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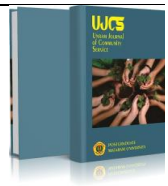

Optimizing 21st Century Skills Through Island-based Physics Multirepresentation Learning at Madrasah Aliyah Negeri 1 Maluku Tengah School

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Abstract: In the current era of globalization, prioritizing four basic skills such as critical thinking, collaboration, communication, and creativity, is needed to prepare students to live in the future. This community service activity aims to optimize these skills through the application of ocean-island-based physics multirepresentation learning, which is relevant to the living environment of students in Central Maluku. The multirepresentation approach helps students understand abstract physics concepts through various forms of representation, such as visual, mathematical, and verbal, which encourages deeper understanding. The context of the sea-island environment, such as currents, waves, and hydrostatic pressure, is used as physics teaching material to increase the relevance and motivation of student learning, as students can see how physics concepts are integrated in their daily lives. The service method used includes observation, teacher training, and implementation of contextual learning based on sea-islands. The results showed that teachers who participated in the training were able to design and implement contextualized multirepresentation physics learning, which is relevant to the local sea-island environment. Students also responded positively and showed improvement in 4C skills through the island sea-based learning process and this learning is expected to continue to evolve and be applied in various learning contexts to advance 21st century skills among students.

Keywords: 21st Century Skills; Multirepresentation Learning; Concept Understanding; Sea-Island Physics

Introduction

21st century education demands several skills beyond traditional academic knowledge to thrive in a globalized society. The 4C skills, namely critical thinking, communication, collaboration, and creativity have emerged as essential competencies for students to succeed academically, professionally, and socially (Osiesi & Blignaut, 2025). The 4Cs are key skills in the teaching and learning process in dealing with serious problems and difficulties at the social, personal, and economic levels (Vlachopoulos & Makri, 2024). Approximately 40% of students graduating from high school do not have adequate readiness for their future jobs. In addition, students are reported to have insufficient competence in some skill areas. For example, employers estimated that the majority of students' basic skills referring to math knowledge and ability (53.3% of students showed deficiencies) and written performance (72.0%) did not develop strongly enough after graduation. Furthermore, students show deficiencies in their applied skills, which include communication skills (80.9%), critical thinking and problem solving (69.6%) and professional work ethic (70.3%) (Kain et al., 2024). In addition, study results show that students' critical and creative thinking skills are still low (Leasa et al., 2020; Leasa et al., 2021). Therefore in 21st century education there is a huge cultural shift seen from traditional summative assessments, such as written assignments and standardized tests, to more innovative holistic

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approaches signaling an important transition in higher education assessment practices, which underscores the importance of integrating learning-focused assessments that balance traditional methods with innovative strategies (Vlachopoulos & Makri, 2024). Meanwhile, the ability of teachers in the 21st century is demanded by professional teaching qualifications (Yurt, 2023). This is because teacher education can be a strong catalyst for long-term reform and support in 21st century education (Häkkinen et al., 2017).

The geographical condition of Central Maluku, which consists of sea and small islands, has great potential as an interesting and relevant physics learning context for students (Batlolona & Jamaludin, 2022). Ocean and island context-based learning, combined with a multirepresentation approach, can be an effective means to develop these skills (Batlolona, 2024). Multirepresentation learning is the use of multiple forms of representation in learning materials simultaneously to enhance meaningful learning that includes external visible representations, such as text, graphs, or images, as well as internal representations in the form of mental models (Gilbert & Treagust, 2009; Bollen et al., 2017). The study results show that physics learning using multiple representations has the opportunity to facilitate students' concept understanding, problem-solving ability, and representation ability. The challenges faced in its use are the difficulty of teachers in organizing representations in a structured and coherent manner, as well as the difficulty of students in representing physics concepts in the form of graphs and equations (Ate, 2025). This service is focused on teaching physics with a sea-island-based multirepresentation approach in Madrasah Aliyah and SMP Maluku Tengah, which aims to maximize 21st century skills through the use of the potential of the surrounding nature.

Physics learning often faces challenges due to the abstract and complex nature of its concepts (Wattimena & Batlolona, 2024). Therefore, it is important for teachers to use various methods of representation in conveying material so that it is more easily understood by students (Munfaridah et al., 2021). Physics learning experts have proven that solving problems that require the use of multiple representations, solves them faster when compared to the available representations. In addition, novice problem solvers tend to use multiple representations extensively in their solutions and they use a selection of representations that closely resemble concepts from different points of view (Kohl & Finkelstein, 2008).

Multirepresentational learning helps to improve students' ability to understand concepts deeply because they are invited to see and connect one concept with a variety of different representations. For example, in learning about hydrostatic pressure, students can see the effect of ocean depth through a graph of pressure against depth, while visualizing the phenomenon in the form of a simple experiment (Berek et al., 2016). In this way, students not only memorize the theory, but also internalize the understanding of the concept through visual and practical experiences. In addition, the multirepresentation approach has been shown to be effective in improving critical thinking skills and problem-solving ability. Students are trained to link between various representations in understanding one concept, which ultimately helps them to think more analytically and deeply (Lichtenberger et al., 2024). This is particularly relevant in the context of physics learning, where analytical and problem-solving skills are essential.

The sea-island environment in Central Maluku provides an ideal context for implementing multirepresentation-based physics learning. The ocean and related phenomena, such as currents, waves and water depth, are real phenomena for students in Central Maluku. Through learning that is relevant to their environment, students can be more interested and motivated in learning physics, as they see how physics concepts apply in their daily lives (Kapanadze et al., 2023). This contextualized approach not only makes learning more interesting, but also helps students in developing thinking skills that are much needed in the modern era (Batlolona, 2025). Overall, ocean-island-based physics multirepresentation learning is expected to make it easier for students to understand complex physics concepts, as well as help them in developing 4C skills which are part of important 21st century skills. Therefore, the purpose of this service is to optimize these skills through the application of ocean-island-based physics multirepresentation learning, which is relevant to the living environment of students in Central Maluku.

Method

This community service was carried out with a mission to optimize 21st century skills through the application of ocean-island based physics multirepresentation learning at Madrasah Aliyah Negeri 1 Maluku Tengah School and Secondary School. This activity is systematically designed through several stages as follows:

1. Initial Observation: Identifying learning needs, infrastructure conditions, and teachers' level of understanding of 21st century skills and multirepresentation learning.
2. Teacher Training: Provide training to physics teachers at Madrasah Aliyah Negeri 1 Maluku Tengah School on the concept and application of ocean-island-based multirepresentation. Training materials include how to develop and use teaching

materials that are appropriate to the environmental context.

3. Implementation of Multirepresentation Learning: Teachers apply physics materials on relevant topics, such as hydrostatic pressure, ocean currents and wave phenomena, through a multirepresentation approach. Teachers are encouraged to use various representations (graphs, diagrams, simple experiments) in explaining the concepts.
4. Evaluation and Reflection: Data collection through questionnaires, interviews, and direct observation during the learning process to assess the effectiveness of this approach. Reflection is conducted with the teacher for further improvement and development.

Interviews and observations are conducted to check how far the perceptions and attitudes and basic competencies possessed by teachers and students towards 21st century skills and explore the variety of problems experienced by teachers in conducting learning oriented towards strengthening 21st century learning. The information obtained is qualitative information. Then to measure the results of the implementation of this community service for students, we conducted a t test to detect an increase in the four 21st century competencies, quantitative data obtained from test results and process observations through creativity and critical thinking test instruments and esay forms we can use a Likert scale to measure how well participants understand the material or skills tested. This scale generally has five levels, namely: Excellent, Good, Fair, Poor, and Very Poor. The Likert scale (pronounced "Lick-urt") was developed by American social scientist Rensis Likert (1903-1981) in 1932 as part of his doctoral thesis, A Technique for the Measurement of Attitudes. In later work, Likert and his colleagues refined the process by simplifying the Thurstone scaling technique, a contemporary method for measuring latent variables such as attitudes on a continuous scale (Koo & Yang, 2025). A collaborative and communicative measurement instrument in the form of a scoring rubric developed by Arter & Mc Tighe (2001).

Result and Discussion

Physics learning in Central Maluku schools faces several challenges in achieving learning objectives that are effective and relevant to students' daily lives. Some of the problems identified in this service process include:

Lack of local context in teaching materials

Physics learning is often taught in the form of abstract theories, without direct connection to students' experiences or environment. Given that the majority of students in Central Maluku live in a sea-island environment, the absence of local context in learning makes physics material difficult for students to understand deeply. This irrelevant physics learning reduces students' motivation and engagement, and weakens their ability to relate scientific concepts to real life. By utilizing natural phenomena around them, such as ocean currents, waves, and hydrostatic pressure, students are expected to be more enthusiastic and able to see a direct connection between physics lessons and their daily environment.

Lack of application of 21st century skills

The physics learning process tends to be monotonous and ineffective in developing 21st century skills. Skills such as critical thinking, collaboration, communication, and creativity are essential in preparing students to face future challenges. However, the learning approach currently used in some Central Maluku schools is still not supportive of the development of these skills. Learning that is structured, but not challenging, makes students more passive and only plays a role as recipients of information. Through the application of an ocean-island-based multirepresentation approach, students are expected to be more active, engage in discussions and collaborate to solve real problems in their environment.

Teacher limitations in implemention

Many teachers still have difficulties in combining several types of representations in one physics learning process that is interesting and easy to understand. Multirepresentation, which includes verbal, visual and mathematical representations, requires specific skills in its implementation. Some teachers are not accustomed to integrating these different forms of representation effectively, which ultimately affects students' understanding. The application of multirepresentation based on the ocean-island context is expected to provide teachers with a better understanding in developing relevant and interesting learning materials and activities.

Improving teachers' competencies in implementing ocean-island-based multirepresentational learning in Central Maluku Madrasah Aliyah (MA)

The implementation of multirepresentation learning in Madrasah Aliyah (MA) Central Maluku has brought significant improvements in teachers' competencies in designing and implementing learning based on ocean-island phenomena. Through intensive training, teachers are able to integrate various forms of representation in learning, such as visualization of natural phenomena, graphs, tables, and mathematical models, which makes

physics material easier for students to understand. Sea-island-based physics learning gives teachers the opportunity to use local contexts close to students' daily lives, for example by using ocean currents as an example to explain force and motion. This allows students to see the connection between physics concepts and their real lives, thus facilitating their understanding of the material being taught. Therefore, the service at Madrasah Aliyah Maluku Tengah by applying this approach not only develops concept understanding but also enriches teachers' competence in designing relevant and interesting learning scenarios. By using natural phenomena around them, students in MA are not only taught theory, but also how to apply knowledge in real-world situations, increasing their understanding in depth.

Students' response to ocean-island based physics multirepresentation learning in Madrasah Aliyah (MA) Central Maluku

The response of students in Central Maluku MA to the ocean-island-based physics learning is very positive. Learning that links physics concepts with natural phenomena around them, such as hydrostatic pressure that can be observed through the phenomenon of sea depth, makes students feel more connected to the material being taught. This contextualized learning allows students to understand physics in a more applicable and relevant way, increasing their motivation to learn. For example, when studying the motion of ocean waves and currents, students can directly see and analyze the phenomenon, which provides a richer and more meaningful learning experience.

The sea-island based learning at MA Maluku Tengah helps students to visualize and relate physics theories to real experiences. This makes physics learning livelier and fun. Students not only learn about abstract concepts but also learn how those concepts relate directly to their daily lives.

Development of collaboration and communication skills through group activities at MA Central Maluku

Development of collaboration and communication skills through group activities at MA Maluku Tengah

Ocean-island-based multirepresentational learning at Central Maluku MA also focuses on developing collaboration and communication skills through various group activities. Students work together in groups to observe natural phenomena such as ocean currents, as well as conduct experiments involving physics concepts such as hydrostatic pressure. These activities not only help them understand physics better, but also train them to work in teams, communicating their ideas and findings clearly. The collaboration and communication skills developed in this group-based learning are essential in the real world, where the ability to work in teams and communicate ideas effectively is needed. Group-based learning also trains students to respect different views and work towards a common solution.

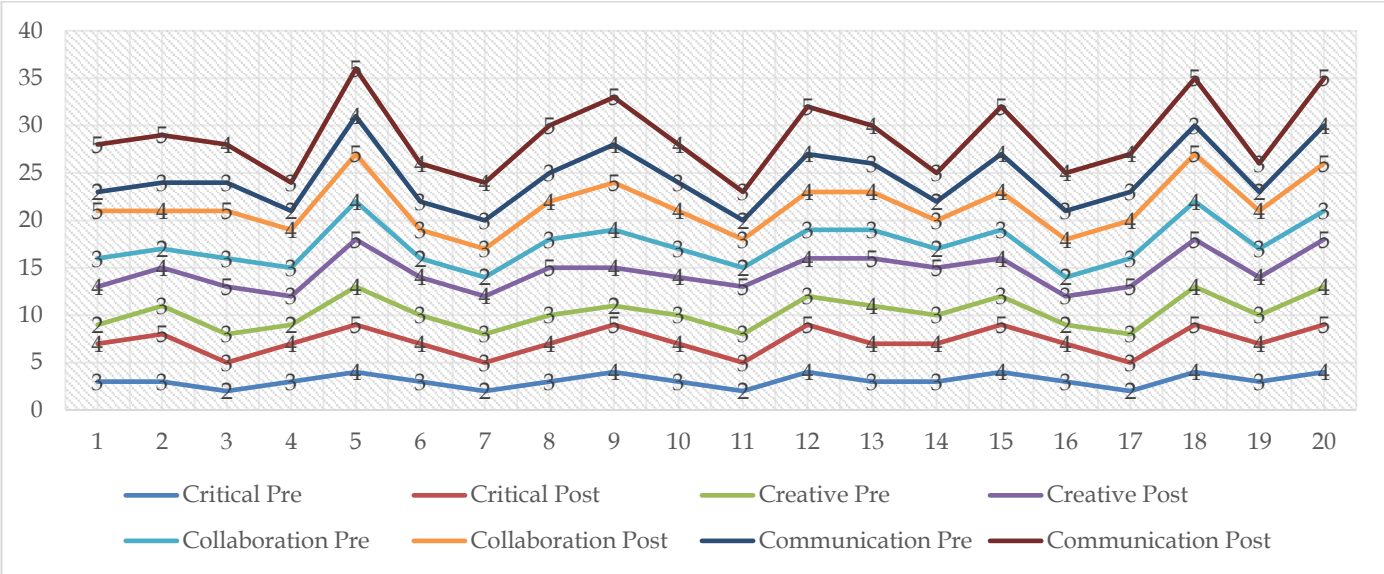

Figure 1. Pretest/posttest results of students' critical thinking, creativity, collaboration and communication skills

Creative thinking in finding solutions to environmental problems at MA Central Maluku

Ocean-island-based learning not only improves students' understanding of physics concepts but also encourages their creativity in finding solutions to environmental problems. Students at MA Maluku Tengah are encouraged to think creatively and design simple tools to solve environmental problems such as

marine pollution and coastal abrasion. For example, students design an ocean depth gauge or propose solutions to reduce plastic waste in the ocean, which gives them the opportunity to apply physics knowledge in real situations. This problem-based approach not only teaches students about physics but also teaches them how to think creatively to solve real-world problems. It encourages students to become more aware of their environment and contribute to nature conservation efforts. In addition, it stimulates students to think critically and connect knowledge on problem issues. In addition, the features of this model are presenting problems, asking questions, facilitating inquiry, and also opening dialog so that it can help improve student learning outcomes and student motivation.

Figure 2. Training process of multirepresentational learning for teachers and implementation of multirepresentational learning for students at Madrasah Aliyah Negeri 1 Maluku Tengah

Based on the data from the pretest and posttest results of critical thinking, there was an increase in the average score from 3.2 to 4.2, an increase of 1.0. Creativity from 3.1 to 4.4 increased by 1.3. Collaboration from 3.0 to 4.3 increased by 1.3 then communication from 3.0 to 4.4 increased by 1.4. Each category (critical thinking, creativity, collaboration, communication) showed significant improvement between the pretest and posttest, with the largest changes in communication and creativity. With this analysis, it can be concluded that the use of multirepresentation in physics learning can improve 21st century skills in students, which is reflected in the progressivity of pretest and posttest scores.

The increase in critical thinking scores indicates that students are better able to analyze and evaluate information in more depth after participating in ocean-island-based learning. In this context, natural phenomena such as ocean currents, waves and hydrostatic pressure are used to help students understand physics principles in a more contextualized manner. This approach encourages students to not only remember formulas or theories, but also to question and analyze the application of physics concepts in their daily lives (Mason & Just, 2015). Students involved in group discussions or hands-on experiments are more likely to develop critical thinking skills as they are exposed to real-world problems that require evidence-based solutions (Adadan et al., 2009).

The significant increase in creativity can be explained by linking physics concepts with practical solutions to local environmental problems, such as marine pollution and coastal abrasion. Ocean-island based learning provides opportunities for students to design innovative tools or solutions relevant to their local conditions. For example, students design an ocean depth gauge or propose solutions to reduce plastic waste in the ocean. This approach encourages students to think creatively in designing and implementing physics knowledge to solve real problems, which serves as an additional motivation for learning (Hahn & Klein, 2023).

The group-based learning implemented during the application of the ocean-island-based multirepresentation strongly supports the development of collaboration skills. Group activities involving direct observation and experimentation, such as the observation of ocean currents and the analysis of hydrostatic pressure, provide students with opportunities to work together to solve problems. This process requires them to share ideas, discuss solutions and work towards a common understanding. Students' ability to work in teams and respect the views of their peers is critical in developing the collaboration skills needed in the world of work and social life.

Students' communication skills experienced the most significant improvement. In ocean-island-based learning, students not only observe natural phenomena, but are also asked to communicate their findings, both in group discussions and presentations. Students who previously lacked confidence in conveying their ideas are now more accustomed and able to explain physics concepts and experiments in a clear and structured way. These improved communication skills are essential in both academic and professional contexts, where the ability to convey information effectively is key to success.

Physics Teachers' Initial Perception of Multirepresentation Learning

Before being given training and further understanding, most physics teachers at MAN 1 Central Maluku had limited perceptions of multirepresentation learning. They tend to see physics learning as an activity that focuses on delivering theories, formulas, and abstract concepts that are explained verbally, without paying attention to the diversity of representations or ways to connect these concepts with the real world of students.

Based on the results of interviews and observations of the shape and profile of student and teacher attitudes towards 21st century skills and multi-representational learning can be described as follows:

Most teachers do not fully understand the importance of using various forms of representation in physics learning.

Representations include various ways to convey information, such as visual representations (pictures, graphs, diagrams), verbal representations (oral or written explanations), and mathematical representations (equations or formulas). These teachers are usually more accustomed to teaching using the lecture method or conventional approaches that focus on understanding theory without much involvement of students in exploration or activities that encourage 21st century skills.

In fact, most physics teachers consider that physics teaching material is sufficient if it is delivered in a theoretically clear way and do not fully realize that students' ability to think critically, collaborate, or communicate can be improved with a more interactive and context-based approach. Thus, their physics learning tends to be monotonous and focuses on delivering theoretical and abstract material (Wan Mohd Nasir et al., 2022).

Training Process and Provision of Multirepresentation Learning Materials

The training provided to physics teachers at MAN 1 Central Maluku on multirepresentation learning based on the ocean-island context brought significant changes in their perspective on physics learning. During the training, teachers were introduced to various concepts and learning techniques that integrate verbal, visual and mathematical representations in a mutually supportive whole. They are also given an understanding of how to utilize local natural phenomena, such as ocean currents, waves and hydrostatic pressure, to explain physics concepts that have been considered abstract.

During the training, teachers began to realize that learning physics that incorporates these various representations not only helps them explain physics concepts in a way that is easier to understand, but can also activate deeper student engagement. For example, teachers were given an example of how to explain the concepts of force and motion using the phenomenon of ocean currents which is very familiar to students in Central Maluku. This opened their minds to the fact that physics can be taught in a more contextualized and engaging way, linking theory to students' everyday experiences (Prins et al., 2018).

Teachers were also given an understanding of the importance of problem-based learning that encourages students to think critically, work together in groups, and communicate their findings clearly. At first, some teachers were hesitant or skeptical about their ability to implement this approach in the classroom. However, after seeing more concrete examples of implementation and practicing designing multirepresentation learning scenarios, they began to understand and feel more confident to implement it. Thus, their self-confidence grew. All this time, they felt shy because they were not brave enough to express their scientific ideas.

Changes in perception and application in the classroom

After attending the training, physics teachers at MAN 1 Central Maluku experienced a significant change in perception towards multirepresentation learning. They began to see the importance of 21st century skills, namely the 4Cs, in the physics learning process. They also understand that learning is not only limited to delivering theoretical material, but also must involve students in various activities that allow them to explore physics concepts in a more applicable and contextual way.

In its application in the classroom, the teacher began to integrate various forms of representation in each topic taught. For example, in explaining the concept of hydrostatic pressure, teachers use visual diagrams of ocean depth, graphs of pressure against depth, as well as simple experiments involving students to measure water pressure at various depths. In addition, they also invite students to discuss in groups how the natural phenomena they observe, such as ocean currents and waves, relate to the physics principles they are learning. Teachers also began to feel more confident in using the problem-based approach. In some lessons, students are invited to design solutions to environmental problems around them, such as marine pollution or the effect of coastal abrasion on ecosystems. This project-based learning not only enriches students' understanding of physics, but also encourages students to think creatively and work together to find solutions. Misconceptions of physics concepts are still prevalent among high school students today, especially static fluid. Sometimes forgetting this problem and more pursuing the meteri rather than deepening the concept for students. Therefore, complete learning is needed so that students'

physics concepts can be stable and embedded in everyone (Jamaludin & Batlolona, 2021).

Impact of perception change on learning quality

This change in teacher perception has a significant positive impact on the quality of physics learning at MAN 1 Central Maluku. With a deeper understanding of multirepresentation learning, teachers become more creative in designing and implementing activities that involve various physics representations. Learning becomes more varied and interesting, which encourages active student engagement.

Students also begin to feel more connected to the material being taught because learning is adapted to the context of their daily lives, especially those related to the ocean-island phenomenon. Physics learning, which initially seemed difficult and abstract, is now easier to understand and more meaningful to them. This is reflected in increased student motivation and participation, as well as their ability to relate physics concepts to real situations around them.

In addition, physics teachers are also beginning to see that by integrating multirepresentations, they are not only teaching physics concepts, but also helping students develop critical 21st century skills, such as critical thinking, collaboration, communication and creativity. These four skills are very useful in preparing students to face future challenges, both in the academic world and the world of work.

Conclusion

This service shows that ocean-island-based physics multirepresentation learning in Central Maluku can optimize 21st century skills in students, especially in terms of critical thinking, communication, collaboration, and creativity. The trained teachers were able to create more interesting and relevant teaching materials, while students showed higher learning motivation and deeper thinking skills. This activity recommends continued training and support for the development of technology-based learning media to support wider implementation.

Changes in the perceptions of physics teachers at MAN 1 Central Maluku towards multirepresentation learning show that with the provision of appropriate materials, understanding of the importance of using various representations in physics learning can develop significantly. Previously, teachers tended to see physics learning conventionally, focusing on theories and formulas only. However, after being given training, these teachers now understand that effective physics learning must involve various representations and contexts that are relevant to students' daily lives.

The application of ocean-island-based multirepresentation learning not only helps teachers in teaching physics in a more engaging and contextualized way, but also enables them to develop students' 21st century skills that are much needed in an increasingly complex and fast-changing world. Based on the analysis of pretest and posttest data, the application of ocean-island-based multirepresentation learning at Madrasah Aliyah Maluku Tengah proved to be effective in improving students' 21st century skills, such as critical thinking, creativity, collaboration, and communication. The contextual approach that connects physics theories with relevant natural phenomena around students, such as ocean currents and hydrostatic pressure, makes learning more interesting and meaningful. The significant improvement in these skills suggests that the application of more dynamic learning methods, based on visual, verbal and mathematical representations, can help students develop better competencies and be better prepared to face future challenges.

The significant improvement in creativity and communication, in particular, suggests that ocean-island-based learning also has a positive impact in preparing students to contribute to solving real-world problems, such as those related to environmental conservation. Therefore, this approach can be used as a model for more relevant and contextualized physics learning in other areas, especially in coastal areas.

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