Jurnal Ilmiah Pendidikan Holistik (JIPH)
Vol.5, No. 2 2026: 139-150

Effectiveness of Online Textbook on Radiology Equipment Techniques in Enhancing Cognitive Abilities of Radiology Students

Fauzyah Aprillia[1]*, Cicillia Artitin
Universitas Baiturrahmah, Indonesia
Corresponding Author: Fauzyah Aprillia fauzyahaprillia@gmail.com

ARTICLE INFO

Keywords: Digital Technology, Online Textbooks, Cognitive Ability, Radiology Education, Quasi-Experimental.

Received : 21 February
Revised : 23 March
Accepted: 23 April

ABSTRACT

The rapid advancement of digital technology has driven significant transformations in educational systems through the adoption of flexible and interactive online learning media. This study aims to analyze the effectiveness of an online textbook in Radiological Engineering on students' cognitive abilities. The research employed a quasi-experimental method with a one-group pretest–posttest design involving 70 students over a one-month period. The results demonstrated an increase in the mean score from 67.56 to 84.67, with a statistically significant difference ($p < 0.001$) and a very large effect size (Cohen's $d = 3.63$). These findings indicate that the online textbook is effective in enhancing students' cognitive abilities. The implications of this study support the integration of digital learning media in radiology education.

DOI: https://doi.org/10.55927/jiph.v5i2.11
ISSN-E: 2829-7911
https://journaljiph.my.id/index.php/jiph/index

INTRODUCTION

The rapid advancement of digital technology over recent decades has driven significant transformations across various aspects of life, including higher education systems. This transformation has not only altered the way learning materials are delivered but has also influenced the patterns of interaction between lecturers and students, as well as the ways in which students access and construct knowledge. In the context of health education, particularly in radiology, the integration of technology has become increasingly important due to the field's complexity, its reliance on advanced technology, and the need for a strong conceptual understanding of the principles underlying the operation of radiological equipment. The integration of technology in learning has been shown to enhance the effectiveness of the educational process by providing broader, more flexible, and interactive access for students, thereby facilitating more independent and student-centered learning (Qolamani & Mohammed, 2023).

In the learning of Radiological Engineering, students' cognitive abilities represent a fundamental aspect that must be optimally developed. These abilities include understanding basic concepts, analyzing the operational principles of equipment, and evaluating safe and effective operational procedures (Mahesti et al., 2025). In radiography education, mastery of the cognitive domain is crucial as it is directly with clinical decision-making and patient safety. Furthermore, radiology education requires the integration of theoretical knowledge and practical skills, making it essential for students to possess a strong cognitive foundation before entering the clinical practice stage (Lee et al., 2013).

However, learning processes that are still predominantly based on conventional methods, such as lectures and printed textbooks, tend to be less capable of accommodating the needs of students in the digital era. These approaches are often passive and provide limited opportunities for deep learning experiences (Akfal et al., 2025). Studies in radiology education have shown that traditional methods have limitations in enhancing students' conceptual understanding, particularly in complex subjects such as radiation physics and imaging technology. This highlights the need for innovation in learning strategies that are more adaptive to technological advancements (Altun et al., 2025a).

To address these challenges, the utilization of digital-based learning media emerges as a promising alternative. Online textbooks, as part of digital learning resources, offer flexibility and easy access, while enabling the integration of multimedia elements that can enhance the quality of material delivery (Stirrat et al., 2024a). The use of multimedia in learning has been proven to improve students' cognitive understanding through more systematic and engaging information presentation. In the context of radiology, digital media such as e-learning and interactive modules have also demonstrated effectiveness in enhancing students' comprehension of medical imaging concepts. Furthermore, technology-based learning can increase students' active engagement, which is a crucial factor in successful learning outcomes (Wachsman et al., 2023).

Nevertheless, the utilization of online textbooks in Radiology Equipment Techniques learning remains relatively limited, particularly in vocational education contexts (Tay & McNulty, 2023). Most previous studies have focused on general e-learning applications without specifically examining the effectiveness of online textbooks in enhancing students' cognitive abilities in radiology equipment techniques. Moreover, research directly linking the use of digital textbooks to improved conceptual understanding among radiology students is still scarce (Grewal et al., 2024). This indicates a research gap that warrants further investigation, especially in applied and competency-based learning contexts such as radiology.(Chen et al., 2022)

Based on the aforementioned discussion, this study aims to analyze the effectiveness of using an online textbook on Radiology Equipment Techniques in enhancing the cognitive abilities of radiology students. This serves as an effort to enrich innovative and adaptive technology-based learning strategies for improving the quality of radiology education.

LITERATURE REVIEW

Cognitive Learning Theory

Cognitive learning theory views learning as a mental process involving the understanding, processing, storage, and evaluation of information. Cognitive abilities encompass hierarchical thinking levels, from remembering to evaluating, which are crucial aspects in radiology education due to the complexity of topics such as radiation physics and equipment operating principles. With the advancement of digital technology, the application of cognitive learning principles has become increasingly relevant in developing multimedia-based media. Studies show that digital learning designed according to multimedia learning principles can significantly enhance students' conceptual understanding and cognitive engagement compared to conventional methods (Altun et al., 2025b).

In addition, cognitive load management is a critical factor in learning effectiveness, where poor design can impede the comprehension process. The integration of digital technology has also been shown to support the development of higher-order thinking skills, such as analysis and evaluation. Therefore, applying cognitive learning principles in the development of online textbooks has the potential to more effectively enhance students' cognitive abilities, particularly in the context of radiology education (Rodrig & Marlow, 2025).

H1: The online textbook on Radiology Equipment Techniques significantly influences the enhancement of radiology students' cognitive abilities.

Technology-Based Learning Theory (E-Learning and Multimedia Learning)

Technology-based learning or e-learning is an educational approach that leverages digital technology to support the delivery of material, interaction, and assessment in the learning process. This approach enables more flexible, adaptive, and student-centered learning. From the perspective of modern learning theory, e-learning serves not only as a medium for information delivery

but also as a tool for building interactive and meaningful learning experiences (Cardona-Acevedo et al., 2025).

Multimedia-based learning allows information presentation through a combination of text, images, animations, and audio, designed according to cognitive principles to enhance understanding and information retention. This principle emphasizes that appropriate integration of visual and verbal elements can help students process information more effectively by optimizing working memory (Maya Putriwan et al., 2025).

With technological advancements, the implementation of e-learning in higher education has shown significant growth, particularly in health and radiology fields that involve complex material requiring strong visualization. Online textbooks, as a component of e-learning, offer advantages in access flexibility, interactivity, and the ability to present material systematically and structured (Stirrat et al., 2024b). Students can access materials anytime and anywhere, enabling more independent and continuous learning. Additionally, online textbooks designed based on multimedia learning principles can enhance students' cognitive engagement through engaging and comprehensible material presentation (Huda et al., 2025).

Previous Research

Various studies have demonstrated that the use of digital-based learning media positively impacts student learning outcomes, particularly in enhancing conceptual understanding and learning engagement. In the context of health education, the integration of learning technology becomes increasingly With technological advancements, the implementation of e-learning in higher education has shown significant growth, particularly in health and radiology fields that involve complex material requiring strong visualization. Online textbooks, as a component of e-learning, offer advantages in access flexibility, interactivity, and the ability to present material systematically and structured. important given the complexity of materials that require high visualization and interactivity (Nurhayati et al., 2025).

Research by Radianti et al. (2020) through a systematic review found that the use of virtual reality–based and multimedia technologies in higher education, particularly in the health field, is able to significantly improve students' conceptual understanding and learning experiences. This indicates that technology-based learning media have potential in supporting cognitive processes through more interactive and immersive material presentation. In addition, Taxipulati & Lu, (2021) stated that multimedia-based learning has a positive effect on students' cognitive learning outcomes, especially when the material is presented in a structured way and in accordance with cognitive learning principles.

Research by Bond, (2020) confirms that the use of educational technology not only improves learning outcomes but also fosters active student engagement in the learning process. This engagement serves as a key factor in enhancing learning effectiveness, as actively engaged students tend to develop a deeper understanding of the material studied. These findings are supported by Chandra et al., (2025) who demonstrate that interactive digital learning has a significant

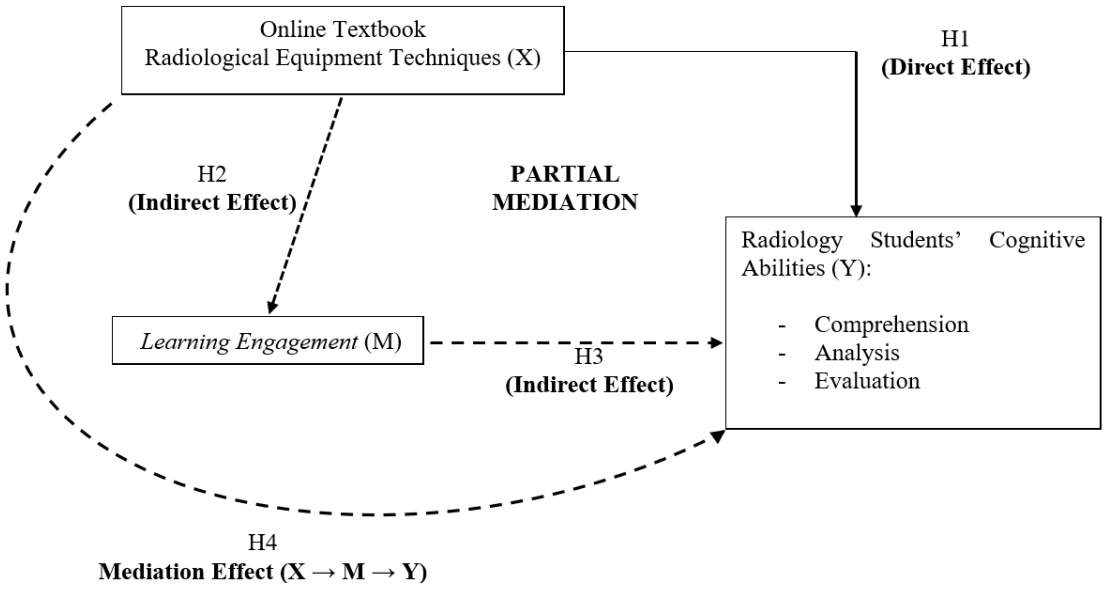
impact on improving higher-order thinking skills, such as analysis and evaluation.

In the context of medical education, research by McGee et al., (2024) shows that the use of digital-based learning technology, including simulations and interactive modules, can enhance students' abilities to understand complex clinical concepts and improve readiness for decision-making. This is highly relevant to radiology education, which demands a deep understanding of equipment operating principles and imaging result interpretation.

Although various studies have proven the effectiveness of technology-based learning, most research still focuses on general e-learning applications, such as online learning platforms, simulations, and instructional videos. Studies specifically examining the effectiveness of online textbooks as primary learning media, particularly for Radiology Equipment Technology material, remain relatively limited (Chen et al., 2022a).

Therefore, there is a research gap that needs further investigation, namely the lack of studies specifically analyzing the impact of using online textbooks on radiology students' cognitive abilities. This research offers novelty by directly testing the role of online textbooks as a technology-based learning medium in enhancing students' cognitive abilities, particularly in the aspects of understanding, analysis, and evaluation within the context of Radiology Equipment Technology learning (Grewal et al., 2024a).

Conceptual Framework



METHODOLOGY

This study employs a quantitative approach with a one-group pretest-posttest quasi-experimental design to determine the effect of using online Radiology Equipment Technology textbooks on students' cognitive abilities. The population consists of all D3 Radiology students taking the Radiology Equipment Technology course. The sample comprises 70 students selected through purposive sampling, specifically active students in the current semester who meet the research criteria.

The instruments used consist of cognitive ability tests developed based on learning indicators, covering the aspects of understanding, analysis, and evaluation. These instruments have been validated by experts and tested for reliability using Cronbach's alpha to ensure consistent and trustworthy measurement results.

The research procedure is conducted in several stages. First, students are given a pretest to assess their initial abilities. Second, an intervention is provided through learning using online textbooks for 1 month. Third, a posttest is administered to measure changes in cognitive abilities after the intervention.

The data obtained were analyzed using SPSS. Prior to hypothesis testing, the Shapiro-Wilk normality test was conducted. Subsequently, a paired sample t-test with a significance level of 0.05 was used to determine differences in abilities before and after the treatment. The magnitude of the treatment effect was calculated using effect size (Cohen's d).

Theoretically, cognitive abilities encompass thinking processes such as understanding, analyzing, and evaluating information. In radiology education, these abilities are crucial due to the complex nature of the material. Digital-based learning, such as online textbooks, can help enhance student understanding and engagement, particularly when well-designed to reduce cognitive load. Additionally, the use of technology in learning can more effectively support improvements in students' higher-order thinking skills.

RESEARCH RESULTS

The research findings are presented systematically through descriptive analysis, assumption tests, hypothesis testing, and effect size measurement to evaluate the effectiveness of online Radiology Equipment Technology textbooks on students' cognitive abilities. Initial analysis classified students' cognitive ability levels based on pretest and posttest scores into specific categories. This classification provides an overview of the cognitive ability distribution before and after the intervention. Results show a shift in cognitive ability categories toward higher levels after using online textbooks, indicating improved student understanding of the learning material.

Tabel 1. Cognitive Ability Level Criteria

No.	Score Range	Cognitive Ability Category	Description

1	1–59	Low	understanding of basic concepts, with difficulty in application and analysis.
2	60–79	Moderate	Adequate understanding with the ability to apply knowledge, though analytical and evaluative skills are still developing
3	80–100	High	Strong comprehension and advanced cognitive skills, including independent analysis, evaluation, and problem-solving.

Subsequently, descriptive statistical analysis was conducted to compare the pretest and posttest mean scores. The analysis results show that the posttest mean score increased compared to the pretest, indicating an improvement in students' cognitive abilities after the intervention. The detailed descriptive analysis results are presented in Table 2.

Tabel 2. Descriptive Statistics of PreTest and PostTest Scores

Variable	N	Min	Max	Mean	SD
PreTest	70	60	75	67.56	4.07
PostTest	70	76	94	84.67	5.28

Findings from Table 2 indicate a substantial increase in mean scores between before and after using online textbooks. Additionally, the data spread shown by standard deviation suggests that student score variation became more concentrated after the intervention.

Before conducting hypothesis testing, normality testing was performed using the Shapiro-Wilk method to ensure data met the normal distribution assumption. Normality test results show significance values for both pretest and posttest data exceeded $\alpha = 0.05$, confirming normal distribution for both datasets. Complete normality test results are presented in Table 3.

Tabel 3. Normality Test Results (Shapiro–Wilk)

Variable	N	Statistic (W)	p-value	Interpretation
PreTest	70	0.970	0.097	Normally distributed
PostTest	70	0.948	0.073	Normally distributed

Based on those normality test results, analysis proceeded using parametric testing, specifically the paired sample t-test, to determine differences in cognitive abilities before and after the intervention. Hypothesis testing results revealed a significant difference between pretest and posttest scores, with a p-value less than 0.05. This indicates that using online textbooks had a significant positive effect on improving students' cognitive abilities. Detailed hypothesis test results are presented in Table 4.

Table 4. Paired Sample t-test Results

Variable	Mean ± SD	N	Mean Difference	95% CI (Lower–Upper)	t	df	p-value
PreTest	67.56 ± 4.071	70	60				
PostTest	84.67 ± 5.277	70	76	-17.679 – -16.550	-60.46	69	<0.001*

Based on the paired sample t-test results presented in Table 4, the pretest mean (± SD) was 67.56 ± 4.071, and the posttest mean was 84.67 ± 5.277, with a sample size (N) of 70 respondents. These results demonstrate an increase in mean scores following the online textbook intervention. The statistical test yielded a mean difference of -17.679 to -16.550 at 95% confidence interval, with a t-value of -60.46 and degrees of freedom (df) of 69. The obtained significance value was $p < 0.001$, indicating a highly significant difference between pretest and posttest scores.

To determine the intervention's effect magnitude, effect size was calculated using Cohen's d, based on the mean difference and pooled standard deviation. The pooled standard deviation is derived from combining pretest and posttest standard deviations via the square root of the average of their squared values.

1. Pooled Standard Deviation CalculationRumus:

$$SD_{pooled} = \sqrt{\frac{SD^2Pre + SD^2Post}{2}}$$
$$= \sqrt{\frac{16.57 - 27,84}{2}}$$
$$= \sqrt{22.205} \approx 4.71$$

2. Cohen's d Calculation

$$d = \frac{17.11}{4.71} \approx 3.63$$

The calculation results show that Cohen's d value is 3.63, which falls into the category of very large effect. This indicates that the use of online textbooks not only produces statistically significant differences but also demonstrates very strong practical impact in enhancing students' cognitive abilities. Thus, the intervention proves substantially effective in supporting improved learning outcomes.

DISCUSSION

This research demonstrates that using online Radiology Equipment Technology textbooks significantly enhances students' cognitive abilities. This is evidenced by the mean score increase from 67.56 (pretest) to 84.67 (posttest), supported by paired sample t-test results showing $p < 0.001$. Additionally, the very large effect size (Cohen's d = 3.63) indicates the intervention not only achieved statistical significance but also produced substantial practical impact.

These findings align with the research by Zhang et al. (2022), which states that the use of digital-based learning media significantly enhances students'

conceptual understanding. This improvement occurs due to the flexibility of material access and students' ability to independently repeat the learning process. This is relevant to the characteristics of the online textbook in this study, which enables a more adaptive learning process.

Furthermore, the research by Putri and Nugroho (2022) shows that e-learning-based education in the health field can enhance students' cognitive abilities, particularly in the aspects of application and analysis. These results support the findings of this study, where a shift in students' cognitive ability categories from moderate to high occurred after the intervention (Riyadi et al., 2025).

Research by Rahman et al. (Riyadi et al., 2025) also reported that the use of digital teaching materials in modern learning models provides a significant improvement in learning outcomes with a large effect size. However, the effect size value in this study is higher than that research, indicating that the online textbook designed specifically according to radiology material needs has more optimal effectiveness.

In addition, the study by Riyadi et al. (2025) found that the use of interactive digital modules can enhance students' knowledge retention and long-term understanding. This advantage is due to the integration of various learning media such as text, images, and visualizations, which likely also serve as supporting factors in this research.

The latest research by Muhamad Basyrul Muvid (2024) states that digital textbooks based on educational technology can increase student engagement, which directly impacts improved learning outcomes. This strengthens the finding that the enhancement of cognitive abilities in this study is not only caused by the material but also by increased active student participation in the learning process.

Nevertheless, the very large effect size in this study needs to be examined carefully. The magnitude of the effect may be influenced by several factors, such as sample homogeneity, question difficulty level, and the absence of a control group for comparison. Therefore, future research is recommended to employ a more complex experimental design involving a control group to obtain more comprehensive results.

Overall, the results of this study indicate that the use of the online textbook *Teknik Pesawat Radiologi* is an effective learning strategy for enhancing students' cognitive abilities. These findings are consistent with various previous studies that affirm the integration of technology in learning significantly improves the quality of the learning process and outcomes.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that the use of the online textbook *Teknik Pesawat Radiologi* has a significant positive impact on improving students' cognitive abilities. This is evidenced by the increase in average scores from 67.56 on the pretest to 84.67 on the posttest, indicating a substantial improvement in mastery of the learning material.

The statistical test results using the paired sample t-test confirmed a significant difference between pre- and post-intervention ($p < 0.001$). Additionally,

the very large effect size (Cohen's d = 3.63) indicates that the intervention has high practical effect strength, making it not only statistically relevant but also educationally meaningful. Thus, the online textbook developed in this study proves effective as a learning medium for enhancing students' cognitive abilities, particularly for technical material requiring deep conceptual understanding.

Future research is recommended to employ an experimental design with a control group to enhance result validity. Additionally, testing should be conducted on a more diverse sample while considering other variables such as learning motivation and student engagement to gain a more comprehensive understanding of the online textbook's effectiveness.

FUTURE RESEARCH

Although this study shows that the use of the online textbook *Teknik Pesawat Radiologi* has significant effectiveness in enhancing students' cognitive abilities, several aspects require further investigation. Future research is recommended to adopt a stronger experimental design, such as a randomized controlled trial (RCT), involving a control group to improve internal validity and strengthen causal inferences.

Additionally, the sample characteristics should be expanded to include more diverse academic backgrounds, institutions, and education levels to enhance the generalizability of findings. Further studies are also advised to integrate other variables, such as learning motivation, engagement, and long-term retention, to gain a more comprehensive understanding of digital learning effectiveness.

Furthermore, future development of online textbooks can focus on integrating interactive multimedia features and adaptive technology to enhance the student learning experience. Thus, subsequent research is expected not only to test effectiveness but also to optimize the design and implementation of digital learning media sustainably.

ACKNOWLEDGMENTS

The authors express gratitude to all parties who have provided support, both directly and indirectly, in the preparation and implementation of this research. Thanks are extended to the advisory lecturer who offered guidance, input, and supervision throughout the research process. The authors also convey appreciation to the D3 Radiology Study Program at Universitas Baiturrahmah for the facilities and opportunities provided during this study.

Gratitude is also directed to the students who participated as respondents in this research. The authors recognize that without the support, cooperation, and assistance from various parties, this research could not have been completed successfully.

DAFTAR PUSTAKA

Akfal, A. Z., Solekh, I. E., & Saefiansyah, P. M. (2025). Digital Transformation in Education : Challenges and Opportunities in Improving the Quality of Learning in the Era of Revolution. 24. https://doi.org/10.30595/pssh.v24i.1594

Altun, I., Turan, O., & Awan, O. (2025a). Revolutionizing radiology education: exploring innovative teaching methods. Abdominal Radiology, 50(12), 6225–6234. https://doi.org/10.1007/s00261-025-05010-x

Altun, I., Turan, O., & Awan, O. (2025b). Revolutionizing radiology education: exploring innovative teaching methods. Abdominal Radiology, 50(12), 6225–6234. https://doi.org/10.1007/s00261-025-05010-x

Cardona-Acevedo, S., Agudelo-Ceballos, E., Cumpa Vásquez, J. T., Martínez Rojas, E., Valencia-Arias, A., Jimenez Garcia, J. A., & Benjumea-Arias, M. L. (2025). E-learning technologies at the secondary education level: literature review. Frontiers in Education, 10. https://doi.org/10.3389/feduc.2025.1539763

Chen, D., Ayoob, A., Desser, T. S., & Khurana, A. (2022). Review of Learning Tools for Effective Radiology Education During the COVID-19 Era. Academic Radiology, 29(1), 129–136. https://doi.org/10.1016/j.acra.2021.10.006

Grewal, I., Salim, H. A., Zamarud, A., Rasagna Mareddy, N. S., Madaan, P., & Aggarwal, K. (2024). Online Learning Resources for Radiology Education: An Educational Perspective. Academic Medicine & Surgery. https://doi.org/10.62186/001c.123611

Huda, M. N., Ismail, S. N., & Muhammad, A. S. (2025). Pesantren Technology-Friendly : Enhancing Learning Effectiveness in The Modern Era. 19(1), 1–22.

Lee, C. S., Nagy, P. G., Weaver, S. J., & Newman-Toker, D. E. (2013). Cognitive and System Factors Contributing to Diagnostic Errors in Radiology. American Journal of Roentgenology, 201(3), 611–617. https://doi.org/10.2214/AJR.12.10375

Mahesti, A., Khamla, C., & Daovanh, S. (2025). Transforming Education in the Digital Era : Teachers ' Views on Challenges and Opportunities in Technology- based Learning. 1(2), 11–21.

Maya Putriwan, Sumarni, Elisa, Arifah Novia Arifin, & Nur Aisyah. (2025). Systematic Literature Review: Tren Penggunaan dan Efektivitas Media Pembelajaran Digital Dalam Konteks Pendidikan Abad Ke-21.

Edukasiana: Jurnal Inovasi Pendidikan, 4(4), 2456–2477. https://doi.org/10.56916/ejip.v4i4.2746

Nurhayati, I., Olivia, A., Mawalia, A., Amalia, A. F., Nabila, A., Definta, A. M., Fitriani, F., Putri, I. S., Legawa, K. P., Sarah, K. A., Septriana, N., Nefi, R., & Hasnita, S. (2025). Student Learning Outcomes on Dry Skin Care Material. 8(2), 287–292.

Qolamani, K. I. B., & Mohammed, M. M. (2023). The Digital Revolution in Higher Education: Transforming Teaching and Learning. QALAMUNA: Jurnal Pendidikan, Sosial, Dan Agama, 15(2), 837–846. https://doi.org/10.37680/qalamuna.v15i2.3905

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education, 147, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Rodrig, L., & Marlow, L. (2025). Cognitive Load Management in Digital Learning Environments : Implications for Student Performance. 2(4), 188–197.

Stirrat, T., Martin, R., Umair, M., & Waller, J. (2024a). Advancing radiology education for medical students: leveraging digital tools and resources. Polish Journal of Radiology, 89, 508–516. https://doi.org/10.5114/pjr/193518

Stirrat, T., Martin, R., Umair, M., & Waller, J. (2024b). Advancing radiology education for medical students: leveraging digital tools and resources. Polish Journal of Radiology, 89, 508–516. https://doi.org/10.5114/pjr/193518

Tay, Y. X., & McNulty, J. P. (2023). Radiography education in 2022 and beyond - Writing the history of the present: A narrative review. Radiography, 29(2), 391–397. https://doi.org/10.1016/j.radi.2023.01.014

Wachsman, U., Shelef, I., Lior, Y., & Ben-Arie, G. (2023). The impact of interactive clinically-based learning on the performance of medical students in radiology. European Journal of Radiology Open, 10, 100493. https://doi.org/10.1016/j.ejro.2023.100493