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Development of Differentiated E-LKPD Integrated with PjBL-STEM to Improve Students Science Literacy

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Abstract: This study aims to test the effectiveness of integrated differentiated PjBl-STEM e-LKPD to improve science literacy. This research method uses the ADDIE R&D model. Classes IX.A, IX.B, IX.C, and IX.D at SMPN 1 Tanjung Bintang became the research sample with purposive sampling. The data analysis technique used the independent sample t-test and ANOVA. Based on expert validation, the percentage of content suitability aspects was 96.42%, construction suitability 96.25% and readability 90%. The average percentage of teacher responses to the content aspect was 95%, readability 93.75%, and attractiveness 98.75%, as well as the results of observations of learning implementation 77.4%, and reflection questionnaires with high criteria. In addition, the percentage of student responses to the readability aspect was 86.25% and attractiveness 90%. Based on these results, the developed e-LKPD is valid and practical with a very high category. The results of the t-test stated that there was a significant difference in the average scientific literacy of students between the control and experimental classes. The results of the ANOVA test stated that there was no effect of using e-LKPD with visual, kinesthetic, and auditory learning styles in improving scientific literacy because the e-LKPD developed had accommodated the needs of all students.

Keywords: Differentiated e-LKPD; PjBL-STEM; Science literacy

Introduction

The state of life in the 21st century is very challenging and competitive. Technological advances provide greater accessibility to educational resources and expand learning spaces. The growing demands of the job market require students to develop skills that are relevant to the changing world of work (Yusuf, 2023). Students need to have skills that enable them to compete globally. Current learning needs to prepare students to face these various problems. Advances in technology and information are developing very rapidly and affecting all areas of human life, one of which is in the field of education (Sumantri, 2019).

The 21st century learning process requires thinking skills including critical thinking and problem solving, communication, collaboration, creative thinking skills and innovation. Therefore, the world of education must be able to provide learning that can develop these 21st century skills (Trilling & Fadel, 2009). Science literacy is one of the components that students need to have (Kimianti & Prasetyo, 2019). Science literacy involves a discovery process that involves observation, hypothesis testing, experiments, and drawing conclusions.

Science literacy is defined as the ability to understand issues related to science, the development of scientific ideas, as a reflection. Where someone who is scientifically literate will be able to understand scientific phenomena about science and technology, by using the abilities they already have in the form of competencies to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically (OECD, 2019). Science literacy is not limited to understanding science, understanding scientific processes and information in everyday life to the decision-making stage (Haerani et al., 2020).

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The profile of students' scientific literacy and creative thinking can be known using assessments to determine the extent of students' scientific literacy and creative thinking abilities. As has been done by the Organization for Economic Cooperation and Development (OECD) through the PISA program in 2022, Indonesia is ranked 63rd out of 73 countries, with a score in the scientific literacy category of 383, lower than Malaysia which is ranked 49th with a score of 416 (OECD, 2023).

Students' scientific literacy can be improved by implementing a learning model that is oriented towards these skills. One alternative learning model is using the Project Based Learning (PjBL) model. Project Based Learning (PjBL) is an innovative learning that encourages students to conduct investigations, work collaboratively in researching and creating projects that apply their knowledge from discovering new things, being proficient in using technology and being able to solve a problem (Afifah et al., 2019). The PjBL model gives students the freedom to plan their learning activities, carry out projects collaboratively, and ultimately produce work products that can be presented to others (Elisabet et al., 2019).

The independent curriculum is a curriculum with intracurricular learning that has various contents so that students have enough time to understand concepts and strengthen competencies (Barlian et al., 2022). In this curriculum, learning is adjusted to the needs and character of students (Husna & Aini, 2023). One of the learning methods that can meet the needs of students in the independent curriculum is by implementing differentiated learning (Aprima & Sari, 2022). Differentiated learning is an approach that can accommodate all the diverse needs of students (Avivi et al., 2023). Differentiated learning with the PjBL model will create meaningful learning that provides students with direct experience in gaining knowledge and developing their skills (Fadhilah et al., 2023). The implementation of differentiated learning is by mapping the learning needs of students. The learning needs of students can be categorized into three aspects, namely: learning readiness, learning profile, and interests and talents (Tomlinson, 2001). Differentiated learning contains 4 main aspects that must be displayed by teachers in the learning process in the classroom, namely content, process, product and learning environment, where these four components are adjusted to the characteristics and needs of students (Wahyuningsari et al., 2022).

Integration of learning with the PjBL model can be combined with the STEM approach, because in STEM there are components of science, technology, engineering, and mathematics that accommodate holistic thinking in solving a problem (Priantari et al., 2020). The purpose of learning with the STEM approach is for students to have scientific and technological literacy as seen from their ability to read, write, observe, and do science, and are able to develop these abilities to be applied in solving everyday life problems related to the STEM field (Bybee, 2013; Belland et al., 2017).

The learning tool needed to integrate PjBL-STEM is e-LKPD, because e-LKPD can make it easier for teachers to teach and provide opportunities for students to be active in learning so as to create a pleasant learning atmosphere (Dewi et al., 2021). E-LKPD is an electronic student worksheet that was developed to encourage innovation and facilitate the learning process and can be accessed via computers, laptops, notebooks, and smartphones (Nurlita, 2023). One of the problems is the lack of interactivity in teaching, where teachers tend to use monotonous teaching methods that do not actively involve students. In addition, teachers have difficulty in dealing with different learning styles of students in the classroom, therefore teachers need to provide assignments and activities that are in accordance with students' learning styles. Based on this, this study needs to develop integrated differentiated e-LKPD PjBL-STEM to improve scientific literacy.

Method

The development model of this research is Research and Development (R & D). The research design used is the ADDIE development model (Analyze, Design, Development, Implementation, Evaluation) (Branch, 2009). The research conducted produced a product, namely teaching materials in the form of integrated differentiated e-LKPD PjBL-STEM to improve science literacy. The ADDIE development model is as in Figure 1.

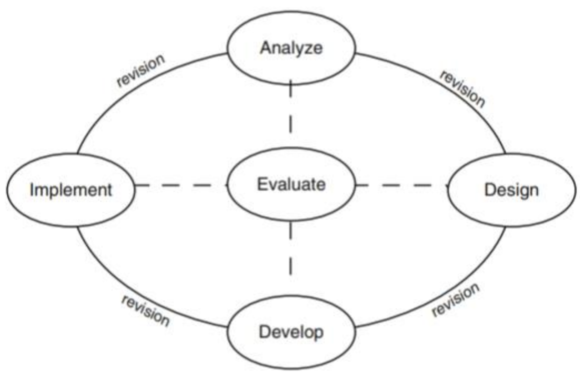

Figure 1. ADDIE development model

Analysis Stage, at the analysis stage the researcher identified the gap between expectations and reality that occurred in the field, namely low scientific literacy. Therefore, the researcher determined the product objective, namely to improve scientific literacy by developing an integrated differentiated e-LKPD product PjBL-STEM. Then the researcher conducted a literature study analysis related to the product to be developed as well as the facilities and infrastructure in the school. After that, the researcher conducted a needs analysis related to the product to be developed in the form of a questionnaire on the needs of educators and students and interviews with science teachers. Then the results of the questionnaire were described in the form of a percentage, then interpreted qualitatively.

At the design stage, the task inventory, compiling performance objectives, producing testing strategies. As for the inventory stage related to the development product, namely collecting learning resources used as product development, finding software that will be used to create an integrated differentiated e-LKPD PjBL-STEM, compiling a science literacy assessment instrument and compiling a storyboard for an integrated differentiated e-LKPD PjBL-STEM.

The purpose of the development stage is to produce and validate an integrated differentiated e-LKPD PjBL-STEM. The product to be created using the Canva application, is changed into electronic form using the Liveworksheets software. The revised product is then validated by 2 expert lecturers of the Master of Science Education FKIP UNILA, and 2 certified educator practitioners, the aspects that are validated are aspects of content suitability, construction and readability. After being validated by the expert, the draft of the integrated differentiated e-LKPD PjBL-STEM is revised according to the expert's input suggestions. After the product is revised, it is then tested on a limited basis with 10 students.

The implementation stage aims to test the integrated differentiated e-LKPD product PjBL-STEM. Grouping students based on their learning styles is done by providing a diagnostic questionnaire at the beginning of learning. Then after grouping learning styles, the e-LKPD product was tested on 4 grade IX students at SMPN 1 Tanjung Bintang. The selection of sample techniques uses purposive sampling considering the number of students with visual, audio and kinesthetic learning styles. The research design used pretest-posttest nonequivalent control group design (Creswell, 2017). Data analysis in this study used independent sample t-test, anova test, and effect size test. The evaluation stage was carried out to assess the quality of the integrated differentiated e-LKPD learning product PjBL-STEM and a series of processes for making the product starting from the analysis stage (analyze), design, developing the product (develop) and implementation.

Result and Discussion

Based on the research conducted at SMPN 1 Tanjung Bintang, data was obtained in the form of validity and reliability data of pretest-posttest question instruments, expert validation data, teacher response data, student response data, pretest-posttest data, learning reflection data using differentiated e-LKPD, and observation data on the implementation of learning using differentiated e-LKPD.

Based on the results of the needs analysis given to 31 science teachers from 14 junior high schools in South Lampung, it was found that 58.1% of teachers had not grouped students according to their learning styles. Teachers stated that 100% of science learning in schools had used LKPD and 51.6% of LKPD were made by themselves and 90.3% were in paper form. Teachers stated that 80.6% had not implemented problem-based learning in the surrounding environment, so 100% of teachers stated that it was necessary to implement project-based learning in science learning. On the other hand, 90.3% of teachers also stated that it was necessary to implement science learning in schools based on STEM in certain projects. According to science teachers, 100% need to train science literacy, so 100% of teachers stated that it is necessary to develop e-LKPD based on PjBL-STEM to improve science literacy.

Based on the analysis of student needs, it was found that 60.6% of science learning in schools already uses mobile phones. Students stated that 80.8% had used LKPD in learning, but LKPD used by 79.2% was still in paper form. On the other hand, 85% of students stated that they needed project-based science learning or PjBL. As many as 47.4% of students were familiar with the STEM approach, and 87.3% stated that learning activities involving the STEM approach were needed. As many as 76.5% of students stated that they had never received questions in learning about problems in everyday life to be solved, and 76.5% of students had never been invited to identify and explain scientific phenomena in learning. Students stated 96.7% science literacy. Based on this, 92.5% of students stated that it is necessary to develop e-LKPD according to your learning style, based on PjBL-STEM which can improve scientific literacy.

Based on expert validation conducted by 4 experts, namely Mrs. Dr. Kartini Herlina, M.Sc. and Mrs. Dr. Dina Maulina, M.Sc. Lecturers from the Faculty of Teacher Training and Education, University of Lampung. The teacher responses conducted by 2 science teachers, namely Mrs. Cupik Handayani, M.Pd. from SMPN 1 Tanjung Sari and Mrs. Arif Vivi Aningsih, M.Pd. SMPN 2 Katibung were obtained as shown in Table 1.

Table 1. Validation Results of Integrated Differentiated E-LKPD PjBL-STEM

Validation aspects	Percentage (%)	Criteria
Content suitability	96.42	Very high
Construction suitability	96.25	Very high
Legibility	90.00	Very high

Based on the results of the expert validation of the content suitability, the percentage stated that the e-LKPD product was valid with very high criteria. This is because the e-LKPD that was developed contains content aspects that are in accordance with current learning achievements which include indicators, material content, discourse, and activity content in accordance with the PjBL-STEM syntax. Based on the results of the content validation which includes aspects of material suitability, the e-LKPD that was developed is suitable for use (Hulu & Dwiningsih, 2021). Based on the results of the expert validation of construction suitability, the percentage stated that the e-LKPD product was valid with very high criteria. This is because the e-LKPD that was developed contains construction aspects in the form of suitability with science literacy indicators and suitability of student learning style construction. Furthermore, in the readability aspect, the results of the expert validation were obtained with a percentage stating that the e-LKPD product was valid with very high criteria. The high readability aspect is because the e-LKPD that was developed has easy access, an attractive appearance, and clear instructions. The readability aspect is related to terminology, clarity of language, and suitability of language (Hidayatullah et al., 2022).

Tabel 2. Results of Teacher Responses to Integrated Differentiated E-LKPD PjBL-STEM

Validation aspects	Percentage (%)	Criteria
Content suitability	95.00	Very high
Legibility	93.75	Very high
Attraction	98.75	Very high

Based on the results of the aspects of content suitability, readability, and attractiveness, a percentage with very high criteria was obtained. This means that the developed e-LKPD is stated to be practical and good for use in science learning. The high validation results are because the developed e-LKPD is in accordance with learning outcomes and contains science literacy indicators. This is in line with research which states that e-LKPD integrated with PjBL-STEM that integrates technology can provide a more interesting and in-depth learning experience, and prepare students to face technological challenges in problem solving (Sulistiani et al., 2024).

Tabel 3. Results of Student Responses to Integrated Differentiated E-LKPD PjBL-STEM

Validation aspects	Percentage (%)	Criteria
Legibility	86.25	Very high
Attraction	90.00	Very high

The results of student responses to e-LKPD have a very high category, because the e-LKPD that was developed was interesting and contained images, videos, and audio so that students were facilitated according to their learning style. In addition, the Differentiated e-LKPD has been designed to stimulate students' imagination and curiosity, especially the material or content contained in the e-LKPD emphasizes the practical application and relevance of learning materials in everyday life. The use of STEM-integrated e-LKPD allows students to connect theoretical concepts with real-world situations, encouraging them to think creatively in solving problems (Sulistiani et al., 2024).

The observation sheet for the implementation of learning using the PjBL-STEM integrated differentiated e-LKPD is used as supporting data for the practicality of the developed e-LKPD.

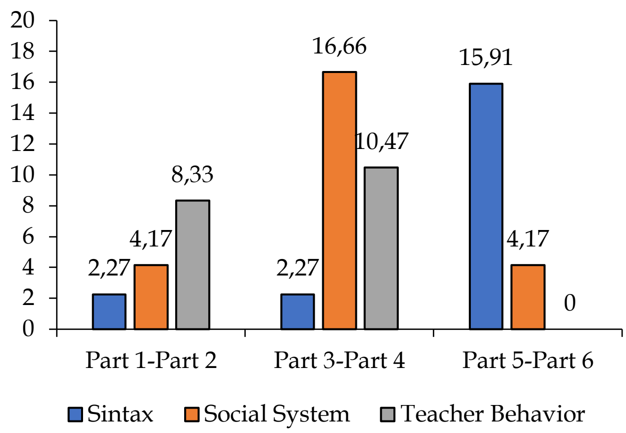

Figure 2. Increase in the percentage of learning implementation between meetings

Based on observation data on the implementation of learning using e-LKPD integrated with PjBL-STEM, it was found that the percentage difference between meetings in the aspects of syntax, social systems, and teacher behavior increased, but at meetings 1-2 and 3-4 the syntax aspect had the same percentage difference, and at meetings 5 and 6 the teacher behavior aspect did not increase but the percentage of each meeting had very high criteria. Based on the results of teacher responses, students, and observations of the implementation of learning, it can be concluded that the e-LKPD product developed is practical. The effectiveness of integrated differentiated e-LKPD PjBL-STEM comes from pretest-posttest data.

Table 4. Average Results of Pretest-Posttest of Science Literacy

Class	Average		N-Gain	Pretest-posttest Increase	Standard deviation	
	Pretest	Postest			Pretest	Postest
Control	40.31	64.79	0.40	24.48	12.96	12.96
Experiment	39.06	79.74	0.66	40.68	13.43	12.98

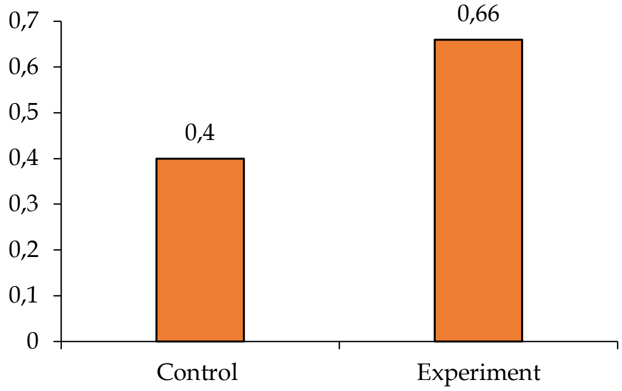

Figure 3. Average n-gain of science literacy

Based on Table 4, it is obtained that there is an increase in the average pretest-posttest in both the control class and the experimental class, but the increase in the experimental class is much higher than the control class. In addition to the increase in pretest and posttest scores, the increase in science literacy is shown through the N-Gain value. The average N-Gain value of students in both the control class and the experimental class for science literacy is shown in Figure 3. Figure 3 shows that the average N-Gain category of the experimental and control classes is in the moderate category, but the N-Gain value of the experimental class is higher than the control class. The effectiveness test in this study includes a test of the difference between the two averages of the control class and the experimental class, and the ANOVA test. The effectiveness test was carried out using SPSS version 27.0 as follows.

Table 5. N-Gain Normality Test of Science Literacy

Class	df	Sig. komogorov-smirnov
Control	64	0.075
Experiment	64	0.058

Based on Table 5, the sig. Komogorov-Smirnov value of scientific literacy in both the control and experimental classes is greater than 0.05. Based on the Ho acceptance test criteria, it means that the research data is normally distributed.

Based on Table 6, the sig value of N-Gain of scientific literacy in both the control and experimental classes is greater than 0.05. Based on the Ho acceptance test criteria, it means that the research data comes from homogeneous variations.

Table 6. N-Gain Homogeneity Test of Science Literacy

Class	df	Sig.
Control	64	0.884
Experiment	64	

Table 7. Independent Sample T Test of Science Literacy

Measured aspects	Class	df	Sig. 2 tailed
Science Literacy	Control Experiment	64	0.000

Based on Table 7, the sig. 2-tailed value of scientific literacy in both the control and experimental classes is less than 0.05. Based on the test criteria, accept H1, meaning that there is a significant difference in the average N-Gain value of scientific literacy of students in the experimental class which is higher than the average N-Gain value of scientific literacy of students in the control class. This is in accordance with research stating that the implementation of PjBL-STEM learning can improve scientific literacy and creative thinking skills (Daryanto & Karim, 2017; Srigati, 2020; Saefullah et al., 2021). According to Azzahra et al. (2023), the use of the PjBL learning model guides students to determine their own learning process in groups, conduct research and create creative projects that can explore knowledge.

Table 8. N-Gain Normality Test of Learning Styles on Science Literacy

Learning styles	df	Sig. kolmogorov-smirnov
Visual	21	0.079
Auditory	22	0.200
Kinesthetic	21	0.200

Based on Table 8, the sig. Komogorov-Smirnov value of students' learning styles towards scientific literacy is greater than 0.05. Based on the Ho acceptance test criteria, it means that the research data is normally distributed.

Based on Table 9, the N-Gain value of students' scientific literacy in each learning style has a sig. > 0.05. This shows the Ho acceptance test criteria which means there is no significant difference between the average N-Gain value of students' scientific literacy with the use of e-LKPD with visual, auditory and kinesthetic learning styles. Based on the ANOVA test, it was found that there was no difference in the scientific literacy values of students who used differentiated e-LKPD which included visual, auditory and kinesthetic. This is because the differentiated e-LKPD that was developed has accommodated the learning needs of students, so that the scientific literacy value has the same increase in students with visual, auditory and kinesthetic learning styles. Differentiated learning is creating classes in the diversity of characters, interests, and needs of students by providing opportunities to process an idea and improve the results of each student, so that they can learn more effectively (Kamal & Qamaruzzaman, 2021).

Table 9. ANOVA Test of Science Literacy

Learning Styles	df	Sig.
Visual	21	
Auditory	22	0.984
Kinesthetic	21	

Table 10. Effect Size Test of Students' Scientific Literacy

Data	Partial eta squared	Effect criteria
Corrected Model	0.040	Small
Initial ability (pretest)	0.040	Small
e-LKPD learning style	0.001	Small

Based on Table 10, the partial eta squared value of the pretest on scientific literacy is 0.040 with a small effect criterion, meaning that students' scientific literacy scores are influenced by the pretest score with a percentage of 4%. The partial eta squared value of the e-LKPD visual, auditory, and kinesthetic learning styles on scientific literacy is 0.001 with a small effect criterion. This means that the scientific literacy score is influenced by the type of e-LKPD, both visual, auditory, and kinesthetic, with a percentage of 1%, because the effect is very small, this influence can be ignored so that the high scientific literacy scores of students are not influenced by e-LKPD with different learning styles because the e-LKPD used has accommodated the learning needs of students. The partial eta squared corrected model value is 0.040 with a small effect criterion, meaning that the pretest and e-LKPD scores, both visual, auditory, and kinesthetic used are only 4% in influencing students' scientific literacy scores, so this influence can be ignored.

Conclusion

Based on the results of the research conducted, it was concluded that learning using integrated differentiated e-LKPD PjBL-STEM can improve scientific literacy at SMPN 1 Tanjung Bintang. The application of the developed e-LKPD guides students to use the knowledge they already have to solve problems that occur in the form of projects that are adjusted to the learning styles of visual, kinesthetic and auditory students. Based on this, integrated differentiated e-LKPD PjBL-STEM has an average percentage of expert validation for the content suitability aspect of 96.42%, the construction suitability aspect of 96.25% and the readability aspect of 90% with very high criteria so that it is declared valid in improving scientific literacy. Integrated differentiated e-LKPD PjBL-STEM has the characteristics of accommodating students' learning styles, an attractive appearance, easy to access, and has an easy-to-understand PjBL-STEM syntax, so that in its learning it encourages students to actively discuss. This is supported by the results of student responses in the readability aspect of 86.25% and the attractiveness of 90% and the percentage of teacher responses with very high criteria in the content suitability aspect of 95%, the readability aspect of 93.75%, and the attractiveness aspect of 98.75%, and supported by the percentage of learning implementation observation results of 77.4% with high criteria. So that the developed e-LKPD is stated to be practical in improving scientific literacy. Integrated differentiated e-LKPD PjBL-STEM is effective in improving scientific literacy. This is based on a significant difference between the average N-Gain value of scientific literacy and creative thinking skills of the experimental class and the control class. This is supported by the small effect size criteria for the use of differentiated e-LKPD with visual, auditory, and kinesthetic learning styles on scientific literacy, meaning that the use of different e-LKPDs still improves scientific literacy because the developed differentiated e-LKPD has accommodated students' learning styles.

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A.S. contributed in conducting research and writing the article; A.S., and A. contributed as article reviewers.

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Conflicts of Interest
The authors declare no conflict of interest.

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