

Collaboration Skills of Phase F High School Students through the Use of Physics Electronic Modules Based on Project Based Learning Integrated with Local Wisdom Maelo Pukek

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Abstract: This research was motivated by the low collaboration skills of high school students in phase F. This was due to a lack of teaching materials that were suitable for the characteristics of physics learning, which emphasizes direct experience for students, and that were suitable for the characteristics of the students being taught. Modules are very suitable for use in the learning process because they can be adapted to student characteristics and needs. Electronic modules based on project-based learning (PjBL) are able to provide direct experiences to students. The integration of electronic PjBL modules with local maelo pukek wisdom, which is closely related to students' lives, is very appropriate for collaboration. Students create miniatures of maelo pukek with their peers by incorporating physics concepts into them, which can develop students' collaboration skills. The physics concept that supports the process of making this net is the concept of fluid dynamics. This study was conducted to determine the level of students' collaborative skills through the use of electronic modules. The research approach used was quantitative with a pre-experimental method. The results showed that students' collaborative skills were quite good, with an average score of 75.00 in the use of project-based electronic modules integrated with local wisdom related to maelo pukek. The ability to provide feedback and discuss with peers is the best indicator of collaborative skills.

Keywords: Collaboration; Dynamic fluid; PjBL; Maelo pukek

Introduction

Students must possess a variety of fundamental abilities in the twenty-first century that are pertinent to global dynamics and upcoming issues. Collaboration is one of these essential abilities. Collaboration, or the capacity to work well and efficiently in groups to accomplish a shared objective, is becoming more and more significant in a variety of spheres of life, including social, professional, and educational settings. By working together, students can improve their communication skills, share ideas, value diversity, work through issues as a team, and get a deeper

comprehension of a subject (Johnson, 1965; Tsaqofah et al., 2024).

Century Skills of 21st defines the signs of collaboration: (1) work together with others; (2) demonstrate the ability to work well and respect one another among different team members; (3) be adaptable and assist one another in a cooperative effort to accomplish shared objectives; (4) exhibit a collaborative attitude of shared responsibility and fully contribute from each team member (Partnership for 21st century, 2019). The ability to collaborate allows students to share ideas and work together to achieve common goals, which is the essence of active and applied learning

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(Gusta & Christina, 2020; Hunaidah et al., 2018; Jannah et al., 2025; Malik & Ubaidillah, 2021; Simin-Ghavifekr, 2020). This active and collaborative learning is necessary in physics education.

Nonetheless, field observations indicate that more work has to be done to help high school students, particularly those in Phase F, strengthen their teamwork skills. Students' ability to collaborate is frequently hampered by individualistic learning styles and a lack of opportunities for organized group activities. The concept of learner-centered learning is really emphasized in the present curriculum, particularly the Merdeka Curriculum, which also makes room for the development of 21st century skills like teamwork (Handayani et al., 2023; Nugroho et al., 2024; Wakhidiyah et al., 2025).

The use of creative and captivating learning models is essential while teaching physics in Phase F high schools, as the subject is frequently regarded as abstract and mental. One strategy that is thought to be successful in raising student engagement and fostering the development of many skills, including teamwork, is project-based learning (PjBL). Through PjBL, students collaborate in groups to plan, carry out, and assess projects that are pertinent to the physics lessons they have learned (Thomas, 2000). Project-based learning activates students' minds to carry out a series of activities together in order to achieve learning objectives (Usman et al., 2024).

Additionally, incorporating local knowledge into instruction can give students a comfortable and relevant context, which will boost their enthusiasm and comprehension of the material. Project-based learning models are even more effective when linked to the local or traditional culture of a region (Tinenti et al., 2025). West Sumatra offers a wealth of local knowledge that can be used into physics education, particularly in regions with a strong marine heritage (Yuliyus & Susilawati, 2021). The "Maelo Pukek" tradition is one instance of this type of local knowledge. In the traditional fishing activity known as "Maelo Pukek," a large group of people cooperate to drag a net, or Pukek, out of the ocean. Collaboration, coordination, labour division, and a basic understanding of the physics of dynamic fluids are all necessary for this procedure.

The integration of physical principles in net design, including the choice of durable yet lightweight materials and the configuration of net shape and size, can enhance fishing effectiveness. A grasp of hydrodynamics is also crucial for creating nets that navigate the water efficiently. Maelo Pukek encompasses intricate interactions among the net, fish, and seawater (Martawijaya et al., 2022). In this scenario, seawater functions as a dynamic fluid. As the net traverses the water, it generates a fluid flow that influences fish

movement. The fluid drag force, which is affected by the water's viscosity and the net's speed, is vital to the fishing operation. Understanding fluid flow patterns and drag forces enables fishermen to develop effective net towing techniques (Azkia et al., 2023).

The significance of local values is gradually diminishing, leading to a decline in students' comprehension of their cultural heritage (Putra et al., 2021; Mungmachon, 2012; Pornpimon et al., 2014; Febriani et al., 2020; Uge et al., 2019). Currently, schools are primarily viewed as educational institutions responsible for the environment, but they have not yet embraced the role of counseling students. Instruction within schools often relies heavily on existing textbooks, with educators serving as the predominant source of knowledge. This dynamic results in a learning environment where educators lead the process, while students primarily engage in passive listening and memorization. Consequently, this approach hampers the development of essential 21st-century skills, particularly in the area of collaboration among students.

The implementation of Electronic Modules (E-Modules) offers a novel approach to delivering Project-Based Learning (PjBL) in Physics, incorporating the local wisdom of 'Maelo Pukek' in a way that is more engaging, interactive, and accessible. E-Modules enable the presentation of content in multiple formats, including text, images, videos, and simulations. They also support a structured progression of project activities and create opportunities for interaction and collaboration among group members.

The novelty of this study is the integration of local wisdom in the form of maelo pukek into a project-based electronic learning module that focuses on students' collaboration skills. Maelo pukek was chosen as local wisdom suitable for the Pariaman area, where most residents work as fishermen (Sari et al., 2020). Fishermen use pukek to catch fish in the sea.

This research aims to determine the level of students' collaboration skills through the implementation of electronic modules that utilize project-based learning, integrated with local wisdom. The objective of this study is to assess the level of students' collaboration skills following their engagement with the electronic module.

Method

This study was analyzed using a quantitative approach with a pre-experimental method. Quantitative research is a research paradigm that emphasizes objectivity, numerical measurement, and statistical analysis to test predetermined theories or hypotheses (Creswell, 2014). The research design used was a one-group post-test only design. This study used one

experimental group by applying an electronic physics module based on project-based learning integrated with local wisdom maelo pukek (Murlin et al., 2022). The stages of the research implementation were as follows:

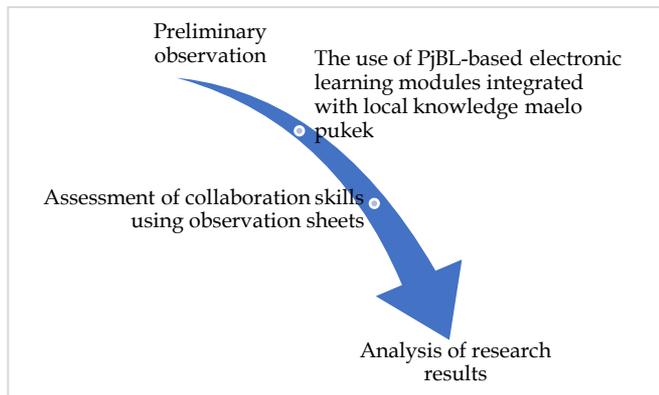


Figure 1. Research process

Assessment of collaboration skills can use observation sheets designed according to collaboration skill indicators (Yanti et al., 2023). This research employs an observation sheet that includes 13 indicators of collaborative skills are: 1) Ensure equitable distribution of tasks among group members; 2) Assist the group in addressing challenges; 3) Provide constructive feedback to fellow team members; 4) Assess the team's advancement in fulfilling the assignment; 5) Contribute to problem-solving independently, without seeking assistance from the educator; 6) Acknowledge and respect the viewpoints of group members; 7) Perform duties in alignment with assigned roles; 8) Maintain courteous interactions with teammates; 9) Engage in discussions to facilitate decision-making within the group; 10) Utilize time effectively; 11) Collaborate through discussions to achieve task completion; 12) Extend assistance to others when necessary; and 13) Complete assignments proactively, without needing reminders (Kelley et al., 2019). Thirteen indicators will be monitored throughout the learning process and evaluated by three observers. The results of the observer's assessment are entered into the category table below (Tapanuli et al., 2018).

Table 1. The Category of Results of the Observer's Assessment

Category	Interval
Good	76 - 100
Good Enough	56 - 75
Less Good	40 - 55
Not Good	< 40

The study sample consists of 25 students from SMA phase F who are the focus of the research, and their collaborative skills will be examined.

Result and Discussion

In the e-module, participants are directed through several key activities: 1) Identifying the core question; 2) Formulating a project design plan; 3) Establishing a timeline for activities; 4) Tracking learner performance progress; 5) Assessing the outcomes of learner performance; 6) Reviewing the overall experience. These phases constitute the project-based learning model. The initial interface of the electronic module is illustrated in the figure below.

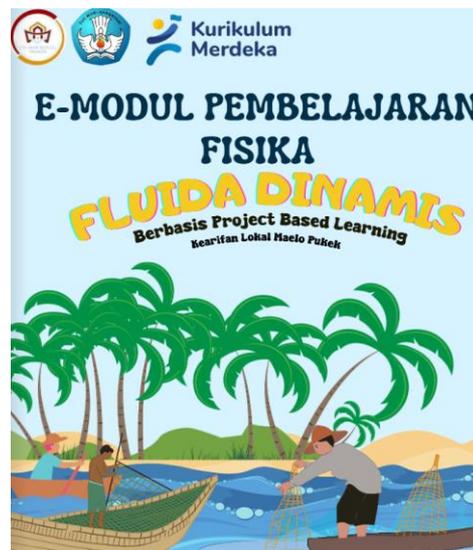


Figure 2. The electronic module

In the initial phases, prior to delving into the content, instructors typically present fundamental questions aligned with the subject matter to be studied. These questions may be structured as a case study, as illustrated in Figure 2.

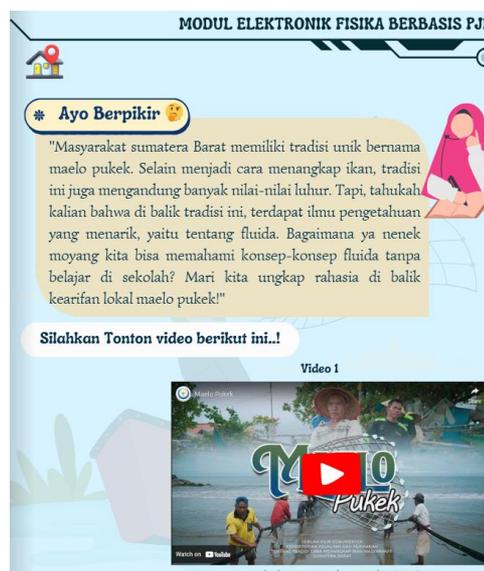


Figure 3. Identifying the core question

In the figure 3, students are guided towards understanding how their ancestors utilized Pukek for fishing, despite lacking knowledge of the underlying physics principles. Subsequently, the teacher and students engage in a collaborative project, fostering cooperation between educators and learners. Once the project design is established, they proceed to create a schedule for the activities. Throughout the project execution, it is essential for educators to actively oversee the students' progress to maintain a supportive learning environment. The educator will evaluate the students' performance in completing the project, with the aim of providing constructive feedback on their comprehension. Feedback is essential for students to improve their understanding (Ovando, 1994). The evaluation serves as a reflection of the activities conducted. At this point, the educator can engage in a brief discussion with the students about any challenges faced during the project. Further details regarding the students' activities are illustrated in the following figure.

MARI MERANCANG

Setelah mempelajari maelo pukek, kita akan melakukan praktikum sederhana untuk memahami konsep fluida dinamis dalam kehidupan nyata. Miniatur maelo pukek ini tidak hanya akan memperlihatkan proses penangkapan ikan secara tradisional, tetapi juga memungkinkan kita untuk menganalisis berbagai prinsip fisika yang terlibat.

Dukungan dasar (basic support)

Pada tahapan ini kamu diarahkan untuk melakukan ide yang cukup untuk terkait materi yang sudah anda pelajari dan mampu mengambil pendekatan sesuai kebutuhannya.

Isilah tabel perencanaan di bawah ini!

Tabel 1: Perencanaan Proyek

NO	Judul	Alat dan Bahan	Mekanisme Kerja

Figure 4. Design plan

Mari menyusun Jadwal

Setelah mendesain proyek serta menentukan tugas dan tanggung jawab masing-masing anggota kelompok, kalian harus menentukan pula jadwal pengerjaannya. Hal ini bertujuan untuk menentukan kapan di mulainya suatu proyek, lama pengerjaannya, dan rencana selesainya. Jadwal ini berfungsi sebagai pedoman untuk mempersiapkan jadwal pengerjaan proyek dapat di buat di buku dengan format sebagai berikut.

Isilah tabel penyusunan jadwal proyek berikut ini!

Tabel 2: Menyusun Jadwal Proyek

NO	Agenda Kerja	Hasil	Kendala	Rencana Berikutnya	Pemanggung Jawab
1.					
2.					
3.					

Figure 5. Activity timeline

AYO BERMONITOR

Tahap ini berfokus terhadap laporan progres dan kendala pengerjaan proyek tiap kelompok yang di sampaikan secara bergantian. Waktu yang masih tersisa dapat di gunakan untuk tindak lanjut pengerjaan proyek. Pendidik hanya mengawasi dan memberikan saran terkait kendala yang akan di hadapi kelompok. Selama pembelajaran berlangsung, pendidik dapat melakukan penilaian formatif sesuai dengan aspek penilaian yang di tentukan.

Menyimpulkan (inference)

Pada tahap ini kamu akan dilatihkan kemampuan untuk lancar menyampaikan pikiran dan ide secara jelas dan mengorganikan hal-hal menurut kategorinya.

Untuk mengetahui perkembangan lebih lanjut mengenai proyek yang sedang kalian kerjakan silahkan isi link monitoring berikut ini!

Siapkan link item ini untuk monitoring perkembangan di samping

Figure 6. Tracking learner's performance

EVALUASI

AYO EVALUASI

Pendidik dan peserta didik secara bersama-sama melakukan evaluasi terhadap kegiatan yang telah selesai di lakukan kemudian menyimpulkan hasil dari kegiatan yang di lakukan

Figure 7. Evaluate and review

In the Maelo Pukek process, the initial step involves deploying the Pukek (net) to the coastal region using a motorized boat, where it is cast to create a sufficiently large circle. According to physical principles, when the Pukek is thrown or spread across the coastal waters, it induces alterations in the water's velocity and pressure surrounding the net. The curved shape of the Pukek leads to an increase in water velocity and a corresponding decrease in pressure. This phenomenon facilitates the effective spreading of the Pukek in the water, illustrating the Bernoulli principle in dynamic fluids. Additionally, when the whip is introduced into the water, it generates a disturbance in the flow. Factors such as water velocity, pressure, and viscosity are crucial in determining how the net moves and disperses within the water (Rizal et al., 2022; Martawijaya et al., 2022).

In Maelo Pukek, the principle of continuity is relevant to the water flow influenced by the movement

of fishing gear. As the equipment operates, it alters the velocity of the surrounding water flow. To maintain a consistent discharge volume, the water flow velocity must adjust in response to variations in the cross-sectional area of the flow. For instance, in a pipe, when fluid flows steadily, the mass of fluid entering one end must equal the mass exiting the other end within the same time frame, in accordance with the law of conservation of mass. This principle inherently leads to the law of conservation of discharge.

According to Bernoulli's principle, there exists a correlation between fluid pressure, the height of the fluid relative to a reference plane, and the velocity of the fluid jet. Specifically, an increase in fluid velocity results in a decrease in pressure, while a decrease in velocity leads to an increase in pressure. This concept is widely recognized as Bernoulli's principle. The Bernoulli equation serves as a reformulation of the conservation of energy principle as it pertains to the flow of ideal fluids. When a net narrows at its center, it accelerates the water flow in that region. In accordance with Bernoulli's principle, this increase in flow velocity results in a reduction of pressure (Martawijaya et al., 2022). The pressure differential between the wider and narrower sections generates a thrust force on the fish, prompting them to swim towards the area of lower pressure, which is located inside the net.

The results of the collaboration between teachers and their students are illustrated in the table below, which highlights the collaboration skills of Phase F high school students.

Table 2. Average Value of Collaboration Skill Indicators

Indicator of Collaboration Skills	Average Value	Category
I1	75	Good Enough
I2	75	Good Enough
I3	92	Good
I4	75	Good Enough
I5	58	Good Enough
I6	75	Good Enough
I7	75	Good Enough
I8	75	Good Enough
I9	83	Good
I10	58	Good Enough
I11	92	Good
I12	58	Good Enough
I13	83	Good

Indicators I3 and I11 achieved the highest ratings compared to the other indicators. Indicator 3 focuses on providing constructive feedback to peers, where the ability to offer such feedback was clearly demonstrated. During a discussion, one student inquired about the underlying concept of creating the Maelo Pukek, prompting responses from other students. The teacher

also contributed feedback, particularly when students asked how the physics principles relate to the construction of the Pukek used for fishing (Azkia et al., 2023). Common questions included the reasoning behind the net's design, specifically why it must taper in the middle, which the teacher addressed using the Bernoulli principle (Martawijaya et al., 2022).

In addition, Indicator 11 pertains to collaborating through discussions to complete tasks. This indicator highlighted students' strong ability to engage in discussions while working on their assignments (Azmi & Festiyed, 2023). The collaborative process encompassed project planning, scheduling, project execution, and the finalization of reports, all carried out collectively (Sarjani et al., 2023).

Conversely, three indicators received the lowest scores: indicators 5, 10, and 12. Indicator 5 relates to independently contributing to problem-solving without seeking help from the educator, indicator 10 focuses on effective time management, and indicator 12 involves providing assistance to others when needed. Throughout the physics learning process utilizing this PjBL module, students exhibited a significant reliance on the teacher. This dependency arose from the necessity to complete projects within a limited timeframe while still pursuing their curiosity. Consequently, time management was not particularly effective, and students did not offer substantial support to other groups in need.

The local wisdom of maelo pukek also provides a unique appeal for students. The resulting projects are closely related to their lives. Project-based learning integrated with local wisdom encourages students to work together better (Musniar et al., 2025). They can exchange ideas clearly related to maelo pukek. The presence of local wisdom in a learning module can foster meaningful understanding in learning physics concepts (Hariana et al., 2023). The presence of local wisdom can also improve higher-order thinking skills, including collaboration skills (Ali & Zaini, 2023; Mulatsih et al., 2023; Musniar et al., 2025).

Despite the strengths and weaknesses of this PjBL module integrated with Maelo Pukek wisdom, its implementation has proven beneficial in enhancing students' collaborative skills. This is evidenced by the overall average score of 75 across the 13 indicators, which falls within the satisfactory range. Engaging in learning activities that emphasize collaboration can foster the development of positive character traits in learners, enhance their sense of responsibility, improve their capacity to integrate information from diverse sources, and promote unity among group members (Nurhayati et al., 2021; Rofiudin et al., 2024). Recognizing the significance of collaboration skills for students, it is essential to incorporate these skills into

both everyday tasks and educational activities within the school environment (Nadia et al., 2024; Nazifah & Asrizal, 2022; Afdilla et al., 2024; Nurwina et al., 2025; Purwanti et al., 2023).

Conclusion

The Maelo Pukek local wisdom integrated project-based learning electronic module can bring students closer to the culture around them. Students' collaboration skills are quite good, with two indicators of good collaboration skills resulting from the use of the Maelo Pukek local wisdom integrated project-based learning electronic module. Students are trained to provide feedback on their peers' ideas and are also trained to discuss solutions to group problems. This electronic module can be applied to assess other 21st-century skills. The design of this electronic module can also be adapted for physics education in other physics concepts by integrating additional local wisdom elements.

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Author Contributions

D.J.: Conceptualized the research, research procedures, analyzed the data, and wrote the article. F.I.: Created the electronic module and collected the data. All authors have read and approved the version of this manuscript to be published.

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Conflicts of Interest

The authors declare no conflict of interest.

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