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Optimization Of Progressive Scientific Literacy Based On The Sciedugame Mobile Application On The Topic Of Earth And The Solar System At SMP Negeri 56 Surabaya

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ABSTRACT

This study aimed to analyze the effect of the *Sciedugame Mobile* application on the development of students' progressive scientific literacy in junior high school science learning. A quasi-experimental design was employed with two eighth-grade classes at SMP Negeri 56 Surabaya. The experimental class used the *Sciedugame Mobile* application, while the control class received conventional instruction. Data were collected through pre-test and post-test assessments, classroom observations, and student questionnaires. The results showed that the experimental group achieved higher learning gains than the control group. The average post-test score in the experimental class was 68.38, compared to 58.48 in the control class. The normalized gain (N-Gain) in the experimental group was 0.49 (moderate), while the control group scored 0.36. A t-test confirmed a significant difference between the two groups (tcount = 1.87 > ttable = 1.67 at $\alpha = 0.05$). In addition, scientific literacy indicators—such as conceptual understanding, scientific process skills, and real-life application—improved more significantly in the experimental class. Observation results also indicated higher implementation quality in the experimental group (97.44%) compared to the control group (76.92%). Furthermore, student responses toward the application were overwhelmingly positive in terms of usability, content clarity, and engagement. These findings suggest that *Sciedugame Mobile* is a promising mobile learning tool to support progressive scientific literacy in science education.

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A. INTRODUCTION

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The Merdeka Curriculum is a transformation of the national learning approach that emphasizes flexibility, contextualization, and the development of student competencies. This curriculum is designed to provide students with the opportunity to explore subject matter in depth and meaningfully, rather than merely aiming for administrative graduation. One of the key components that distinguishes the Merdeka Curriculum from the 2013 Curriculum is the Learning Outcomes (Capaian Pembelajaran or CP), which replace the previous structure of Core Competencies and Basic Competencies (KI-KD). CP serves as a concrete form of paradigm shift from content-based approaches to learning that cultivates 21st-century skills. At Phase D for Science (IPA) subjects, especially in the comprehension element, it is stated that students must be able to elaborate on the relative positions of the Earth, Moon, and Sun within the solar system, as well as understand the structure of the Earth's layers in relation to natural phenomena and disaster mitigation (Kemendikbudristek, 2022).

According to the Kamus Besar Bahasa Indonesia (KBBI), elaboration means working diligently and meticulously. In the educational context, elaboration refers to the ability to develop ideas in order to solve problems in detail (Ode, 2019). Wiggins and McTighe define elaboration as an integral part of effective learning, aiming to deepen understanding and apply knowledge across various contexts (Hosseini et al., 2019). It is a process of expanding and enriching students' comprehension through detailed explanations, additional examples, and connecting new concepts to prior knowledge. To achieve deep understanding, students must engage in elaborative processes that involve analysis, synthesis, and evaluation of information (Wiggins & Christopherson, 2019). This requires learners not only to memorize facts but also to develop scientific skills through critical, analytical, and reflective thinking.

A survey at SMP Negeri 56 Surabaya revealed that students' understanding of the Earth and Solar System remains low: only 54% showed adequate comprehension, 32% demonstrated scientific process skills, and 39% achieved scientific literacy. Yet, 82% answered contextual questions correctly, indicating strong potential if supported by contextual and innovative learning. These findings underline the urgency of developing strategies aligned with the Merdeka Curriculum to enhance progressive scientific literacy.

In the CP of the Merdeka Curriculum, scientific process skills have become inseparable. There are six types of process skills that must be developed: observing; questioning and predicting; designing and conducting investigations; processing and analyzing data; evaluating and reflecting; and communicating results (Kemendikbudristek, 2022). This highlights that science learning can no longer be limited to one-way information transfer from teacher to student but must instead be based on active exploration and inquiry. In relation to scientific literacy, OECD (2017) states that this ability encompasses understanding scientific concepts and processes, evaluating evidence, and making decisions based on science. PISA, as a global benchmark, defines scientific literacy into three main components: scientifically explaining phenomena, designing investigations, and evaluating and interpreting scientific data. Unfortunately, the 2022 PISA report shows that Indonesia's scientific literacy score declined by 13 points compared to 2018, indicating stagnation or even regression in students' ability to understand and apply science in real life (OECD, 2023).

The decline in scientific literacy is closely linked to adolescents' uncontrolled gadget use and online gaming. Studies show gaming addiction reduces motivation and causes psychological issues (Anwar & Winingsih, 2021; Haidar & Antika, 2022), with WHO classifying it as a mental disorder (Kemenkes, 2018). Indonesia even ranks third globally in online gaming, with 94.5% of users aged 16–64 (katadata.co.id), making this both a social and educational challenge.

Nevertheless, many studies show that the use of digital technology and educational games can serve as a solution to bridge digital entertainment with the learning process. Research by Karlina & Abidin (2022) found that HOTS-based educational games contributed significantly to a 50.76% increase in scientific literacy. Another study by Andari (2020) showed that the use of the Kahoot! application significantly improved students' learning outcomes and interaction compared to conventional methods such as PowerPoint. These findings suggest that well-designed digital media can serve as powerful tools to enhance conceptual understanding and scientific skills. However, most existing research still focuses on short-term outcomes and lacks emphasis on sustainable, progressive scientific learning. Thus, the state of the art shows that while game-based learning has proven effective in increasing student engagement and outcomes, there is still a lack of digital media specifically designed to cultivate long-term, continuous scientific literacy in accordance with the demands of the Merdeka Curriculum.

With this condition, there is a clear gap in the use of digital learning media, particularly in efforts to build progressive scientific literacy. Previous studies have generally been limited to evaluating short-term learning outcomes and have not explored the potential of mobile learning platforms that integrate contextual exploration with progressive inquiry in science education. Therefore, the novelty of this research lies in the implementation and optimization of the Sciedugame Mobile application as a game-based learning platform that not only supports interactive learning but also focuses on progressive scientific literacy in the topic of the Earth and the Solar System.

Based on this background, the purpose of this study is to implement and optimize the use of Sciedugame Mobile in science learning in order to improve conceptual understanding, scientific process skills, and progressive scientific literacy of junior high school students on the topic of the Earth and the Solar System.

B. METHODS

This study employed a quantitative method to examine the effect of the Sciedugame Mobile application on students' progressive scientific literacy. Quantitative research was chosen because it enables objective and numerical analysis to identify relationships between variables (Ghanad, 2023). The research was conducted at SMP Negeri 56 Surabaya, East Java, Indonesia**,** from May 13 to September 12, 2024. This school was selected purposively because preliminary observations showed that students' scientific literacy and process skills, particularly in the topic of the Earth and the Solar System, were still relatively low, making it a relevant setting for the study.

The participants consisted of 70 eighth-grade students selected through purposive sampling. They were divided into two groups: the experimental group (Class VIII B, 35 students) received instruction using Sciedugame Mobile for 2 instructional hours (JP) per session, while the control group (Class VIII C, 35 students) underwent traditional instruction without the application. The independent variables were the use and duration of Sciedugame Mobile, while the control variables included instructional time, grade level, and number of students. The dependent variables consisted of progressive scientific literacy, learning outcomes, and student responses to the intervention.

Operational definitions of variables referred to curriculum objectives (Kemendikbudristek, 2022) and PISA scientific literacy indicators (OECD, 2017). Research instruments included pre–post tests (15 multiple-choice items), rubric-based observation sheets, and structured questionnaires (Singh et al., 2017). Validity was established through expert judgment and Aiken's V (Aiken, 1980), while reliability was tested with Cronbach's Alpha (Cronbach, 1951).

Table 1. Indicators of Scientific Literacy Assessed in the Instrument

No	Indicator Category	Item Numbers
1	Understanding scientific concepts	1, 2, 3, 4, 5, 6
2	Connecting science to real-life problems	13, 14, 15
3	Scientific process skills	7, 8, 9, 11

No	Indicator Category	Item Numbers
4	Representing scientific understanding	10, 12
5	Mobile-based structural task completion	[Practical Task]

The research procedure included a preparation phase (school observation, instrument and material development, sampling), an implementation phase (administration of pre-test, learning intervention using the application, post-test, and observation), and a final analysis phase (data processing, interpretation, and conclusion drawing). Data collection involved both test and non-test techniques, while data analysis included descriptive statistics to calculate the implementation percentage of scientific literacy (Sugiyono, 2022), normality testing using the Chi-Square method (Pearson, 1900), homogeneity testing using Hartley's Fmax (Siantur, hypothesis testing with a parametric t-test at a 0.05 significance level , and normalized gain (N-Gain) analysis to measure learning effectiveness (Hake, 1998). The N-Gain results were interpreted using the classification shown in Table 2.

Table 2. Normalized Gain (N-Gain) Interpretation Criteria

N-Gain Value	Interpretation
≥ 0.70	High
0.30 – 0.69	Medium
0.00 – 0.29	Low

C. RESULT AND DISCUSSION

1. Implementation of Learning

a. Learning Implementation Results

Based on the observation results of learning implementation in the experimental and control classes in Table 3., it was found that the use of *Sciedugame Mobile* had a higher level of implementation compared to conventional methods. The implementation percentage in the experimental class reached 97% and 95%, while in the control class it was only 77% and 82%. This difference indicates that application-based learning is more effective in enhancing student engagement during the learning process. In the experimental class, almost all aspects of learning received the maximum score (3) from both observers, particularly in terms of student enthusiasm, group discussions, application exploration, and understanding of the material. However, some aspects still received slightly lower scores (2), such as the explanation of learning objectives, instructional clarity, and connecting the material to broader scientific concepts. Nevertheless, the experimental class showed significant advantages in aspects such as teacher guidance in accessing the application, student exploration within the app, and increased understanding of the material—features that were not found in the control class.

Students in the experimental class were more active in discussions and collaboration in completing tasks compared to those in the control class. Additionally, the aspect of application exploration in learning was only present in the experimental class, indicating that the use of *Sciedugame Mobile* provided a more interactive and contextual learning experience. The students' improvement in understanding the material was also higher than that of the control group, supporting the hypothesis that application-based learning can enhance students' scientific literacy.

Table 3. Observation of Learning Implementation in Experimental and Control Classes

Aspect	Experimental Class		Control Class	
	Observer 1	Observer 2	Observer 1	Observer 2
Implementation Percentage	97.44%	94.87%	76.92%	82.05%
Implementation Criteria	Very Good	Very Good	Good	Good

b. Discussion

The findings indicate that the use of Sciedugame Mobile significantly improved instructional quality and student engagement. Higher implementation scores in the experimental class, especially in enthusiasm, group discussion, and re-explaining concepts, show that application-based learning supports active and meaningful learning aligned with progressive scientific literacy.

Nevertheless, some indicators such as clarity of objectives, explanation of methods, and connection to broader concepts scored lower. This suggests that while digital learning promotes interaction, teacher-led direction and contextual integration remain essential. As Arends (2012) notes, clear objectives help students follow lesson direction, while Vygotsky (1980) emphasizes scaffolding in technology-based learning, where understanding develops through progressive exploration.

Another strength observed was the teacher's guidance in using the application, which ensured effective digital engagement (Ortikov & Ugli, 2024). Student participation in exploration and simulation also confirmed the interactive nature of the app, consistent with Rahayu et al. (2022) who showed that simulation-based learning improves conceptual understanding. Collaboration and task completion were likewise stronger in the experimental class, in line with constructivist learning theory that emphasizes self-directed exploration. Overall, Sciedugame Mobile enhanced not only technical execution but also engagement, collaboration, and mastery of concepts. These results affirm its potential as an effective tool to foster progressive scientific literacy in junior high school science learning.

2. Effect of Sciedugame Mobile on Scientific Literacy

a. Results of the Influence of the Implementation of the Sciedugame Mobile Application on Progressive Scientific Literacy

The implementation of *Sciedugame Mobile* was analyzed for its impact on the progressive scientific literacy of junior high school students. This study involved 70 eighth-grade students from SMP Negeri 56 Surabaya, divided into two groups: an experimental class that received instruction using the mobile application and a control class that received conventional learning without the application. Pre-tests and post-tests were administered to both groups, consisting of 15 multiple-choice questions and 5 essay questions aligned with scientific literacy indicators.

Table 4. Frequency Data of Pre-test and Post-test Scores

Data & Class	f0 (Experiment Class)	f1 (Experiment Class)	f0 (Control Class)	f1 (Control Class)
0–25	3	0	4	0
26–50	30	0	31	8
51–75	2	33	0	27
76–100	0	2	0	0
Total	35	35	35	35

The experimental class showed a greater improvement in scores compared to the control group. The pre-test average in the experimental class was 37.33 (SD = 8.12), increasing to 68.38 (SD = 8.30) on the post-test. Meanwhile, the control group improved from 35.24 (SD = 7.85) to 58.48 (SD = 10.11). Both groups were statistically equivalent at the start of the study, as indicated by Hartley's test of homogeneity (Fcount < Ftable) and Chi-Square normality test (χ^2count < χ^2table).

Table 5. Results of the Homogeneity Test of Pretest and Posttest Values

Test Type	S^2 Control	S^2 Experiment	F-count	F-table	Conclusion
Pre-Test	20.25	24.01	1.19	2.04	Homogeneous
Post-Test	27.04	14.44	1.87	2.04	Homogeneous

Table 6. Research Data Normality Test

Category	f_0 Control Class	f_0 Experiment Class	f_h Control Class	f_h Experiment Class	Chi-Square Control Class	Chi-Square Experiment Class
Passed	0	2	27	34	27.00	30.12
Not Passed	35	33	8	1	91.13	1024.00
Total χ^2	–	–	–	–	**1172.24**	

A parametric independent t-test was conducted to assess significance, resulting in tcount = 1.87 > ttable = 1.67 (α = 0.05) Table 7., indicating a statistically significant difference in post-test scores. Further analysis using normalized gain (N-Gain) showed that the experimental class achieved an average gain of 0.49 (moderate), while the control group had a lower gain of 0.36. Table 8. summarizes the comparative gain scores across the five indicators of progressive scientific literacy.

Table 7. T-test on Increasing Scientific Literacy

Category	N (Sample Size)	Variance (S^2)	Mean ($\bar{x}$)	Total S^2	Standard Deviation	t-count	t-table
Experiment Class	35	76.04	68.19	89.11	9.44	1.87	1.67
Controll Class	35	102.18	58.48	-	-	-	-

Table 8. N-gain results of progressive scientific literacy assessment

Scientific Literacy Indicator	Experimental Class	Control Class
Understanding scientific concepts	0.65 (Moderate)	0.33 (Moderate)
Connecting science with real-life problems	0.63 (Moderate)	0.29 (Low)
Completing mobile-based scientific tasks	0.61 (Moderate)	0.34 (Moderate)
Developing scientific process skills	0.56 (Moderate)	0.27 (Low)
Representing scientific understanding	0.56 (Moderate)	0.31 (Moderate)

These results suggest that the *Sciedugame Mobile* application not only enhances conceptual understanding but also strengthens students' ability to apply scientific knowledge in real-world contexts and improve inquiry-based skills. The gain scores indicate that students in the experimental group achieved higher levels of scientific literacy across all measured dimensions. With an overall effectiveness level of 68%, the mobile application is categorized as "quite effective" and is recommended as an instructional tool for progressive science learning at the junior high school level.

b. Discussion

The implementation of Sciedugame Mobile significantly improved students' progressive scientific literacy, as shown by higher post-test scores and N-Gain values in the experimental class (0.49) compared to the control class (0.36). This indicates that mobile-based learning is more effective than conventional methods in supporting conceptual understanding and engagement. Sciedugame Mobile provides exploratory and problem-solving-based activities that help students connect scientific concepts with real-life contexts, consistent with Oskarita & Arasy (2024) who note its impact on critical and analytical thinking. In line with Piaget's theory, the app supports students in the concrete to early formal operational stage by offering interactive simulations that foster discovery learning.

The highest improvement occurred in conceptual understanding (N-Gain = 0.65), while scientific process skills also improved (0.56), surpassing the control group. These findings align with Sweller's (1988) Cognitive Load Theory, where multimedia learning reduces extraneous load and enhances retention. This study also supports previous findings (Karlina & Abidin, 2022; Andari, 2020) on the positive role of game-based learning, while contributing new evidence on mobile apps specifically designed for progressive scientific literacy. Overall, Sciedugame Mobile is recommended as an effective tool to strengthen conceptual mastery, problem-solving, and real-world application in junior high school science learning.

3. Student Responses to the Use of Sciedugame Mobile

a. Results of Student Responses to the Implementation of the Sciedugame Mobile Application

The results of the student response questionnaire showed that the majority of students responded positively to the use of *Sciedugame Mobile* in learning the topic of Earth and the Solar System. Most students reported that the application was easy to access, engaging, and helped them understand the material more deeply. However, several students experienced technical difficulties or suggested improvements regarding the user interface (UI) and features.

According to the questionnaire data, most students favored the use of *Sciedugame Mobile* as a learning medium due to its accessibility, attractive design, and interactive features that made learning more enjoyable. This finding is supported by the Self-Determination Theory (Criollo-C et al., 2021), which states that students are more motivated to learn when they feel in control of their own learning process. The responses also align with Keller's ARCS Model (1987), which suggests that an effective instructional medium should capture Attention, ensure Relevance, boost Confidence, and provide Satisfaction in the learning process.

Table 9. Student Response to the Sciedugame Mobile Application

Response Aspect	Response Score					
	1	2	3	4	YES	NO
Tendency to Use Sciedugame Mobile Application for Mobile Learning	1	2	16	16	–	–

Evaluation of Application UI and UX	1	3	15	16	–	–
Ease of Accessing the Sciedugame Mobile Application	1	2	13	19	–	–
Development of GIM Application	1	1	14	19	–	–
Can the Sciedugame Mobile Application Help in Learning?	–	–	–	–	34	0
Is the Sciedugame Mobile Application Relevant to Earth and Solar System Topics?	–	–	–	–	1	1

In comparison to traditional learning methods, *Sciedugame Mobile* offers a more interactive and technology-based approach that supports more effective understanding of scientific concepts. This is consistent with Mayer's Cognitive Theory of Multimedia Learning (2005), which highlights the effectiveness of combining visual, auditory, and interactive elements to improve conceptual comprehension.

Although the responses were predominantly positive, several technical issues were reported: (1) Difficulties in accessing the application due to device or internet limitations; (2) Compatibility challenges on certain student devices; (3) Suggestions to enhance the user interface to be more intuitive and visually appealing.

These challenges are in line with Cognitive Load Theory (Sweller, 1988), which emphasizes that overly complex or poorly designed learning media can increase extraneous cognitive load, thus hindering learning. To address these issues, it is recommended that: (a) Interactive features such as adaptive quizzes and virtual simulations be improved; (b) UI/UX be simplified to ensure usability for students less familiar with digital learning; (c) An offline mode be developed for students with limited internet access.

Overall, the questionnaire data suggests that *Sciedugame Mobile* has high potential as a digital learning tool, with broad student support for its use in science education. The application not only supports scientific literacy but also enhances student motivation and engagement in learning through an enjoyable and explorative experience.

b. Discussion

Student responses toward Sciedugame Mobile were generally positive, highlighting its ease of access, clarity, design, and interactivity. These results show that the application effectively promotes engagement and comprehension in science learning. From the perspective of Self-Determination Theory (Ryan & Deci, 1985) and Keller's ARCS Model (1987), students' enthusiasm reflects intrinsic motivation supported by attention, relevance, confidence, and satisfaction.

The interactive and gamified features—quizzes, simulations, and missions—encourage active knowledge construction in line with Constructivist Learning Theory and Mayer's Cognitive Theory of Multimedia Learning (2005). Such media not only enhance retention but also connect abstract concepts to real-life applications. Minor challenges were noted, such as device compatibility and internet access, which may increase extraneous cognitive load (Sweller, 1988). To address this, refinement of UI/UX and offline access is recommended. Overall, student feedback confirms that Sciedugame Mobile is both functional and motivating, supporting progressive scientific literacy in junior high school learning.

D. CONCLUSION AND SUGGESTIONS

The study demonstrates that Sciedugame Mobile significantly enhances students' progressive scientific literacy in the topic of Earth and the Solar System. Implementation in the experimental class was more effective than in the control group, particularly in fostering conceptual understanding, exploration, and engagement. Learning outcomes also improved, as shown by higher post-test scores and N-Gain (0.68 vs. 0.36), confirming the superiority of mobile-based learning over conventional methods.

Student responses were highly positive, with most considering the application easy to use, visually appealing, and supportive of learning, though minor technical issues such as device compatibility and internet access were noted. Overall, Sciedugame Mobile is an innovative and effective tool for junior high school science education, with future development needed to improve accessibility and integration with broader pedagogical strategies.

Research suggestion is (1) Sciedugame Mobile should be integrated into junior high school science learning as supportive media to enhance scientific literacy, both for content delivery and evaluation; (2) Teachers need to ensure students' access to compatible devices and internet, provide guidance in operating the app, and emphasize conceptual explanation and contextual integration; (3) Further research is recommended to evaluate the long-term effectiveness of Sciedugame Mobile, develop advanced features such as AR or virtual labs, and examine its impact on critical thinking, problem-solving, and hybrid learning.

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REFERENCES

Andari, R. (2020). *PEMANFAATAN MEDIA PEMBELAJARAN BERBASIS GAME EDUKASI KAHOOT! PADA PEMBELAJARAN FISIKA*. *6*(1). https://scholar.google.co.kr/citations?u

Anwar, N. R., & Winingsih, E. (2021). *PENGARUH KECANDUAN GAME ONLINE TERHADAP PRESTASI AKADEMIK SISWA SEKOLAH MENENGAH PERTAMA NEGERI 5 BANJAR DIMASA PANDEMI COVID-19*. https://ejournal.unesa.ac.id/index.php/jurnal-bk-unesa/article/view/44159/37560

Ghanad, A. (2023). An Overview of Quantitative Research Methods. *INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS*, *06*(08). https://doi.org/10.47191/ijmra/v6-i8-52

Haidar, W. M., & Antika, E. R. (2022). Prestasi Akademik Siswa Ditinjau Dari Kecanduan Bermain Game Online Mobile Legends. *TERAPUTIK: Jurnal Bimbingan Dan Konseling*, *5*(3), 319–325. https://doi.org/10.26539/teraputik.53872

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hosseini, H., Chalak, A., & Biria, R. (2019). Impact of Backward Design on Improving Iranian Advanced Learners' Writing Ability: Teachers' Practices and Beliefs. *International Journal of Instruction*, *12*(2), 33–50. https://doi.org/10.29333/iji.2019.1223a

Karlina, L., & Abidin, Z. (2022). Meta analisis pengembangan media pembelajaran game edukasi biologi berbasis soal HOTS (Higher Order Thinking Skill) terhadap literasi sains siswa SMA. *Jurnal Ilmiah Wahana Pendidikan*, *8*(10), 209–215. https://doi.org/10.5281/zenodo

Kemendikbudristek. (2022). *Capaian Pembelajaran Ilmu Pengetahuan Alam Fase D*. Kementerian Pendidikan, Kebudayaan Dan Riset Teknologi Republik Indonesia.

Kemenkes. (2018). *Kemenkes: Kecanduan Game Adalah Gangguan Perilaku*. Kementerian Kesehatan Republik Indonesia.

Mayer, R. E. (2005). *The Cambridge Handbook of Multimedia Learning*. Cambridge University Press. http://molwave.chem.auth.gr/sigalas_edu/files/Multimedia_Learning.pdf

Ode, A. S. (2019). KEMAMPUAN BERPIKIR KRITIS DAN KREATIF MATEMATIS MELALUI PEMBELAJARAN BERBASIS MASALAH. In *Journal of Mathematics Education and Science* (Vol. 5, Issue 1).

OECD. (2017). *PISA 2015 Assessment and Analytical Framework*. OECD. https://doi.org/10.1787/9789264281820-en

OECD. (2023). *PISA 2022 Results Factsheets Indonesia PUBE*. https://oecdch.art/a40de1dbaf/C108.

Ortikov, U., & Ugli, K. (2024). *THE EFFECTIVENESS OF TECHNOLOGY-ENHANCED LANGUAGE LEARNING METHODS* (Vol. 4, Issue 3). www.oriens.uz

Oskarita, E., & Arasy, H. N. (2024). The Role of Digital Tools in Enhancing Collaborative Learning in Secondary Education. *International Journal of Educational Research*, *1*(1), 26–32. https://doi.org/10.62951/ijer.v1i1.15

Pearson, K. (1900). X. *On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling*. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, *50*(302), 157–175. https://doi.org/10.1080/14786440009463897

Rahayu, M., Asyhari, A., & Anjani, A. V. (2022). Scaffolding in guided inquiry learning with google classroom: Effect on physics conceptual understanding. *Jurnal Inovasi Pendidikan IPA*, *8*(2), 174–184. https://doi.org/10.21831/jipi.v8i2.48365

Ryan, R. M., & Deci, E. L. (1985). *Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being Self-Determination Theory*. Ryan.

Singh, C. K. S., Lebar, O., Kepol, N., Rahman. Rafiah Abdul, & Mukhtar, K. A. M. (2017). An Observation Of Classroom Assessment Practices Among Lecturers In Selected Malaysian Higher Learning Institutions. *Malaysian Journal of Learning and Instruction*, *14*(1), 23–61.

Sugiyono. (2022). *Metode Penelitian Kuantitatif Kualitatif Dan R&D* (2nd ed.). Alfabeta.

Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. In *COGNITIVE SCIENCE* (Vol. 12).

VYGOTSKY, L. S. (1980). *Mind in Society* (M. Cole, V. Jolm-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4

Wiggins, B. J., & Christopherson, C. D. (2019). The replication crisis in psychology: An overview for theoretical and philosophical psychology. *Journal of Theoretical and Philosophical Psychology*, *39*(4), 202–217. https://doi.org/10.1037/teo0000137