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Improving Digital Literacy of Elementary Teacher Candidates Through Digital-Based RADEC Learning Model

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ABSTRACT

In the digital age, enhancing digital literacy among prospective primary school teachers is crucial for effective education. The purpose of this study is to evaluate how well RADEC's digital learning paradigm improves digital literacy skills compared to traditional training. The study involved 100 students from two institutions and used a quasi-experimental pretest-posttest control group design. They were divided into two groups. The experimental group received the RADEC intervention, and the control group used conventional teaching methods. Data was collected using digital literacy evaluation. The normality test showed that the data was not distributed normally; As a result, the analysis must use nonparametric statistical techniques. The Wilcoxon Marked Rating Test is the most commonly used technique in this regard. Both groups showed different digital literacy scores between pretest and posttest. The experimental group showed a more significant improvement ($Z = -6.205$, $p < 0.001$) compared to the control group ($Z = -3.036$, $p < 0.002$). These findings suggest that the digital-based RADEC learning model is significantly more effective in enhancing digital literacy among prospective teachers than traditional methods, highlighting the need for innovative teaching strategies in teacher education programs.

Keywords: digital literacy, RADEC learning model, quasi-experimental design, teacher education, Indonesia

INTRODUCTION

As we all know that digital literacy is a critical ability for aspiring teachers in today's digital age, particularly at the basic education level (Feng and Sumettikoon, 2024). Effective use of information and communication technologies helps students learn and equips them to handle the challenges of a society that is becoming more interconnected by the day. Therefore, to include technology into their instruction, aspiring teachers must acquire sufficient digital literacy (Giakas et al., 2024). One creative strategy for raising future teachers' digital literacy is the RADEC (Read, Answer, Discuss, Explain, Create) learning paradigm (Satria and Sopandi, 2019). By using this paradigm, aspiring educators develop their critical and creative thinking skills in addition to their technological proficiency. Collaboration and conversation are fostered by this interactive learning process, which is crucial in the context of 21st century education.

The RADEC model's application in Indonesian education has the potential to yield major benefits (Siregar et al., 2020). In this setting, aspiring educators will receive training in reading and evaluating digital content, responding to pertinent inquiries, engaging in peer discussions, elucidating acquired concepts, and developing original goods or solutions (Suhardiman et al., 2024). As a result, they will be more equipped to handle obstacles

in the always changing field of education. Government policies that promote the use of technology in education also emphasize the significance of fostering digital literacy among aspiring educators. It is anticipated that aspiring educators would acquire the digital skills required for successful instruction through training and professional development initiatives (Suherman et al., 2020). This is consistent with initiatives to raise the standard of education in Indonesia, particularly in the elementary grades.

In this project, the authors investigate how the RADEC model can be used to enhance Indonesian pre-service teachers' digital literacy (Handayani et al., 2019). The authors also will examine the various approaches and techniques that can be applied to include this concept into the curriculum for teacher education, and discuss the difficulties that could arise when putting this model into practice, and how to get beyond them (Bal and Akcil, 2024). It is envisaged that this research will significantly advance Indonesian education by using a methodical and evidence-based approach. Enhancing the digital literacy of aspiring educators not only equips them to become more effective instructors but also assists them in becoming social change activists.

However, we believe that increasing digital literacy among prospective teachers through the RADEC model will have a positive impact on students and society as a whole (Rahman et al., 2020). By preparing prospective teachers who are competent in the use of technology, we can create a generation that is better prepared to face future global challenges. This research is expected to be the first step in realizing this vision. Introduction In today's digital era, this research is a very important for prospective teachers, especially at the basic education level. The ability to use information and communication technologies effectively not only supports the learning process but also prepares students to face the challenges of an increasingly connected world. Therefore, prospective teachers need to develop adequate digital literacy to integrate technology in their teaching (Banihashem et al., 2024).

Meanwhile, The RADEC (Read, Answer, Discuss, Explain, Create) learning paradigm is a novel way to promote digital literacy in potential teachers (Sukardi et al., 2021). Using this technique, potential teachers learn not only to use technology, but also to think critically and creatively when solving challenges. This interactive learning approach promotes collaboration and conversation, which is critical in the context of 21st-century education (Lestari et al., 2021). The introduction of the RADEC model in Indonesian education could have a huge positive influence. Prospective instructors will be prepared in this context to read and analyze digital information, respond to pertinent questions, engage in peer discussions, explain concepts learnt, and develop unique products or solutions. As a result, kids will be more prepared to address obstacles in an ever-changing educational environment.

Based on the introduction above, the author explores the following research questions:

1. Is there a discernible difference between the control group's pretest and post-test results using the traditional teaching approach?
2. Does the experimental group that used the digitally based RADEC (Read, Answer, Discuss, Explain, and) learning model have significantly different pretest and posttest scores?
3. After applying their respective learning models, how do the experimental group's digital literacy score improvements compare to those of the control group?
4. Does the digital-based RADEC learning model improve future elementary school teachers' digital literacy more effectively than the traditional learning model?
5. What are the implications of implementing the digital-based RADEC model for teacher education programs in Indonesia?

LITERATURE REVIEW

Indonesia Digital Literacy and Challenge

The condition of digital literacy in Indonesia is still a serious concern for the government and society. According to data from UNESCO, Indonesia is still below the world average in terms of digital literacy. This can be seen from the results of a survey that shows that only 34.6% of the Indonesian population has access to the internet, and only 12.6% have adequate digital literacy skills (Sorokolit et al., 2024). If we look at it in the context of education, prospective teachers need to have digital literacy skills, especially at the basic education level. The ability to practice communication technologies and information effectively not only supports the learning process but also prepares students to fight for the world. Therefore, prospective teachers need to develop adequate digital literacy to integrate technology in their teaching (Cuiñas and Augusto, 2022; Lestari et al., 2022).

Digital Literacy Statistical Index in Indonesia

Indonesia's digital literacy index score increased from 3.46 in 2020 to 3.54 in 2022, according to a 2022 survey. This indicates that Indonesia's digital culture and capabilities have significantly improved, although internet ethics and security across the country have weakened (Nuryadi and Widiatmaka, 2023). This shows that, compared to the previous year, Indonesians are better at double-checking information found on the internet and paying more

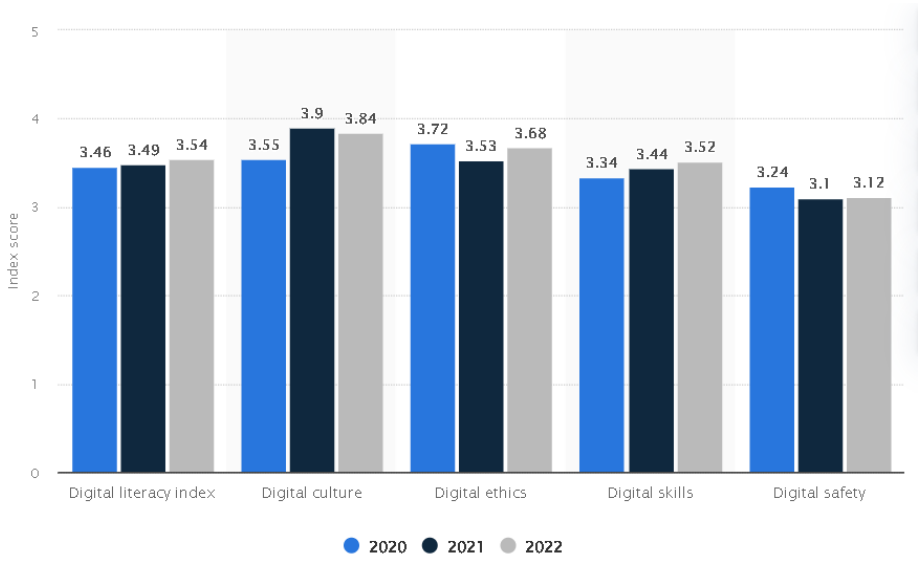

Figure 1. Indonesia digital literacy index (Source: Indonesia Statistical Index, 2022)

attention to the opinions of readers from various ethnic, religious, and political backgrounds. However, Indonesian internet users do not care about sharing content without consent and are unaware of the importance of safeguarding their data (**Figure 1**).

In line with research conducted by Axelrod and Kahn (2024) shows that prospective teachers in Indonesia still have difficulties in developing digital literacy. The study found that only 25% of prospective teachers have adequate digital literacy skills, while the other 75% still need professional training and development to improve their digital literacy skills. The RADEC (Read, Answer, Discuss, Explain, Create) is an innovative learning model approach in improving digital literacy among prospective teachers. By applying this model, prospective teachers not only learn to use technology, but also to think critically and creatively in solving problems. This interactive learning process encourages collaboration and discussion, which is very important in the context of 21st century education (Mago et al., 2023).

Based on the research conducted by Sukardi et al. (2021), it was found that implementing the RADEC model in Indonesian education can have a major positive impact. This study discovered that prospective teachers who participated in the RADEC model-based training program had higher levels of digital literacy than prospective teachers who did not participate. Setiawan et al. (2020) explored that prospective instructors are expected to grasp the digital skills required for effective teaching through training and professional development programs. This is consistent with efforts to increase the quality of education in Indonesia, particularly at the basic level. By increasing the digital literacy of potential teachers, here we do not only prepare them to become better educators, but also help them to become agents of change in society (Jasin et al., 2024). However, the condition of digital literacy in Indonesia shows significant challenges (Nuryadi and Widiatmaka, 2023). Despite advances in technology access, there are still many regions that are experiencing a digital divide. According to a report from the Ministry of Communication and Information Technology, only about 50% of the population in rural areas has adequate internet access. This has an impact on digital literacy skills, where many prospective teachers do not have direct experience in using technology for learning (Isnah et al., 2022).

We do believe that the importance of digital literacy among prospective teachers cannot be ignored, especially in the context of learning that is increasingly dependent on technology. Research shows that prospective teachers who have good digital literacy tend to be more effective in teaching and can utilize various digital resources to improve the student learning experience. Therefore, the development of digital literacy must be a priority in teacher education. The RADEC learning model offers an interesting approach to improving digital literacy. By integrating the elements of reading, answering, discussing, explaining, and creating, this model encourages prospective teachers to be more active in the learning process. Sukardi et al. (2022) shows that prospective teachers involved in the RADEC model show significant improvements in their digital literacy skills, as well as creative thinking skills and critical. Meanwhile, challenges in the implementation of the RADEC model also need to be considered. Some prospective teachers may feel uncomfortable with the use of technology or lack confidence in their digital skills. Therefore, it is important to provide adequate training and ongoing support so that they can overcome these barriers. Research by Hayati et al. (2023) emphasizes the need for mentoring programs for prospective teachers to ensure the success of the implementation of this model. Government policies that support the development of digital literacy also play an important role. Training programs designed to improve the digital skills of prospective teachers should be integrated into the educational curriculum. This is in line with efforts to improve the quality of

education in Indonesia, where digital literacy is one of the key competencies that must be possessed by educators (Septiani et al., 2024).

METHOD

Research Design

A quasi-experimental design model is used in a pretest-posttest control group design model. By contrasting the pretest and posttest results of the experimental group—which received special treatment—with the control group, which received traditional instruction, this design was utilized to assess the efficacy of the learning intervention.

Population and Sample

The population for this study comprised students from the Elementary School Teacher Education Study Program (PGSD) at two institutions in Indonesia. The research sample was selected using purposive sampling, with a total of 100 students divided into two groups:

1. Experimental group: 50 students from STKIP Babunnajah who received the intervention of the digital-based RADEC learning model.
2. Control group: 50 students from STKIP Syekh Mansur who followed the conventional learning model.

Both institutions were selected based on comparable characteristics including: similar accreditation status, comparable student academic profiles (based on entry test scores), similar faculty qualifications, and equivalent technological infrastructure. This selection aimed to minimize potential confounding variables while acknowledging the limitation that institutional differences might still influence results.

Research Instruments

The digital literacy assessment instrument used in this study was adapted from the International ICT Literacy Panel framework, which evaluates five core components: access, manage, integrate, evaluate, and create. The instrument consisted of 30 items across these domains, with each item scored on a scale of 1–5. The instrument underwent content validation by three experts in educational technology and demonstrated good reliability (Cronbach's alpha = 0.87) in a pilot study with 30 students from a similar demographic. The assessment was administered as both a pretest and posttest to measure students' digital literacy skills development before and after the learning intervention.

Data Collection Techniques

The same assessment instrument was used for data collection in both the pretest and posttest phases for both groups. The pretest was administered before the learning intervention began, and the posttest was administered after the complete learning sequence concluded. All participants provided informed consent, and the study received approval from the institutional ethics committee.

Data Analysis Techniques

The data analysis approach used in this research is carried out in stages. First, the data were examined for regularity using the Shapiro-Wilk and Kolmogorov-Smirnov tests. If the test results show a significance value of less than 0.05 ($p < 0.05$), indicating that the data is not normally distributed, the analysis is continued using a non-parametric statistical test.

One of the methods used in this analysis is the Wilcoxon Signed Ranks Test, which examines the differences between the pretest and posttest scores for each group. The effectiveness of the digital-based RADEC learning paradigm in raising students' digital literacy is then evaluated using the results of this statistical test.

RESEARCH RESULTS

Normality Test Results

The data from both the experimental and control groups were tested for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests. The results are presented in **Table 1**.

Table 1. Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistics	df	Significance	Statistics	df	Significance
Pretest control	.228	50	.000	.866	50	.000
Post-test control	.241	50	.000	.902	50	.001
Pretest experiment	.275	50	.000	.854	50	.000
Post-test experiment	.442	50	.000	.576	50	.000

[a] Lilliefors significance correction

Table 2. Descriptive statistics of digital literacy scores

	N	Mean	SD	Median	Min	Max
Pretest Control	50	62.48	10.25	63.50	40	85
Posttest Control	50	65.94	9.84	66.00	42	88
Pretest Experiment	50	61.84	9.68	62.00	38	83
Posttest Experiment	50	82.76	7.53	84.50	65	95

Table 3. Wilcoxon signed ranks test

Ranks		N	Mean rank	Sum of ranks
Posttest control – pretest control	Negative ranks	3[a]	8.00	24.00
	Positive ranks	16[b]	10.38	166.00
	Ties	31[c]		
	Total	50		
A pretest experiment – a pretest experiment	Negative ranks	0[d]	.00	.00
	Positive ranks	50[e]	25.50	1,275.00
	Ties	0[f]		
	Total	50		

[a] Posttest control < Pretest control
[b] Posttest control > Pretest control
[c] Posttest control = Pretest control
[d] Experiment posttest < Experiment pretest
[e] Posttest experiment > Pretest experiment
[f] Posttest experiment = Pretest experiment

As shown in **Table 1**, both the experimental and control groups exhibited non-normal data distributions, with p-values for both the Shapiro-Wilk and Kolmogorov-Smirnov tests below 0.05 ($p < 0.05$). This finding necessitated the use of non-parametric statistical tests, specifically the Wilcoxon Signed Ranks Test.

Descriptive Statistics

The descriptive statistics in **Table 2** show that both groups had comparable pretest scores, with the control group at a mean of 62.48 (SD = 10.25) and the experimental group at 61.84 (SD = 9.68). After the intervention, the experimental group showed a substantially larger improvement with a mean posttest score of 82.76 (SD = 7.53) compared to the control group's 65.94 (SD = 9.84).

Wilcoxon Signed Ranks Test Results

The experimental and control groups were not normally distributed, according to the data from the Shapiro-Wilk and Kolmogorov-Smirnov normality tests. The p-value for the Shapiro-Wilk and Kolmogorov tests is less than 0.05 ($p < 0.05$). This confirms that the data distributions were non-normal. The Wilcoxon Marks rating test is therefore a superior non-parametric test. The Wilcoxon test results, including z and p values, were used to determine the significance of the difference between pretest and posttest scores for each group.

The difference between each group's pretest and post-test scores was examined using the Wilcoxon Signed Ranks Test, a non-parametric test appropriate for circumstances in which the data is not normally distributed. Considering the direction and size of the shift, this test determines whether two measurements paired in a single group differ significantly. The test's findings will reveal if the experimental and control groups' intervention significantly altered their posttest scores in comparison to their pretest scores.

The Wilcoxon Signed Ranks Test was conducted to examine differences between pretest and posttest scores within each group. The results are presented in **Table 3**.

Based on the results of the analysis using the Wilcoxon Signed Ranks Test, the difference between pretest and posttest scores in the control group and the experimental group can be interpreted as follows. For the control group, out of a total of 50 subjects, as many as 16 subjects experienced an increase in scores after the intervention

Table 4. Advanced Wilcoxon signed ranks test

	Posttest control – Pretest control	Experiment posttest – Experiment pretest
Z	–3.036[b]	–6.205[b]
Asymptotic significance (2-tailed)	.002	.000
Effect size (r = Z / √N)	0.30	0.62

[a] Wilcoxon signed ranks test
[b] Based on negative ranks

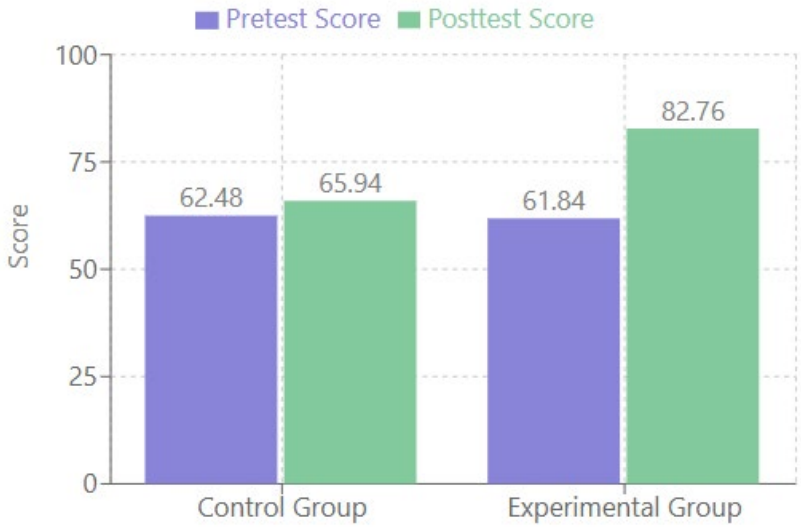

Figure 2. Comparison of mean pretest and posttest scores between groups

with an average rating of 10.38 and a total rating of 166.00. On the other hand, 3 subjects experienced a decrease in scores with an average rating of 8.00 and a total rating of 24.00. Meanwhile, as many as 31 subjects had a fixed score between the pretest and posttest, which suggests that most participants in the control group did not experience significant changes after the intervention. This indicates that the method or treatment applied to the control group has less real impact on the improvement of posttest scores.

Meanwhile, analysis of the experimental group's data revealed that all 50 participants saw an increase in their pretest and posttest scores. There was no fixed score or drop in any of the subjects' scores. With a total rating of 1275.00, the experimental group's average score improvement rating was 25.50. These findings demonstrate how much more successfully the experimental group's intervention improved the outcomes that were measured than the control group did.

Furthermore, an additional statistical test analysis was conducted by examining the Z and p-value (**Table 4**). For the control group, the Z value was –3.036 with p = 0.002 (< 0.05), indicating a statistically significant difference between the pretest and posttest scores. The magnitude of the Z-value reflects the strength of this difference, with larger absolute values indicating stronger effects. For the experimental group, a Z-value of –6.205 with p = 0.000 indicated a very significant difference between the pretest and the posttest; a very small p-value verifies that the experimental group's score change was caused by the impact of the particular intervention and not chance.

The statistical analysis revealed significant differences between pretest and posttest scores in both groups. For the control group, Z = –3.036 with p = .002 (< .05), indicating a statistically significant difference. The effect size (r = 0.30) represents a medium effect according to Cohen's criteria.

For the experimental group, Z = –6.205 with p < .001, demonstrating a highly significant difference between pretest and posttest scores. The effect size (r = 0.62) indicates a large effect, suggesting the digital-based RADEC learning model had a substantially stronger impact on digital literacy improvement compared to conventional methods.

The experimental group demonstrated an improvement of 20.92 points (from 61.84 to 82.76), while the control group improved by only 3.46 points (from 62.48 to 65.94).

Figure 2 illustrates the substantial difference in improvement between the two groups, with the experimental group showing a much steeper increase in scores after the intervention compared to the control group.

DISCUSSION

The study's findings demonstrated that the experimental group's and the control group's pretest and posttest scores differed significantly. This indicates that the interventions given in the form of conventional learning in the control group and the digital-based RADEC model in the experimental group, influence the improvement of digital literacy of prospective primary school teachers. However, the effectiveness of these two methods shows different results, with the digital-based RADEC model having a more significant impact than conventional methods.

Meanwhile, in the control group, despite the increase in scores after learning, the conventional method used still has limitations. Conventional learning models tend to focus on delivering material linearly and do not encourage active student interaction in understanding the concept of digital literacy in depth (Yaki, 2022). These outcomes are consistent with research showing that passive learning is frequently less successful in developing the critical and analytical abilities required in the digital age (Molin-Karakoc, 2025; Setiawati and Setyarini, 2020).

Conversely, the efficacy of the digital-based RADEC model, which prioritizes read, answer, discuss, explain, and create activities, is indicated by a more notable improvement in scores in the experimental group. With this paradigm, students have more chances to actively engage in the learning process, delve deeply into concepts, and hone their more sophisticated problem-solving abilities. Prior research has demonstrated that interactive digital-based learning approaches are superior to traditional approaches in enhancing conceptual understanding and critical thinking abilities.

In addition, the use of technology in the digital-based RADEC model contributes to increasing students' digital literacy. By utilizing digital learning resources, students have the opportunity to interact with a variety of learning media that are more varied and contextual. This allows them to develop digital navigation skills, information filtering, as well as technology-based problem-solving, all of which are essential elements in digital literacy. These findings are in line with previous research that shows that the integration of technology in learning can improve information absorption and adaptation skills to digital developments (Gezer and Karagözoğlu, 2023; Shatunova et al., 2021).

The compression between the control group and the experiment showed that the digital-based RADEC learning model was more effective in improving digital literacy than conventional methods. Students in the experimental group not only experienced improved conceptual understanding but also demonstrated better ability to apply their digital skills in various learning contexts. This advantage underscores the importance of innovation in learning strategies, especially in facing the challenges of the world of education in the digital era (Blankendaal-Tran, 2023; Nikou and Aavakare, 2021).

Thus, the results of this study demonstrate that the adoption of the digital-based RADEC model has a more substantial impact than conventional techniques in boosting the digital literacy of future primary school teachers. Therefore, the application of technology-based and interactive learning models needs to be considered more broadly in the educational curriculum to prepare prospective educators who are more adaptive and competent in facing the demands of the digital era.

CONCLUSION

The conclusion of this study confirms that the digital-based RADEC learning model is more effective in improving the digital literacy of prospective elementary school teachers compared to the conventional learning model. This model not only improves conceptual understanding.

Although this study provides strong evidence regarding the effectiveness of the digital-based RADEC model, some limitations need to be noted. One of them is that the scope of the sample is still limited to certain groups, so the generalization of the results of this study requires further research with a wider population. In addition, external factors such as students' technological backgrounds and access to digital devices can also affect learning outcomes. Going forward, further research can explore how the digital-based RADEC model can be applied to various levels of education and other disciplines. In addition, the development of learning strategies that are more adaptive to technological developments also needs to be studied so that their effectiveness is more optimal.

The implications of this study show that educational institutions need to consider integrating digital-based learning models into the curriculum to prepare prospective teachers who are more competent in facing the challenges of the digital era. It is hoped that innovations in this learning strategy can have a positive impact on improving the quality of education as a whole.

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Ethical considerations

This research was conducted with approval from the institutional ethics committee. All participants provided informed consent before participating in the study. Data collected during this research were anonymized and stored securely in accordance with data protection regulations. The research dataset has been archived and is available for verification upon reasonable request to the corresponding author.

Declaration of conflict of interest

The authors declare no conflict of interest in the process of conducting this research and preparing this article.

REFERENCES

Axelrod, D. and Kahn, J. (2024). "Then you go to snap": Multimodal making of digital comics in a language arts high school classroom. *Educational Technology Research and Development*, 72(1), 41–57. https://doi.org/10.1007/s11423-023-10285-2

Bal, E. and Akcil, U. (2024). The implementation of a sustainable online course for the development of digital citizenship skills in higher education. *Sustainability*, 16(1), 445. https://doi.org/10.3390/su16010445

Banihashem, S. K., Kerman, N. T., Noroozi, O., Moon, J. and Drachsler, H. (2024). Feedback sources in essay writing: Peer-generated or AI-generated feedback? *International Journal of Educational Technology in Higher Education*, 21, 23. https://doi.org/10.1186/s41239-024-00455-4

Blankendaal-Tran, K. N., Meulenbroeks, R. F. G. and van Joolingen, W. R. (2023). Digital research skills in secondary science education: A guiding framework and university teachers' perception. *European Journal of STEM Education*, 8(1), 03. https://doi.org/10.20897/ejsteme/13017

Cuiñas, A. A. F. and Augusto, V. P. (2022). The smell of printed books: A qualitative comparison between printed and digital formats. *American Journal of Qualitative Research*, 6(1), 214–225. https://doi.org/10.29333/ajqr/12053

Feng, L. and Sumettikoon, P. (2024). An empirical analysis of EFL teachers' digital literacy in Chinese higher education institutions. *International Journal of Educational Technology in Higher Education*, 21, 42. https://doi.org/10.1186/s41239-024-00474-1

Gezer, U. and Karagözoğlu, N. (2023). Examining the relationship between teachers' levels of digital literacy and their attitudes towards distance education. *TAY Journal*, 7(1), 204–231. https://doi.org/10.29329/tayjournal.2023.537.10

Giakas, A. M., Narayanan, R., Ezeonu, T., Dalton, J., Lee, Y., Henry, T., Mangan, J., Schroeder, G., Vaccaro, A. and Kepler, C. (2024). Assessing the accuracy and utility of ChatGPT responses to patient questions regarding posterior lumbar decompression. *Artificial Intelligence Surgery*, 4(3), 233–246. https://doi.org/10.20517/ais.2024.24

Handayani, H., Sopandi, W., Syaodih, E., Suhendra, I. and Hermita, N. (2019). RADEC: An alternative learning of higher order thinking skills (HOTs) students of elementary school on water cycle. *Journal of Physics: Conference Series*, 1351, 012074. https://doi.org/10.1088/1742-6596/1351/1/012074

Hayati, N., Kadarohman, A., Sopandi, W., Martoprawiro, M. A. and Pratiwi, A. (2023). The effect of the RADEC model on conceptual understanding of polycyclic aromatic hydrocarbons (PAHs) topic. *Pertanika Journal of Social Sciences and Humanities*, 31(4), 1649–1667. https://doi.org/10.47836/pjssh.31.4.15

Indonesia Statistical Index. (2022). *Digital literacy index in Indonesia from 2020 to 2022, by type*. Available at: https://www.statista.com/statistics/1337349/indonesia-digital-literacy-index-by-type/

Isnah, E. S., Suyatno and Subandiyah, H. (2022). The effect of digital literacy on language ability in higher education: Experience from a developing country. *Journal of Higher Education Theory and Practice*, 22(11), 215–222. https://doi.org/10.33423/jhetp.v22i11.5425

Jasin, M., Anisah, H. U., Fatimah, C. E. A., Azra, F. E. A., Suzanawaty, L. and Junaedi, I. W. R. (2024). The role of digital literacy and knowledge management on process innovation in SMEs. *International Journal of Data and Network Science*, 8(1), 337–344. https://doi.org/10.5267/j.ijdns.2023.9.020

Lestari, H., Ali, M., Sopandi, W., Wulan, A. R. and Rahmawati, I. (2022). The impact of the RADEC learning model oriented ESD on students' sustainability consciousness in elementary school. *Pegem Journal of Education and Instruction*, 12(2), 113–122. https://doi.org/10.47750/pegegog.12.02.11

Lestari, H., Sopandi, W., Sa'ud, U. S., Musthafa, B., Budimansyah, D. and Sukardi, R. R. (2021). The impact of online mentoring in implementing RADEC learning to the elementary school teachers' competence in training students' critical thinking skills: A case study during COVID-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, 10(3), 346–356. https://doi.org/10.15294/JPII.V10I3.28655

Mago, Z., Wojciechowski, Ł. P., Balážiková, M. and Shelton, A. J. (2023). Learning by playing: A case study of the education in photography by digital games. *Journal of Education Culture and Society*, 14(1), 465–479. https://doi.org/10.15503/jecs2023.1.465.479

Molin-Karakoc, L. M. I. (2025). Exploring the digital literacies of refugees from a funds-of-knowledge perspective. *Journal of Ethnic and Cultural Studies*, 12(2), 200–230. https://doi.org/10.29333/ejecs/2236

Nikou, S. and Aavakare, M. (2021). An assessment of the interplay between literacy and digital technology in higher education. *Education and Information Technologies*, 26(4), 3893–3915. https://doi.org/10.1007/s10639-021-10451-0

Nuryadi, M. H. and Widiatmaka, P. (2023). Strengthening civic literacy among students through digital literacy in society 5.0. *Journal of Education and Learning*, 17(2), 215–220. https://doi.org/10.11591/edulearn.v17i2.20746

Rahman, A., Suherman, A., Susilawati, D. and Putra, G. P. (2020). RADEC (reading, answering, demonstrating, explaining, and creating) in LMS to teach tennis without field practicing. *Universal Journal of Educational Research*, 8(11), 5433–5442. https://doi.org/10.13189/ujer.2020.081146

Satria, E. and Sopandi, W. (2019). Applying RADEC model in science learning to promoting students' critical thinking in elementary school. *Journal of Physics: Conference Series*, 1321, 032102. https://doi.org/10.1088/1742-6596/1321/3/032102

Septiani, S., Sutarto, J., Utomo, C. B. and Widiyanto. (2024). Happy teachers, quality schools: Improving teacher performance through happiness, motivation, and quality of work life. *Perspektivy Nauki i Obrazovania*, 72(6), 733–746. https://doi.org/10.32744/pse.2024.6.46

Setiawan, D., Sopandi, W. and Hartati, T. (2020). The influence of read, answer, disscuss, explain, and create (RADEC) learning model on the concept mastery of elementary school students on the water cycle topic. *Journal of Physics: Conference Series*, 1521, 042113. https://doi.org/10.1088/1742-6596/1521/4/042113

Setiawati, D. and Setyarini, S. (2020). Promoting EFL young learners' higher order thinking skills (HOTs) through interactive digital storytelling, in *Proceedings of the 12th International Conference on Education Technology and Computers* (pp. 57–61). ACM. https://doi.org/10.1145/3436756.3437021

Shatunova, O., Bozhkova, G., Tarman, B. and Shastina, E. (2021). Transforming the reading preferences of today's youth in the digital age: Intercultural dialog. *Journal of Ethnic and Cultural Studies*, 8(3), 62–73. https://doi.org/10.29333/ejecs/347

Siregar, L. S., Wahyu, W. and Sopandi, W. (2020). Polymer learning design using read, answer, discuss, explain and create (RADEC) model based on Google Classroom to develop student's mastery of concepts. *Journal of Physics: Conference Series*, 1469, 012078. https://doi.org/10.1088/1742-6596/1469/1/012078

Sorokolit, N., Rymar, O., Bodnar, I., Khanikiants, O. and Solovey, A. (2024). Multimedia technologies as tools for fostering digital literacy in education. *ETR*, 2, 493–498. https://doi.org/10.17770/etr2024vol2.8077

Suhardiman, S., Margana, Putro, N. H. P. S., Hakiki, M. and Fadli, R. (2024). Using the Buana online course web-based mobile application to improve English for specific purpose engineering courses. *International Journal of English Language and Literature Studies*, 13(3), 449–463. https://doi.org/10.55493/5019.v13i3.5189

Suherman, A., Supriyadi, T. and Safari, I. (2020). Promoting digital literacy skills: An action research to people of Kampung Literasi. *Universal Journal of Educational Research*, 8(4), 1372–1386. https://doi.org/10.13189/ujer.2020.080430

Sukardi, R. R., Sopandi, W. and Riandi, R. (2021). Repackaging RADEC learning model into the online mode in science class. *Journal of Physics: Conference Series*, 1806, 012142. https://doi.org/10.1088/1742-6596/1806/1/012142

Sukardi, R. R., Sopandi, W., Riandi, R., Beeth, M. E. and Shidiq, A. S. (2022). What creative ideas came up about global warming in RADEC online class? *Asia Pacific Journal of Educators and Education*, 37(2), 51–83. https://doi.org/10.21315/apjee2022.37.2.4

Yaki, A. A. (2022). Fostering critical thinking skills using integrated STEM approach among secondary school biology students. *European Journal of STEM Education*, 7(1), 06. https://doi.org/10.20897/ejsteme/12481

