physics concepts, so they do not know what steps to take and usually only rely on one person they think can do the task. Students are required to

be able to collaborate with other people so they can work effectively in groups.

The results of observations on students' critical and creative thinking abilities include the criteria for being lacking. To improve creative thinking and critical thinking skills in the underdeveloped category from project-based learning (Rachmawati et al., 2018). Learning with this technique still needs to be developed and followed up better, considering the rapid development of natural science and technology in various areas of social life, which is a sign of the emergence of the 21st century. This is the opinion that several students' abilities, such as creativity and innovation, critical thinking and problem-solving, communication and collaboration, must be developed to face the challenges of the 21st Century (Yani & Ruhimat, 2018).

Students' critical and creative thinking abilities are measured by giving questions in essay form. This is intended so that when training critical and creative thinking skills, students need to be given space for a variety of creative answers, and it is even hoped that educators can accept answers from students that are considered unusual (Trianto, 2007). Creative thinking skills are also part of higher-order thinking skills, which focus on creating ideas and generating various abilities and appropriate responses to a problem (Wibowo, 2013). Therefore, educators play an important role in developing students' creative thinking skills. According to Guilford (2012), creativity is the ability to see several solutions to a problem, a type of thinking that has received little attention in education.

CONCLUSION

This study aims to produce an assessment instrument for learning physics with a project-based learning model to improve students' 4C skills. Based on initial observations made in three schools in Padang City, it was found that critical thinking skills (45.65%), creative thinking skills (40.46%), communication skills (61.77%) and collaboration skills (61.46%). This shows that the 4C skills of students are still lacking. To overcome this, the researchers proposed a solution: developing an assessment instrument for learning physics in a project-based learning model to improve students' 4C skills.

REFERENCES

- A. Sudewi I.G., N, S., & M. Kirna I. (2013). Penerapan Model Pembelajaran Berbasis Proyek Untuk Meningkatkan Kemampuan Berpikir Kritis Pada Siswa Kelas X Multimedia 3 SMK Negeri 1 Sukasada. *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha Program Studi Teknologi Pembelajaran*, 3.
- Andriani, A. A. (2022). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Berpikir Kritis Mahasiswa Program Studi Pendidikan Fisika Universitas Muhammadiyah Makassar. *Jurnal Pendidikan Fisika*, 4, 106–111.
- Aristiadi, H., & Putra, R. R. (2018). Pengaruh Penggunaan Lembar Kerja Peserta Didik (LKPD) Berbasis Proyek Terhadap Hasil Belajar Peserta Didik Pada Konsep Pemanasan Global (Studi Eksperimen di Kelas VII SMP Negeri 6 Kota Tasikmalaya Tahun Ajaran 2017/2018). *Bioedusiana*, 3(2), 77–84. <http://jurnal.unsil.ac.id/index.php/bioed/index>
- Birgili, B. (2015). Creative and Critical Thinking Skills in Problem-based Learning Environments. *Journal of Gifted Education and Creativity*, 2(2), 71–71.
- David, G. A. (1973). *Psychology of Problem Solving* (Issue 4). Basic Books.
- Dewi, E. R., & Kustiarini. (2022). Implementasi Model Pembelajaran Two StayTwo

- Stray (Tsts) Berbasis Peta Konsep Sebagai Upaya Meningkatkan Keterampilan Komunikasi Mahasiswa. *Jurnal Riset Pendidikan Dasar*, 05(2), 161–173.
- Eggen, P., & Kauchak, D. (2016). *Education Educational Psychology Educational Psychology: Windows on Classrooms*, 10e.
- Elisa, C. E., Muharini, R., & Hadi, L. (2020). Penerapan Model Pembelajaran Project Based Learning Terhadap Keterampilan Komunikasi Pada Materi Pemisahan Campuran di SMP. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, 9(1), 1–9.
- Emzir. (2014). *Metodologi Penelitian Kualitatif Analisis Data* (4th ed.). Rajawali Pers.
- Ennis, R. (1991). *Critical Thinking*. Prentice Hall.
- Fakhriyah, F. (2014). Penerapan Problem Based Learning Dalam Upaya Mengembangkan Kemampuan Berpikir Kritis Mahasiswa. *Jurnal Pendidikan IPA Indonesia (JPII)*, 3(1), 95–101.
- Fauziah, L. (2015). *Pengaruh Model Pembelajaran Pjbl (Project Based Learning) Terhadap Keterampilan Berpikir Kreatif Siswa Kelas Xi Pada Konsep Struktur Dan Fungsi Jaringan Tumbuhan*.
- Festiyed. (2018). Studi Pendahuluan Pengimplementasian Kurikulum 2013 dalam Mengintegrasikan Pendekatan Saintifik Melalui Model Inkuiri dan Authentic Assessment dalam Pembelajaran IPA di Kota Padang 1. *SEMIRATA*.
- Gunawan. (2015). *Model Pembelajaran Sains berbasis ICT*. FKIP UNRAM.
- Hasruddin. (2009). Memaksimalkan Kemampuan Berpikir Kritis Melalui Pendekatan Kontekstual. *Jurnal Tabularasa PPS UNIMED*, 6(1), 48–60.
- Ismuwardani, Z., Nuryatin, A., & Doyin, M. (2019). Implementation of Project-Based Learning Model to Increased Creativity and Self-Reliance of Students on Poetry Writing Skills Article Info. *Journal of Primary Education*, 8(1), 51–58.
- Jenderal, D., Tinggi, P., Pendidikan, K., Kebudayaan, D., Penyusunan, P., & Tinggi, K. P. (2020). *Di Era Industri 4.0 Untuk Mendukung Merdeka Belajar-Kampus Merdeka*.
- Kardoyo, Nurkhin, A., Muhsin, & Pramusinto, H. (2020). Problem-based learning strategy: Its impact on students' critical and creative thinking skills. *European Journal of Educational Research*, 9(3), 1141–1150. <https://doi.org/10.12973/EU-JER.9.3.1141>
- Kulsum, U., & Nugroho, S. E. (2014). Penerapan Model Pembelajaran Cooperative Problem Solving Untuk Meningkatkan Kemampuan Pemahaman Konsep Dan Komunikasi Ilmiah Siswa Pada Mata Pelajaran Fisika. *UPEJ*, 3(2), 73–78.
- Lestari, R. A., Hadisaputro, S., & Nuswowati, M. (2015). Pembelajaran Berbasis Proyek dengan Produk Artikel Untuk Meningkatkan Hasil Belajar Siswa. *Chemistry in Education*, 4(2).
- Lolanessa, L., Kaniawati, I., & Nugraha, G. (2020). Pengaruh Model Problem Based Learning (Pbl) Menggunakan Pendekatan STEM dalam Meningkatkan Keterampilan Pemecahan Masalah Siswa SMP. *Wahana Pendidikan Fisika (WaPFI)*, 5(1), 113–117.
- Marzano, R. J. (1988). *Dimensions of thinking: a framework for curriculum and instruction*. Association for Supervision and Curriculum Development.
- Mihardi, S., Harahap, M. B., & Sani, R. A. (2013). The Effect of Project-Based Learning Model with KWL Worksheet on Student Creative Thinking Process

- in Physics Problems. *Journal of Education and Practice*, 4(25), 188–200.
- Mohamed, A. H. H. (2008). The effect of using the dimensions of thinking model in developing map reading skills and creative thinking abilities of elementary students Developing Phonological Awareness Battery for Omani Preschoolers View project The effect of phonological awareness on developing oral reading skills for grades 1-3 of basic education in Oman View project. *The International Centre For Innovation in Education*, 1131–1138. <https://www.researchgate.net/publication/259739530>
- Montuori, A. (2003). Frank Barron: A Creator On Creating. *Journal of Humanistic Psychology*, 43(2), 7–23.
- Nurlina, N. (2020). Application of Guided Inquiry Learning Model Towards Science Process Skills. *Jurnal Pendidikan Fisika*, 8(1).
- Perkins, D. N. (1984). *Schools can promote creative thinking by focusing on aesthetics, purpose, mobility, objectivity, and intrinsic motivation and encouraging students to work at the edge of their competence.*
- Pratiwi, I. A., Ardianti, S. D., & Kanzunudin, M. (2018). Peningkatan Kemampuan Kerjasama Melalui Model Project Based Learning (PjBL) Berbantuan Metode Edutainment pada Mata Pelajaran Ilmu Pengetahuan Sosial. *Jurnal Refleksi Edukatika*, 8, 177–182.
- Rachmawati, I., Feranie, S., Sinaga, P., & Saepuzaman, D. (2018). Penerapan Pembelajaran Berbasis Proyek Untuk Meningkatkan Keterampilan Berpikir Kreatif Ilmiah Dan Berpikir Kritis Ilmiah Siswa SMA Pada Materi Kesetimbangan Benda Tegar. *Jurnal Wahana Pendidikan Fisika*, 3(2), 25–30.
- Saenab, S., Yunus, S. R., & Husain. (2019). Pengaruh Penggunaan Model Project Based Learning Terhadap Keterampilan Kolaborasi Mahasiswa Pendidikan IPA. *Jurnal Biology Science & Education*, 2019, 8(1), 29–41.
- Sagala, S. (2017). Supervisi Pembelajaran dalam Profesi Pendidikan. In *Jurnal Administrasi Pendidikan* (Issue 2). Alfabeta.
- Suranti, N. M. Y., & Sahidu, H. (2016). Pengaruh Model Project Based Learning Berbantuan Media Virtual Terhadap Penguasaan Konsep Peserta didik pada Materi Alat-alat Optik. *Jurnal Pendidikan Fisika Dan Teknologi*, II(2), 73–79.
- Trianto. (2007). *Model Pembelajaran Terpadu dalam Teori dan Praktek*. Prestasi Pustaka.
- Triningsih, R., & Mawardi. (2020). Efektivitas Problem Based Learning dan Project Based Learning Ditinjau dari Keterampilan Berpikir Kritis Siswa SD. *Jurnal Riset Pendidikan Dasar*, 03(01), 51–56.
- Wartika, I. K., Candiasa, I. M., & Suarni, N. K. (2014). Pengaruh Model Pembelajaran Kooperatif Tipe STAD Berbasis Asesmen Kinerja terhadap Hasil Belajar Fisika Ditinjau dari Sikap Ilmiah (Studi Eksperimen Pada Siswa Kelas XI IPA SMA Negeri 1 Kuta). *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, 4.
- Wati, A. W. (2014). *Analisis Kemampuan Berpikir Kritis Siswa dalam Memahami Masalah Matematika pada Materi Fungsi di kelas XI IPA MA Al-Muslihun Kanigoro Blitar Semester Genap Tahun Ajaran 2012/2013.*
- Wibowo, F. C., & Suhandi, A. (2013). Penerapan Model Science Creative Learning (SCL) Fisika Berbasis Proyek Untuk Meningkatkan Hasil Belajar Kognitif Dan

- Keterampilan Berpikir Kreatif. *JPII*, 2(1), 67–75.
- Wicaksono, V. D. (2016). Critical Thinking Skills Enhancement Through Reflective Journal of Civics 5 Th Graders In SDN Ngenep 5. *The First International Conference on Child-Friendly Education*, 209–215.
- Widyastuti, E. (2017). Effect Of Authentical Assessment And High Order Thinking Skill (HOTS) Against Troubleshooting Physical Problems (An Experiment in The Students of SMA Negeri 2 Depok City). *Jurnal Evaluasi Pendidikan*, 8(2), 109–116.
- Yalcin, S. A., Turgut, Ü., & Büyükkasap, E. (2009). The Effect of Project Based Learning on Science Undergraduates' Learning of Electricity, Attitude towards Physics and Scientific Process Skills. *International Online Journal of Educational Sciences*, 1(1), 81–105. www.iojes.net
- Yance, R. D., Ramli, E., & Mufit, F. (2013). Pengaruh Penerapan Model Project Based Learning (PBL) Terhadap Hasil Belajar Fisika Siswa Kelas Xi Ipa Sma Negeri 1 Batipuh Kabupaten Tanah Datar. In *Pillar Of Physics Education* (Vol.1).
- Yani, & Ruhimat. (2018). *Teori dan Implementasi Pembelajaran Saintifik Kurikulum 2013*. PT Refika Aditama.
- Zulfa, A. R. (2020). *Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Think Talk write pada Tema Sistem Organ Manusia untuk Meningkatkan Keterampilan Komunikasi Sains di SMPN 1 Ponogoro*.