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Worksheet Based on Project-Based Learning in Science Learning in Elementary School

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ABSTRAK

Permasalahan yang mendasari penelitian ini adalah belum optimalnya penerapan bahan ajar yang dapat meningkatkan kreativitas dan inovasi siswa, sesuai dengan keterampilan abad ke-21. Penelitian ini bertujuan untuk menguji kepraktisan desain worksheet berbasis Project-Based Learning (PjBL) dalam pembelajaran IPA di sekolah dasar. Jenis penelitian yang digunakan adalah penelitian pengembangan dengan menggunakan model 4-D (Define, Design, Develop, Disseminate). Subjek penelitian ini melibatkan ahli desain, ahli materi, ahli teknologi, serta guru dan siswa untuk menguji aspek validitas, kepraktisan, dan kemenarikan. Data dikumpulkan melalui metode nontes berupa angket yang dianalisis secara kuantitatif untuk mengevaluasi kualitas produk. Hasil penelitian menunjukkan bahwa rata-rata nilai validasi worksheet berbasis PjBL mencapai 98%, menunjukkan bahwa produk ini sangat valid. Selain itu, hasil uji kepraktisan oleh guru dan siswa menempatkan worksheet ini dalam kategori sangat praktis. Berdasarkan hasil tersebut, worksheet berbasis PjBL dinyatakan layak dan efektif digunakan sebagai bahan ajar dalam pembelajaran di sekolah dasar. Implikasi penelitian ini menunjukkan bahwa pengembangan bahan ajar berbasis PjBL dapat menjadi solusi inovatif untuk meningkatkan kualitas pembelajaran di SD.

ABSTRACT

The underlying problem of this research is the lack of optimal application of teaching materials that can increase students' creativity and innovation, in accordance with 21st century skills. This study aims to test the practicality of Project-Based Learning (PjBL)-based worksheet design in science learning in elementary schools. The type of research used is development research using the 4-D model (Define, Design, Develop, Disseminate). The subject of this research involves design experts, material experts, technology experts, as well as teachers and students to test aspects of validity, practicality, and attractiveness. Data was collected through a non-test method in the form of a questionnaire that was quantitatively analyzed to evaluate product quality. The results of the study show that the average validation score of PjBL-based worksheets reaches 98%, indicating that this product is very valid. In addition, the results of the practicality test by teachers and students placed this worksheet in the very practical category. Based on these results, PjBL-based worksheets are declared feasible and effective to be used as teaching materials in elementary school learning. The implications of this study show that the development of PjBL-based teaching materials can be an innovative solution to improve the quality of learning in elementary schools.

1. INTRODUCTION

According to the World Economic Forum in 2015, the 21st century is often called the century of technological science, which requires a lot of skills and expertise. Related to learning, the demands of the 21st century include a reorientation change in learning, namely (a) shifting the learning paradigm from teacher-centered to student-centered learning, self-learning, and self-understanding (metacognition) because this learning is considered to be more empowering for students in all aspects; (b) shifting from learning to memorize concepts to learning to discover and build their concepts, which is proven to be able

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to improve students' ability to think at a higher level, critically, creatively and skillfully solve problems; (c) shifting from classical individual learning to cooperative group learning which not only teaches thinking skills but is also able to teach students other skills such as social skills (Ferrari et al., 2020; Ronsivalle et al., 2019). This shift has given students the opportunity to take responsibility for their learning. Student-centered learning or active learning is an approach in which the content, resources, strategies, and pace of learning are determined and controlled by the students. The teacher acts as a facilitator and guides the students to acquire the necessary skills that can help them learn independently and from each other (Lee & Hannafin, 2016; Yousaf et al., 2023). Active learning enhances students' higher-order cognitive skills and motivates them to become independent and self-regulated learners (Södervik et al., 2015; Vančugovienė et al., 2024).

The skills that students must learn in school to prepare for work and life in society are referred to here as 21st-century skills and require the integration of essential training across the curriculum (Alghamdi & Al-Ghamdi, 2021; Alismail, 2023). Such cognitive competencies are of particular importance in the field of education, as they lay the foundation for future academic and personal progress. Primary school students would benefit significantly from developing analytical solid thinking skills, which makes these abilities essential for success in various industries and areas of life. A study by previous research revealed that Thai students' analytical thinking skills are below the international average, which highlights the need for effective interventions to address this issue (Phurikultong & Kantathanawat, 2022; Rodrangsee et al., 2022). These findings underscore the importance of researching to explore innovative strategies to improve analytical thinking skills in Thai elementary school students (Kwangmuang et al., 2024; Richert & Schlesinger, 2017). In Indonesia, literacy has become one of the educational needs in the 21st century. Teachers need to encourage mastery of science literacy so that it can be embedded in students. With the facts of science, students are expected to have learning skills and decision-making skills. Implementation of literacy education can be done through the management of literacy culture in schools (Herlanti et al., 2019; Indriayu, 2018).

A frequently applied solution to this challenge is problem-based learning. This teaching method uses complex real-world problems to structure learners' self-guidance and collaborative identification and acquisition of relevant and operational knowledge. A well-designed problem will guide learners to use relevant knowledge and skills to deduce basic principles and procedures on their own (Karamustafaoğlu & Pektaş, 2023; Sullivan et al., 2021). The implementation of science learning in elementary schools is still dominated by learning material delivery, examples, and structured tasks. Learning using textbooks from the Ministry of Education is quite dense and sometimes takes more time to complete the learning material. Educators use student worksheets, which are effective because the material is short, and the worksheets are many so that students can practice working on problems more (Afrijal et al., 2023; Qalfin et al., 2024). The positive impact of using worksheets for students can increase their ability to think creatively and critically, improve problem-solving skills, improve their understanding of concepts, and master 21st-century life skills that can be integrated into worksheets, so it is hoped that through the learning process that involves this higher-level thinking process can produce quality students (Biantoro & Pertiwi, 2024; Kurniawati et al., 2024).

Worksheets have been applied in various learning activities in recent years, especially as a learning tool to guide students in field observation and exploration (Celik et al., 2022; Özmen & Atıcı, 2014). Worksheets are an alternative solution for students to continue learning science that accommodates simple independent experiments. In addition, students working on worksheets can stimulate intellectual and scientific process skills systematically and comprehensively so as to obtain the expected learning outcomes and be more memorable so that it becomes long-term knowledge for students (Dewi et al., 2022; Herlina, 2021). Prior knowledge is needed to assist learning when students answer questions on worksheets. Students cannot gain a deep understanding through observation and exploration unrelated to the academic background of prior knowledge (Lee & Hannafin, 2016; Yousaf et al., 2023). Therefore, the use of worksheets as a learning tool is subject to the limitations of the paper presentation format, and learners cannot obtain immediate feedback and be reminded of prior knowledge when answering questions on the worksheets (Chang et al., 2016; Zhang et al., 2020). Related literature mentions that worksheets are essential to improve efficiency in the learning environment and also simplify concepts for students to construct in their minds (Ayyıldız et al., 2023; Suryawati et al., 2020). While students carry out their activities, they use reflective worksheets to develop their scientific process skills (Letina, 2020; Mutlu, 2020). Worksheets are considered to make students active in a learning environment that shows them how to obtain findings in a controlled way by making observations, forming hypotheses, and conducting experiments around a particular topic. The results of a Turkey study showed that learning with cartoon-based worksheets can improve concepts and replace their alternative concepts with more scientific ones (Çilingir Altiner, 2024; Taşlıdere, 2021). In addition, in Ghana and Ethiopia, the use of concept cartoons to

diagnose and correct students' misconceptions about certain science concepts has been shown (Kumi-Manu, 2021; Mekonnen et al., 2024). In practice, the more students write on a piece of paper, the more students write and the more likely they are to keep it and refer back to it (Chan, 2017; Finbråten et al., 2022).

PjBL has a moderate to significant positive impact on student academic achievement compared to traditional education. It is also important to remember that project-based learning can only partially replace traditional education. Students work to solve and evaluate a problem and present the results to an audience that allows them to acquire the knowledge and skills needed for life (Alemneh & Gebrie, 2024; Kong et al., 2024). It is characterized by student autonomy, cooperation, communication, and reflection in real-life practice. The research findings revealed the adaptability of PBL to cognitive rhythms. It aims to strengthen information intake and motivation, as well as increase cognitive engagement and dynamic application of thinking. The flexibility of PBL helps in customizing education and encourages innovation (Basri et al., 2024; Yu, 2024). More specifically, it allows students to learn by finding solutions, asking questions, debating ideas, designing plans, and communicating with others (Stephenson & Isaacs, 2019; Wu, 2024). PjBL encourages cooperation between students and the teacher and acts only as a guide during the project (Hasni et al., 2016; Santos et al., 2023). It is an efficient method for the development of twenty-first-century skills, as it supports critical thinking and problem-solving, interpersonal communication, information and media literacy, cooperation, leadership, problem-solving creatively, flexibility, and originality. It also helps develop students' abilities, skills, attitudes, and values that enable them to understand global challenges in an ever-changing global economy (Beagon et al., 2019; Gomez-del Rio & Rodriguez, 2022).

Self-education is part of PjBL, which makes students more responsible for all aspects of their tasks. They must plan their tasks and assess the completeness of their tasks. It also allows us to deepen and broaden knowledge, integrate knowledge into a comprehensive knowledge system, and realize the meaning and purpose of knowledge. Students will learn to work independently and creatively, plan and complete their work, take responsibility for their work and overcome obstacles, work with information, present their work, express themselves correctly and argue, cooperate, communicate, tolerate, and accept the opinions of others, evaluate their work and the work of others. Project-based learning is considered a handy tool for mobilizing students, exciting interpretation of educational content, and acquiring new knowledge, but also for developing personal features necessary for cooperation with others and solving problematic situations (Hasanah et al., 2022; Nilada et al., 2024). This makes a strong connection between students' involvement in their projects and their learning outcomes (Pedersen & Hobye, 2020; Wilson et al., 2016). Project-based learning is considered a highly effective way of education and is considered the highest level of teacher didactic skills. The cornerstone of project-based learning is the correct idea that students should not learn abstract definitions; instead, they should learn by solving complex projects (Gómez-Pablos et al., 2017; Maros et al., 2023).

According to the Buck Institute for Education in 1999, PjBL is a student-centered learning model involving students in problem-solving activities and meaningful tasks, providing opportunities for students to work autonomously (develop their understanding) and produce products. The PjBL learning model is the choice among other learning models because it is considered very suitable and can provide opportunities to develop students' understanding of creative thinking. PjBL is a learning model that has been widely developed in developed countries such as the United States. In addition, the PjBL model itself is a refinement of the PBL model. Learning with PjBL needs to be supported using learning media that can activate and involve students in designing their learning. One of the active learning media that can be used is *worksheet*s. The results of previous research show that PjBL-based student practical worksheets are declared feasible, effective, efficient, and practical and get a positive response from their users so that they can be applied in learning (Hanipah et al., 2018; Suwarno et al., 2020).

The novelty of this study is that this research focuses on the development and design of Project-Based Learning (PjBL)-based worksheets in science learning in elementary schools, which are still rarely explored in the academic literature. The study examines how PjBL-based worksheets can enhance students' 21st century skills such as creativity, innovation, and problem-solving. This study aims to explore the practicality and effectiveness of PjBL-based worksheets in improving the quality of science learning in elementary schools. By identifying the challenges and opportunities in the application of this worksheet in the classroom, the research is expected to make a significant contribution to the improvement of teaching materials that support active and project-based learning, as well as help students develop the critical and independent thinking skills needed in the modern era.

2. METHOD

The research design used in this study is the 4-D development research design (Four D models). This design includes four stages: Define, Design, Develop, and Disseminate. *First, Definition Stage.* This stage was divided into several steps, namely: (a) Initial Analysis, which was carried out to find out the basic problems in developing *worksheets*; (b) Learner Analysis was carried out by observing the characteristics of learners. Learner analysis includes characteristics of academic ability, age, and motivation toward the subject; (c) Task Analysis, which consisted of analyzing learning objectives related to LKPD and was developed through *worksheets*; (d) Concept Analysis, which aimed to determine the instructions and stages of the *worksheet* developed. e) Analysis of Learning Objectives was carried out to determine indicators of learning achievement based on material analysis. *Second, Design Stage.* After getting problems from the definition stage, the design stage was then carried out. This design stage aimed to design a *worksheet* that can be used in science learning. The design stage included: (a) Worksheet Selection, which was carried out to identify worksheets that were relevant to the characteristics of the material and according to the needs of students; (b) Format Selection, It was carried out so that the format chosen is in accordance with the learning material. Format selection in development is intended by designing the contents of the *worksheet,* which includes layout design, color, and writing; (c) Initial Design: It was a *worksheet* design that was made by the researcher and then revised by the supervisor. After getting a revised *worksheet* from the supervisor, this design was carried out at the validation stage. Third, *Development Stage.* This development stage aimed to produce a revised *worksheet*. There were two steps in this stage, namely as follows: (a) Expert Validation: expert validation served to validate the content of science material in the *worksheet* before testing, and the validation results were used to revise the initial product. After being validated and revised, improvements were made. Further improvements were tested on students in the limited field trial stage; (b) Product Trial: after expert validation was carried out, a limited field trial was carried out to determine the results of the application of *worksheets* in classroom learning, including measuring the effectiveness of science learning in elementary schools with PjBL. Fourth, *Dissemination Stage.* After the limited trial and the instrument have been revised, the next stage is the dissemination stage. The purpose of this stage is to disseminate the *worksheet* so that it is widely used. In this study, this stage has not been carried out.

The data collection techniques in this study were as follows: 1) *Worksheet* validation sheet, which is used to obtain data about the expert's assessment of the developed *worksheet*. The results of this assessment were used as a basis for product improvement before being tested. The *worksheet* validation sheet consisted of a *worksheet* practicality assessment sheet, which was arranged using a Likert scale. 2) Student response sheet: This instrument was used to determine the student's response to the *worksheet* developed. Data Analysis Technique This stage was carried out after the necessary information had been collected. The methods used were: 1) Analysis of *worksheet* practicality and learner responses; this questionnaire was used to collect information from learner responses regarding PjBL-based *worksheet* products. This quantitative questionnaire is analyzed and presented in the form of percentages using a Likert scale. This scale is made with a format as in Table 1.

Table 1. Likert Scale

Value	Figures
Very appropriate, very interesting, very precise, very clear	4
Appropriate, interesting, precise, clear	3
Not appropriate, not interesting, not precise, not clear	2
Very inappropriate, very uninteresting, very imprecise, very unclear	1

The data from the validator team's assessment of the *worksheet* product was analyzed by finding the Aiken index coefficient. Validators provided suggestions and input for improvement, which became the basis for product revision. The interpretation of the product validity index value is shown in Table 2.

Table 2. Interpretation of Product Validity Index Values

Formula	Scale Range	Classification
$X > X_i + 1{,}8 \times S_{bi}$	$V > 0{,}84$	Very Valid
$X_i + 0{,}6 \times S_{bi} < \bar{X} \leq \bar{X}_i + 1{,}8 \times S_{bi}$	$V > 0{,}68 - 0{,}84$	Valid
$X_i - 0{,}6 \times S_{bi} < \bar{X} \leq \bar{X}_i + 0{,}6 \times S_{bi}$	$V > 0{,}52 - 0{,}68$	Moderately Valid
$X_i - 1{,}8 \times S_{bi} < \bar{X} \leq \bar{X}_i - 0{,}6 \times S_{bi}$	$V > 0{,}36 - 0{,}52$	Less Valid
$\bar{X} \leq \bar{X}_i - 1{,}8 \times S_{bi}$	$V \leq 0{,}36$	Invalid

Practicality assessment through learning implementation assessment from educators and students in this study was analyzed using descriptive statistics. These statistics were used to determine the average value of the coefficient and the percentage of responses from students and educators. The results were then interpreted on a Likert scale (very practical, practical, moderately practical, less practical, and not practical). The interpretation of product practicality is shown in Table 3.

Table 3. Interpretation of Product Practicality

Formula	Scale Range	Classification
$X > X_i + 1{,}8 \times S_{bi}$	$\bar{X} > 4{,}2$	Very Practical
$X_i + 0{,}6 \times S_{bi} < X \leq X_i + 1{,}8 \times S_{bi}$	$\bar{X} > 3{,}4 - 4{,}2$	Practical
$X_i - 0{,}6 \times S_{bi} < X \leq X_i + 0{,}6 \times S_{bi}$	$\bar{X} > 2{,}6 - 3{,}4$	Moderately Practical
$X_i - 1{,}8 \times S_{bi} < X \leq X_i - 0{,}6 \times S_{bi}$	$\bar{X} > 1{,}8 - 2{,}6$	Less Practical
$X \leq X_i - 1{,}8 \times S_{bi}$	$\bar{X} \leq 1{,}8$	Not Practical

(Afrijal et al., 2023)

3. RESULT AND DISCUSSION

Result

This study used validation tests and questionnaires as data collection media. The results of *worksheet* validation by material experts and technology experts to test the practicality of using the *worksheet* are presented in Table 4, and Table 5.

Table 4. Scores of Material Expert Validation Results

No.	Aspects	The Total of Items	Scores	Maximum Score	Percentage
1	Cover Design	3	12	12	100 %
2	Content Design	6	23	24	96 %
Total		**9**	**35**	**36**	**98%**

Table 5. Scores of Technologist Validation Results

No.	Aspects	The Total of Items	Scores	Maximum Score	Percentage
1	Cover Design	3	12	12	100 %
2	Content Design	6	24	24	100%
Total		**9**	**36**	**36**	**100%**

Based on this data, the response from the validation of material experts and technology experts to the *worksheet* in learning science in elementary schools with PjBL is very good, this is supported by the percentage results obtained of 98% and can be categorized as very feasible to use as media. Furthermore, the validated worksheet was used in a small-scale trial of 15 students from several elementary schools in Ambon City to get student responses. 5 Questionnaires were given to the Elementary School of Inpres 25 Ambon, Public Elementary School 1 Latihan SPG, and Public Elementary School 47 to be filled in by the class students. Student response data is presented in Table 5. This study used questionnaires as a data collection medium. Questionnaires were distributed to students manually. The number of questionnaires distributed was 15 questionnaires 5 for students at Elementary School of Inpres 25 Ambon, 5 for students at Public Elementary School 1 Latihan SPG, and 5 for students at Public Elementary School 47.

Table 6. Student Response Questionnaire Calculation Data

Students	Acquisition	Presentation (%)	Criteria
1	28	88	Very feasible
2	24	75	feasible
3	30	94	Very feasible
4	31	97	Very Feasible
5	29	91	Very Feasible
6	27	84	Very Feasible
7	29	91	Very Feasible

Students	Acquisition	Presentation (%)	Criteria
8	28	88	Very Feasible
9	29	91	Very Feasible
10	31	97	Very Feasible
11	26	81	Very Feasible
12	23	72	Feasible
13	30	94	Very Feasible
14	25	78	Feasible
15	29	91	Very Feasible
Average number	**27.93**	**87**	**Very Feasible**

Sourced from the data in Table 6, it is obtained that students' response to the worksheet in learning science in elementary schools with PjBL is very good. This is supported by the results of the average percentage of 87% and can be categorized as very suitable for use as a science learning media.

Discussion

The results of this development research are discussed in three main topics, namely describing PjBL-based *worksheets* in learning for elementary school students' science validly, practically, and effectively. Judging from the validity of the product in this study, the use of *worksheets* in science learning can have a positive impact on learners. *Worksheets* can help learners gain a better understanding of science concepts because they can work on questions that are structured and relevant to the material being studied. It can also improve learners' problem-solving skills because they are invited to analyze information, make predictions, and draw conclusions from the data provided. In addition, the use of *worksheets* can motivate learners to learn because they can see their progress and feel actively involved in learning. The use of worksheets can also have a positive impact on teachers because it helps teachers develop active learning, spurring teachers to be able to equalize learning with the development of the 21st century (Fatmawati et al., 2023; Ghaisani & Setyasto, 2023). Some developed countries, such as Turkey, have implemented the integration of augmented reality (AR) into *worksheets*. AR can help learners tackle authentic tasks. Other researchers have found that AR improves understanding of science content that is difficult to teach or material that is difficult to visualize, such as radiation or other abstract biological material. Mobile-based AR can also increase students' motivation when learning science (Aydin, 2021; Yapici & Karakoyun, 2021). The results of other studies show that *worksheets* can be used effectively to acquire basic knowledge about biodiversity (Kitikidou et al., 2024; Morris et al., 2014). It can also be used to integrate the findings into worksheet design for out-of-school learning.

The validity of the PjBL-based science *worksheet* developed in it provides students with the opportunity to communicate and conclude learning topics logically and rationally. The ability to think logically and rationally is one of the principles of scientific thinking. The student *worksheets* developed are in accordance with curriculum standards and competencies, easy to understand, relevant to the needs, and can be practiced in students' real lives (Ekayana, A. A. G. et al., 2024; Nurhidayah & Pratama, 2024). PjBL-based science student *worksheets* that are practical mean that all learning activities can be carried out properly within the specified time. PjBL provides opportunities for students to actively build their knowledge and solve problems through activities in producing a product. The PBL approach has a series of standard features, starting with a driving question; students explore the driving question by participating in authentic and situational inquiry practices as part of collaborative activities, the teacher supports student learning and addresses learning objectives, and students create a series of products that address the driving question. Project Based Learning (PBL) motivates students from diverse backgrounds to continue learning. This project presents the design features that unite the Framework's assets with PBL, then examines these features to derive design principles that serve as a commitment to designing for teacher change and student learning. The design principles guide developing materials that support the depth needed to drive large-scale change in teacher practice: adaptive, responsive, intellectually engaging, and satisfying (Mentzer et al., 2017; Miller et al., 2021). PjBL learning activities include identifying various problems, answering basic questions, observing surrounding phenomena, studying related materials through reading materials, and showing learning videos carried out individually or in groups. The timing of projects and worksheets is correct at the end of learning, and all groups communicate the results of their work through presentations and draw conclusions from learning topics together. After completing projects and worksheets on time, by the end of the lesson, the whole group can communicate the results of their work through presentations and conclude the learning topic together.

This is in line with previous research that PjBL has a positive impact in improving science learning achievement compared to conventional learning, with the highest increase in learning achievement (Ayaz

& Söylemez, 2015; Bilgin et al., 2015). The same thing is in line with the previous research shows that, first, there is a significant difference in academic achievement between students who learn with the PjBL model and direct instruction (Firdaus et al., 2023; Santyasa et al., 2020). Higher academic achievement was achieved by students who studied using the PjBL model. Second, there is a significant difference in academic achievement between students who have high academic procrastination and those with low academic procrastination. Higher learning achievements are achieved by students who have LAP. Third, there is an interactive effect between the learning model and academic procrastination on students' academic achievement. A strong interaction occurred at low procrastination for both learning models. Students' learning motivation can increase during PjBL, so it encourages students to develop their potential to learn to solve a problem (Al-Busaidi & Al-Seyabi, 2021; Chiang, C. L. & Lee, 2016). Increased motivation is related to students' attitude in following the lesson. Similar research shows that there is a different attitude tendency between students who follow PjBL learning and students who follow conventional learning (Julian, 2017; Tak et al., 2025). This is evident from the data in Table 5, which shows a very high student response of 87% after learning with PjBL-based worksheets. The PjBL learning model is very effective in reducing students' academic procrastination during learning because the opportunity to actively build knowledge is more significant than when following conventional learning (Asri et al., 2017; Sheykholeslami, 2017). Meanwhile, academic procrastination is often the cause of student failure in obtaining learning achievement. This finding shows that high academic procrastination as a cause of failure is more significant, while low academic procrastination has a greater chance of obtaining better physics learning achievement. The low level of academic procrastination will eventually help students achieve higher levels of learning. (Santyasa et al., 2020; Zacks & Hen, 2018).

The use of *Worksheet* teaching materials is very important to support quality science learning in elementary school. To produce quality teaching materials, educators are essential. Educators need to play an active, creative, and innovative role in learning so that student learning outcomes are maximized (Amali et al., 2020; Fatchurahman, M. A. S. M. et al., 2022). There are some benefits of teaching materials in the form of *Worksheets* for educators as a medium for carrying out learning activities. *Works* that are assessed can increase educators' credit scores and can be an income enhancer for educators if their work is published. The benefits for students include learning activities becoming more attractive, students getting more opportunities to learn independently with the guidance of educators, and students getting convenience in learning each competency they must master. Teaching materials can provide convenience for educators and improve the ability of students. The role of well-designed and well-prepared teaching materials in teaching science is vital, considering the nature of some science subjects is complex and abstract (Arop et al., 2015; Etop et al., 2023). The teaching material that educators generally use is a *Worksheet*. Besides being practical, giving PJBL-based *worksheets* to students can also make it easier for educators to provide material and assignments because they are more organized. However, the student worksheets that are most widely used in schools are still very general. Student worksheets only contain general material quoted from textbooks or modules. In addition, images are limited to illustrative images taken from sources such as the internet; in fact, most are available in printed form.

PjBL-based *worksheets* that meet good criteria will result in an effective learning process. Learning by using PjBL-based *worksheets* can improve the learning outcomes of students who are taught by providing student *worksheets* better than those taught without providing student worksheets. The use of PjBL-based *worksheets* with a scientific approach and plant structure and function material is very suitable for use in the learning process. In using *worksheets*, students can read material that is equipped with pictures so that students will better understand the material studied (Pulungan et al., 2022; Suryawati et al., 2020). *Worksheets* are able to attract student interest and are an alternative to enriching natural learning materials that are aligned with the subject matter (Fardinelly, S. et al., 2024; Maharani & Marhamah, 2024). One of the efforts to improve communication skills is using *worksheets*. Therefore, the presence of PjBL-based *worksheets* can help teachers create order in students in finding and organizing concepts with a systematic process. In addition, it is one of the learning media with the aim of activating students, allowing students to learn on their own according to their abilities and interests, and stimulating learning activities and different teaching methods so that students are not bored (Nağaç & Kalaycı, 2021; Rochman et al., 2024). Local potential is the resources of a particular region, including cultural diversity and natural products. Indonesia is a country that has abundant natural biodiversity and landscapes that make a variety of unique local potential throughout its territory. Maluku is one of the regions that has unique local potential. Therefore, the exploration and inventory of Indonesia's wealth in the field of education, in this case, the development of teaching materials, is essential and exciting (Hayati & Desstya, 2023; Rohmatulloh et al., 2019). In addition to improving student learning processes and outcomes, local potential-based *worksheets* can also broaden students' knowledge of local potential in their area and contextual learning expectations.

The results of this study make an important contribution to understanding the application of Project-Based Learning (PjBL) in science learning in elementary schools. This study shows that PjBL-based worksheets have a significant role in improving students' skills, such as problem-solving, creativity, and collaboration. This worksheet not only serves as a learning tool, but also encourages students to be more actively involved in the learning process and apply scientific concepts in real contexts. Efforts to develop this PjBL-based worksheet are getting more attention because it can provide a more meaningful learning experience for students, which reflects the importance of a student-centered learning approach. The role of this PjBL-based worksheet shows how innovative learning methods can enrich the teaching-learning process in elementary schools. This can be the basis for further research on how this kind of worksheet design can be integrated with the national curriculum to achieve better learning outcomes. Furthermore, this study underscores the need for a more inclusive and creative approach to the development of teaching materials, which can ultimately support the improvement of the quality of science education at the primary level. One of the limitations of this study is that it has not investigated the long-term impact of the implementation of PjBL-based worksheets on student learning outcomes. External factors such as the availability of facilities and support from the school can also affect the effectiveness of this worksheet, which requires further research. Recommendations for further research include a more in-depth examination of the influence of PjBL-based worksheets in the broader educational context and how this approach can be applied to a range of other subjects. Research should also include perspectives from teachers and students to get a more comprehensive picture of the effectiveness of these teaching materials.

4. CONCLUSION

The selection of PjBL-based *worksheets* in science learning in elementary schools is one of the good alternatives to be applied in the current learning process. The use of PjBL-based *worksheets* can be an effective way to improve students' science learning. The impact of using worksheets in science learning is to help students gain a better understanding of science concepts. Based on the results of the research conducted, there needs to be a follow-up to expand its benefits further. In addition, schools and teachers need to pay attention to developing innovative learning media and learning models and building learner activeness. Suggestions for the future are worksheets that teachers can develop according to the needs of students in the classroom. Worksheet development can increase teachers' creativity and innovation. Teachers can use materials from the surrounding environment so that children also have a sense of belonging to the world around them.

5. REFERENCES

Afrijal, Yulianti, D., Rohman, F., & Sunyono. (2023). STEAM-Based Science Student Worksheets to Improve Elementary School Students' Scientific Literacy. *Thinking Skills and Creativity Journal*, *6*(2), 94–105. https://doi.org/10.23887/tscj.v6i2.67152.

Aiken, L. R. (1980). Content validity and reliability of single items or questionnaires. *Educational and Psychological Measurement*, *40*(4), 955–959. https://doi.org/10.1177/001316448004000419.

Al-Busaidi, S., & Al-Seyabi, F. (2021). Project-based learning as a tool for student-teachers' professional development: A study in an Omani EFL teacher education program. *International Journal of Learning, Teaching and Educational Research*, *20*(4), 116–136. https://doi.org/10.26803/ijlter.20.4.7.

Alemneh, S., & Gebrie, G. (2024). The role of project-based learning in improving the writing ability and sub-writing abilities of 10th grade Amharic speaking students. *Social Sciences and Humanities Open*, *9*, 1–9. https://doi.org/10.1016/j.ssaho.2024.100843.

Alghamdi, A. K., & Al-Ghamdi, N. A. (2021). Elementary teachers' thoughts about distance education and learning 21st-century skills during covid pandemic. *International Journal of Learning, Teaching and Educational Research*, *20*(3), 33–50. https://doi.org/10.26803/ijlter.20.3.3.

Alismail, H. A. (2023). Teachers' perspectives of utilizing distance learning to support 21st century skill attainment for K-3 elementary students during the COVID-19 pandemic era. *Heliyon*, *9*(9), 1–13. https://doi.org/10.1016/j.heliyon.2023.e19275.

Amali, L. N., Zees, N., & Suhada, S. (2020). Motion Graphic Animation Video as Alternative Learning Media. *Jambura Journal of Informatics*, *2*(1), 23–30. https://doi.org/10.37905/jji.v2i1.4640.

Arop, B. A., Umanah, F. I., & Effiong, O. E. (2015). Effect of instructional materials on the teaching and learning of basic science in junior secondary schools in Cross River State, Nigeria. *Global Journal of Educational Research*, *14*(1), 67–73. https://doi.org/10.4314/gjedr.v14i1.9.

Asri, D. N., Setyosari, P., Hitipeuw, I., & Chusniyah, T. (2017). The Influence of Project-based Learning

Strategy and Self-regulated Learning on Academic Procrastination of Junior High School Students' Mathematics Learning. *American Journal of Educational Research*, *5*(1), 88–96. https://doi.org/10.12691/education-5-1-14.

Ayaz, M. F., & Söylemez, M. (2015). The effect of the project-based learning approach on the academic achievements of the students in science classes in Turkey: A meta-analysis study. *Egitim ve Bilim*, *40*(178), 255–283. https://doi.org/10.15390/EB.2015.4000.

Aydin, M. (2021). Investigating pre-service science teachers' mobile augmented reality integration into worksheets. *Journal of Biological Education*, *55*(3), 276–292. https://doi.org/10.1080/00219266.2019.1682639.

Ayyıldız, Y., Tarhan, L., & Gil, A. (2023). Comparing the effectiveness of the learning material and the learning method in students' achievement in chemistry lesson on chemical changes. *Research in Science & Technological Education*, *41*(4), 1372–1393. https://doi.org/10.1080/02635143.2022.2086535.

Basri, N., Salija, K., Baa, S., & Muhammad, A. P. A. (2024). Unlocking Creativity and Engagement in Students through Project-Based Learning. *Journal of Hunan University Natural Sciences*, *51*(1), 112–120. https://doi.org/10.55463/issn.1674-2974.51.1.11.

Beagon, Ú., Niall, D., & Ní Fhloinn, E. (2019). Problem-based learning: student perceptions of its value in developing professional skills for engineering practice. *European Journal of Engineering Education*, *4*(6), 850–865. https://doi.org/10.1080/03043797.2018.1536114.

Biantoro, P. P., & Pertiwi, K. R. (2024). Development of IBSC (Investigation Based Science Collaborative) Based Student Worksheet on Human Respiratory System to Improve Science Literacy and Collaboration Skills of Grade XI Students. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6473–6489. https://doi.org/10.29303/jppipa.v10i9.8560.

Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics Science and Technology Education*, *11*(3), 469–477. https://doi.org/10.12973/eurasia.2014.1015a.

Celik, E., Baki, G. O., & Isik, A. (2022). the Effect of Cluster Teaching With Worksheets on Students' Academic Achievement in Distance Education. *Turkish Online Journal of Distance Education*, *23*(3), 137–153. https://doi.org/10.17718/tojde.1137255.

Chan, Z. C. (2017). A qualitative study on using concept maps in problem-based learning. *Nurse Education in Practice*, *24*, 70–76. https://doi.org/10.1016/j.nepr.2017.04.008.

Chang, R. C., Chung, L. Y., & Huang, Y. M. (2016). Developing an interactive augmented reality system as a complement to plant education and comparing its effectiveness with video learning. *Interactive Learning Environments*, *24*(6), 1245–1264. https://doi.org/10.1080/10494820.2014.982131.

Chiang, C. L., & Lee, H. (2016). The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students. *International Journal of Information and Education Technology*, *6*(9), 709–712. https://doi.org/10.7763/ijiet.2016.v6.779.

Çilingir Altiner, E. (2024). Exploring measurement estimation strategies through concept cartoons designed with Realistic Mathematics Education. *Humanities and Social Sciences Communications*, *11*(1), 1–10. https://doi.org/10.1057/s41599-024-03067-5.

Dewi, A. K., Slamet, S. Y., Atmojo, I. R. W., & Syawaludin, A. (2022). The Influence of Interactive Digital Worksheets Based on Level of Inquiry Towards Science Process Skills in Elementary School. *Pegem Egitim ve Ogretim Dergisi*, *13*(1), 251–258. https://doi.org/10.47750/pegegog.13.01.27.

Ekayana, A. A. G., Parwati, N. N., Agustini, K., & Ratnaya, I. G. (2024). Enhancing Creative Thinking Skills and Student Achievement: An Innovative Approach through Integrating Project-Based Learning with STEAM and Self-Efficacy. *International Journal of Educational Methodology*, *10*(1), 923–935. https://doi.org/10.47750/pegegog.14.04.03.

Etop, E. E., Iboro, S. G., & Obogo, A. I. (2023). Influence of locally available instructional materials on biology students' academic achievement in abak local government area of akwa ibom state, nigeria. *Global Journal of Educational Research*, *22*(1), 81–87. https://doi.org/10.4314/gjedr.v22i1.9.

Fardinelly, S., Slamet, A., & Susanti, R. (2024). Electronic Liveworksheet- Based LKS Teaching Materials for Middle School Science Learning. *Journal of Educational Sciences*, *8*(1), 118–127. https://doi.org/10.31258/jes.8.1.p.118-127.

Fatchurahman, M. A. S. M., Della, H., & Setiawan, M. A. (2022). Development of animation learning media based on local wisdom to improve student learning outcomes in elementary schools. *International Journal of Instruction*, *15*(1), 55–72. https://doi.org/10.29333/iji.2022.1514a.

Fatmawati, F., Rivaldi, M., & Suhaeni, S. (2023). Development of Electronic Student Worksheets Based Local Potential to Enhance Students' Science Learning Outcomes. *JIPI (Jurnal IPA Dan Pembelajaran IPA)*, *7*(1), 56–71. https://doi.org/10.24815/jipi.v7i1.29443.

Ferrari, L., Macauda, A., Soriani, A., & Russo, V. (2020). Educational robotics and artificial intelligence

education: what priorities for schools? *Re-Open Journal per La Formazione in Rete*, *20*(3), 68–85. https://doi.org/10.13128/form-10038.

Finbråten, H. S., Grønlien, H. K., Pettersen, K. S., Foss, C., & Guttersrud, Ø. (2022). "Nursing students' experiences with concept cartoons as an active learning strategy for developing conceptual understanding in anatomy and physiology: A mixed-method study". *Nurse Education in Practice*, *65*, 1–11. https://doi.org/10.1016/j.nepr.2022.103493.

Firdaus, M. A., Jamal, M. Y. S., & Arifin, B. S. (2023). Improving Student Learning Outcomes Through Project-Based Learning in Islamic Religion Lessons. *Tafkir: Interdisciplinary Journal of Islamic Education*, *4*(2), 241–254. https://doi.org/10.31538/tijie.v4i2.400.

Ghaisani, N. R. T., & Setyasto, N. (2023). The Development of Liveworksheets-Based Electronic Student Worksheets (E-LKPD) to Improve Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6147–6156. https://doi.org/10.29303/jppipa.v9i8.4571.

Gomez-del Rio, T., & Rodriguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. *Education for Chemical Engineers*, *40*, 17–28. https://doi.org/10.1016/j.ece.2022.04.002.

Gómez-Pablos, V. B., del Pozo, M. M., & Muñoz-Repiso, A. G. V. (2017). Project-based learning (PBL) through the incorporation of digital technologies: An evaluation based on the experience of serving teachers. *Computers in Human Behavior*, *68*, 501–512. https://doi.org/10.1016/j.chb.2016.11.056.

Hanipah, S., Florentinus, T. S., & Rifai, A. (2018). The Effectiveness of Problem Based Learning and Project Based Learning Model to Improve Natural Science Study Outcomes. *Innovative Journal of Curriculum and Educational Technology*, *7*(1), 1–6. https://doi.org/10.15294/ijcet.v7i1.24383.

Hasanah, H., Desniarti, D., & Siregar, N. (2022). Increasing Student Creativity through Project Based Learning Models in Thematic Learning. *Literature for Social Impact and Cultural Studies*, *4*(3), 1116–1121. https://doi.org/10.37010/lit.v4i3.1044.

Hasni, A., Bousadra, F., Belletête, V., Benabdallah, A., Nicole, M. C., & Dumais, N. (2016). Trends in research on project-based science and technology teaching and learning at K–12 levels: a systematic review. *Studies in Science Education*, *52*(2), 199–231. https://doi.org/10.1080/03057267.2016.1226573.

Hayati, H. N., & Desstya, A. (2023). Science Learning by Utilizing Natural Resources at Kak Seto's Homeschooling. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, *5*(2), 485–505. https://doi.org/10.37680/scaffolding.v5i2.3111.

Herlanti, Y., Mardiati, Y., Rahmawati, R., Putri, A. M. K., Jamil, N., Miftahuzzakiyah, M., & Sugiarti, S. (2019). Finding learning strategy in improving science literacy. *Jurnal Penelitian Dan Pembelajaran IPA*, *5*(1), 59–71. https://doi.org/10.30870/jppi.v5i1.4902.

Herlina, K. (2021). Developing electronic student worksheet (E-Worksheet) based project using Fliphtml5 to stimulate science process skills during the Covid-19 pandemic. *Integrative Science Education and Teaching Activity Journal*, *2*(1), 59–73. https://doi.org/10.21154/insecta.v2i1.2555.

Indriayu, M. (2018). The Influence of Science Literacy-Based Teaching Material Towards Science Achievement. *International Journal of Evaluation and Research in Education*, *7*(3), 182–187. https://doi.org/10.11591/ijere.v7i3.14033.

Julian, P. K. (2017). The effects of a project-based course on students' attitudes toward mathematics and students' achievement at a two-year college. *Mathematics Enthusiast*, *14*(1), 509–516. https://doi.org/10.54870/1551-3440.1408.

Karamustafaoğlu, O., & Pektaş, H. M. (2023). Developing students' creative problem solving skills with inquiry-based STEM activity in an out-of-school learning environment. *Education and Information Technologies*, *28*(6), 7651–7669. https://doi.org/10.1007/s10639-022-11496-5.

Kitikidou, K., Milios, E., Stampoulidis, A., Pipinis, E., & Radoglou, K. (2024). Using Biodiversity Indices Effectively: Considerations for Forest Management. *Ecologies*, *5*(1), 42–51. https://doi.org/10.3390/ecologies5010003.

Kong, S. C., Cheung, M. Y. W., & Tsang, O. (2024). Developing an artificial intelligence literacy framework: Evaluation of a literacy course for senior secondary students using a project-based learning approach. *Computers and Education: Artificial Intelligence*, *6*, 1–11. https://doi.org/10.1016/j.caeai.2024.100214.

Kumi-Manu, R. N. (2021). Concept Cartoon as a Teaching Technique for Conceptual Change: A Ghanaian Junior High School Experience. *American Journal of Educational Research*, *9*(9), 587–599. https://doi.org/10.12691/education-9-9-5.

Kurniawati, W., Umardianti, U., Novitasari, R. K., & Al Husna, A. (2024). Differentiated Science Student Worksheets : What is the Level of Collaboration Skills of Students of the Elementary School Teacher Education Study Program? *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *10*(2), 627.

https://doi.org/10.33394/jk.v10i2.11279.
Kwangmuang, P., Jarutkamolpong, S., Duangngern, P., Gessala, N., & Sarakan, P. (2024). Promoting analytical thinking skills development in elementary school students through animated cartoons. *Computers in Human Behavior Reports*, *15*, 1–11. https://doi.org/10.1016/j.chbr.2024.100467.
Lee, E., & Hannafin, M. J. (2016). A design framework for enhancing engagement in student-centered learning: Own it, learn it, and share it. *Educational Technology Research and Development*, *64*, 707–734. https://doi.org/10.1007/s11423-015-9422-5.
Letina, A. (2020). Development of students' learning to learn competence in primary science. *Education Sciences*, *10*(11), 1–14. https://doi.org/10.3390/educsci10110325.
Maharani, P., & Marhamah, M. (2024). Development of E-Student Worksheet Based Task-Based Learning Through LiveWorksheets.com for High School Students. *Al-Ishlah: Jurnal Pendidikan*, *16*(2), 1205–1217. https://doi.org/10.35445/alishlah.v16i2.5183.
Maros, M., Korenkova, M., Fila, M., Levicky, M., Maros, M., Korenkova, M., Fila, M., & Levicky, M. (2023). Project-based learning and its effectiveness : evidence from Slovakia. *Interactive Learning Environments*, *31*(7), 4147–4155. https://doi.org/10.1080/10494820.2021.1954036.
Mekonnen, Z. B., Yehualaw, D. D., Mengistie, S. M., & Mersha, B. S. (2024). The effect of 7E learning cycle enriched with computer animations on students' conceptual understanding and overcoming misconceptions. *Journal of Pedagogical Research*, *8*(2), 325–356. https://doi.org/10.33902/JPR.202425017.
Mentzer, G. A., Czerniak, C. M., & Brooks, L. (2017). An Examination of Teacher Understanding of Project Based Science as a Result of Participating in an Extended Professional Development Program: Implications for Implementation. *School Science and Mathematics*, *117*(1–2), 76–86. https://doi.org/10.1111/ssm.12208.
Miller, E. C., Severance, S., & Krajcik, J. (2021). Motivating Teaching, Sustaining Change in Practice: Design Principles for Teacher Learning in Project-Based Learning Contexts. *Journal of Science Teacher Education*, *32*(7), 757–779. https://doi.org/10.1080/1046560X.2020.1864099.
Morris, E. K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., & Rillig, M. C. (2014). Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. *Ecology and Evolution*, *4*(18), 3514–3524. https://doi.org/10.1002/ece3.1155.
Mutlu, A. (2020). International and Multidisciplinary Perspectives Evaluation of students ' scientific process skills through reflective worksheets in the inquiry-based learning environments. *Reflective Practice*, *21*(2), 271–286. https://doi.org/10.1080/14623943.2020.1736999.
Nağaç, M., & Kalaycı, S. (2021). The effect of STEM activities on students' academic achievement and problem solving skills: Matter and heat unit. *E-Kafkas Journal of Educational Research*, *8*(3), 480–498. https://doi.org/10.30900/kafkasegt.964063.
Nilada, N., Payougkiattikun, W., & Thongsuk, T. (2024). The Study of Scientific Creativity using a Project-Based Learning Management Model. *International Journal on Social and Education Sciences*, *6*(2), 253–263. https://doi.org/10.46328/ijonses.667.
Nurhidayah, D., & Pratama, A. T. (2024). Students' e-worksheet based on project and Character of Pancasila through environmental issues: What are the characteristics? *Research and Development in Education (RaDEn)*, *4*(1), 113–126. https://doi.org/10.22219/raden.v4i1.32182.
Özmen, B., & Atıcı, B. (2014). The effects of social networking sites in distance learning on learners' academic achievements. *European Journal of Open, Distance and E-Learning*, *17*(2), 61–75. https://doi.org/10.2478/eurodl-2014-0019.
Pedersen, S., & Hobye, M. (2020). education sciences Implications of Assessing Student-Driven Projects : A Case Study of Possible Challenges and an Argument for Reflexivity. *Education Sciences*, *10*(1), 1–17. https://doi.org/10.3390/educsci10010019.
Phurikultong, N., & Kantathanawat, T. (2022). Flipping the Undergraduate Classroom to Develop Student Analytical Thinking Skills. *Emerging Science Journal*, *6*(4), 739–757. https://doi.org/10.28991/ESJ-2022-06-04-06.
Pulungan, M., Maharani, S. D., Waty, E. R. K., Safitri, M. L. O., Suganda, V. A., & Husni, F. T. (2022). Development of E-Student Worksheets in the form of Picture Stories Using Live Worksheets in Primary Schools. *Jurnal Iqra': Kajian Ilmu Pendidikan*, *7*(2), 157–167. https://doi.org/10.25217/ji.v7i2.1759.
Qalfin, M., Saptono, S., Ellianawati, E., & Dewi, N. R. (2024). Effectiveness of Differentiated Digital Student Worksheets Based on Socio-Scientific Issues to Improve Students' Science Literacy. *Unnes Science Education Journal*, *13*(2), 86–93. https://doi.org/10.15294/usej.v13i2.10030.
Richert, R. A., & Schlesinger, M. A. (2017). The role of fantasy–reality distinctions in preschoolers' learning from educational video. *Infant and Child Development*, *26*(4). https://doi.org/10.1002/icd.2009.
Rochman, S., Algiranto, A., Ekasari, A., & Turaqulov, B. T. (2024). Development Of Student Worksheets

Integrated With Pbl-Stem On Temperature And Heat Material. *EduFisika: Jurnal Pendidikan Fisika*, *9*(2), 237–246. https://doi.org/10.59052/edufisika.v9i2.36817.

Rodrangsee, B., Tuntiwongwanich, S., Pimdee, P., & Moto, S. (2022). Development of an Online Active Learning Model Using the Theory of Multiple Intelligence to Encourage Thai Undergraduate Student Analytical Thinking Skills. *Journal of Higher Education Theory and Practice*, *22*(12), 63–75. https://doi.org/10.33423/jhetp.v22i12.5463.

Rohmatulloh, A., Prasetyo, Z. K., & Pambudi, H. A. (2019). Implementation of the 2013 Curriculum for Science Learning. *Mimbar Sekolah Dasar*, *6*(1), 105–115. https://doi.org/10.53400/mimbar-sd.v6i1.15912.

Ronsivalle, G. B., Boldi, A., Gusella, V., Inama, C., & Carta, S. (2019). How to implement educational robotics' programs in Italian schools: A brief guideline according to an instructional design point of view. *Technology, Knowledge and Learning*, *24*, 227–245. https://doi.org/10.1007/s10758-018-9389-5.

Santos, C., Rybska, E., Klichowski, M., Jankowiak, B., Jaskulska, S., Domingues, N., Carvalho, D., Rocha, T., Paredes, H., Martins, P., & Rocha, J. (2023). Science education through project-based learning: A case study. *Procedia Computer Science*, *219*(2022), 1713–1720. https://doi.org/10.1016/j.procs.2023.01.465.

Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project based learning and academic procrastination of students in learning physics. *International Journal of Instruction*, *13*(1), 489–508. https://doi.org/10.29333/iji.2020.13132a.

Sheykholeslami, A. (2017). The effectiveness of cognitive and meta-cognitive learning strategy training on academic procrastination of students with low academic achievement. *Journal of School Psychology*, *6*(3), 65–84. https://doi.org/10.22098/jsp.2017.585.

Södervik, I., Virtanen, V., & Mikkilä-Erdmann, M. (2015). Challenges in understanding photosynthesis in a university introductory biosciences class. *International Journal of Science and Mathematics Education*, *13*, 733–750. https://doi.org/10.1007/s10763-014-9571-8.

Stephenson, C., & Isaacs, T. (2019). The role of the Extended Project Qualification in developing self-regulated learners: exploring students' and teachers' experiences. *The Curriculum Journal*, *30*(4), 392–421. https://doi.org/10.1080/09585176.2019.1646665.

Sullivan, K., Bray, A., & Tangney, B. (2021). Developing twenty-first-century skills in out-of-school education: the Bridge21 Transition Year programme. *Technology, Pedagogy and Education*, *30*(4), 525–541. https://doi.org/10.1080/1475939X.2020.1835709.

Suryawati, E., Suzanti, F., Zulfarina, Z., Putriana, A. R., & Febrianti, L. (2020). The Implementation of Local Environmental Problem-Based Learning Student Worksheets to Strengthen Environmental Literacy. *Jurnal Pendidikan IPA Indonesia*, *9*(2), 169–178. https://doi.org/10.15294/jpii.v9i2.22892.

Suwarno, S., Wahidin, W., & Nur, S. H. (2020). Project-based learning model assisted by worksheet: It's effect on students' creativity and learning outcomes. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(1), 113–122. https://doi.org/10.22219/jpbi.v6i1.10619.

Tak, C. C., Zulnaidi, H., & Eu, L. K. (2025). Factors influencing the attitude of undergraduate students towards mathematical reasoning: An approach using AMOS-structural equation modelling. *Infinity Journal*, *14*(1), 109–124. https://doi.org/10.22460/infinity.v14i1.p109-124.

Taşlıdere, E. (2021). Relative effectiveness of conceptual change texts with concept cartoons and 5e learning model with simulation activities on pre-service teachers' conceptual understanding of waves. *Participatory Educational Research*, *8*(4), 215–238. https://doi.org/10.17275/PER.21.87.8.4.

Vančugovienė, V., Södervik, I., Lehtinen, E., & McMullen, J. (2024). Individual differences in secondary school students' conceptual knowledge: Latent profile analysis of biology concepts. *Learning and Individual Differences*, *111*, 1–17. https://doi.org/10.1016/j.lindif.2024.102436.

Wilson, A., Howitt, S., & Higgins, D. (2016). A fundamental misalignment: intended learning and assessment practices in undergraduate science research projects. *Assessment & Evaluation in Higher Education*, *41*(6), 869–884. https://doi.org/10.1080/02602938.2015.1048505.

Wu, X. Y. (2024). Unveiling the dynamics of self-regulated learning in project-based learning environments. *Heliyon*, *10*(5), 1–19. https://doi.org/10.1016/j.heliyon.2024.e27335.

Yapici, İ. Ü., & Karakoyun, F. (2021). Using augmented reality in biology teaching. *Malaysian Online Journal of Educational Technology*, *9*(3), 40–51. https://doi.org/10.52380/mojet.2021.9.3.286.

Yousaf, A., Moin, H., Majeed, S., Shafi, R., & Mansoor, S. (2023). The positive impact of introducing modified directed self-learning using pre–small group discussion worksheets as an active learning strategy in undergraduate medical education. *Medical Education Online*, *28*(1), 1–10. https://doi.org/10.1080/10872981.2023.2204547.

Yu, H. (2024). Enhancing creative cognition through project-based learning: An in-depth scholarly

exploration. *Heliyon*, *10*(6), 1–9. https://doi.org/10.1016/j.heliyon.2024.e27706.

Zacks, S., & Hen, M. (2018). Academic interventions for academic procrastination: A review of the literature. *Journal of Prevention & Intervention in the Community, 46*(2), 117–130. https://doi.org/10.1080/10852352.2016.1198154.

Zhang, J., Huang, Y., Liu, T., Sung, Y., Chang, K., & Zhang, J. (2020). Augmented reality worksheets in field trip learning. *Interactive Learning Environments*, *31*(1), 4–21. https://doi.org/10.1080/10494820.2020.1758728.