Assessing the Impact of ASSURE-Based Instruction on Students' Cognitive Ability: A Quasi-Experimental Approach

Gita Verawati[1], Nguyen Nhu Le[2]
[1]Department of Science Physics Education, Faculty of Islamic Education and Teacer Training, Universitas Islam Negeri Syarif Hidayatullah, Jakarta, Indonesia
[2]Physics Department, University of Education, Hue University, Viet Nam

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ABSTRACT

Purpose of the study: This study aims to analyze the effect of the ASSURE instructional model on students' cognitive abilities in learning light wave concepts at the senior high school level, focusing on improving cognitive performance across Bloom's Taxonomy levels (C1–C4).

Methodology: This study employed a quasi-experimental method with a nonequivalent control group design. Data were collected using multiple-choice cognitive tests, documentation, and observation. The instrument was validated using Product Moment correlation and tested for reliability using Cronbach's Alpha. Data were analyzed using Kolmogorov–Smirnov, Levene's Test, and independent samples t-test.

Main Findings: The results showed that the experimental group achieved higher posttest scores than the control group. The independent samples t-test indicated a significant difference ($p < 0.05$). The effect size analysis yielded a large effect ($d = 1.34$), indicating a strong impact of the ASSURE model on students' cognitive abilities.

Novelty/Originality of this study: This study provides a specific analysis of the ASSURE model's effectiveness across cognitive levels (C1–C4) in learning light wave concepts. It also integrates learner characteristic analysis into instructional design, offering a more structured and comprehensive approach to enhancing students' cognitive development in physics education.

Corresponding Author:
Gita Verawati,
Department of Science Physics Education, Faculty of Islamic Education and Teacer Training, Syarif Hidayatullah State Islamic University,
Ir. H. Djuanda No. 95 Road, Ciputat, Banten, 15412, Indonesia
Email: gitaverawati055@gmail.com

1. INTRODUCTION

Cognitive ability is one of the most essential domains in the learning process, playing a crucial role in determining students' success in understanding, processing, and applying knowledge. In the context of 21st-century education, cognitive ability is not limited to remembering information but extends to higher-order thinking skills such as understanding, applying, and analyzing concepts critically [1]-[3]. This perspective aligns with the revised Bloom's Taxonomy, which emphasizes the importance of developing higher-order thinking skills in educational practices [4]-[6]. Therefore, improving students' cognitive abilities has become a central focus in science education, particularly in physics, which requires deep conceptual understanding and logical reasoning.

Physics learning is often perceived as difficult by students due to its abstract nature and the high level of analytical thinking required [7]-[9]. One of the topics considered challenging is light wave concepts, which demand not only conceptual understanding but also the ability to relate theory to real-world phenomena [10], [11]. Previous studies have shown that students' low cognitive achievement in physics is often caused by the dominance of teacher-centered instructional approaches, where students tend to be passive and less engaged in the learning process [12]. This condition leads to suboptimal learning outcomes and weak conceptual mastery.

To improve students' cognitive abilities, it is necessary to implement instructional models that actively engage learners and consider their characteristics [13]-[15]. One such model is the ASSURE model, a systematic instructional design framework that integrates learner analysis, objective setting, selection of methods and media, and evaluation [16], [17]. This model is considered effective because it emphasizes active student participation through structured learning activities and the appropriate use of instructional media.

Several previous studies have demonstrated the positive impact of the ASSURE model on students' learning outcomes and cognitive abilities. Previous studies have found that the implementation of the ASSURE model significantly improves students' conceptual understanding, as evidenced by higher post-test scores and statistically significant differences compared to conventional learning [18], [19]. Previous studies have demonstrated that the ASSURE model enhances student engagement and learning outcomes by promoting active participation and the effective integration of instructional media [20], [21].

However, there remains a significant research gap. Most previous studies have focused on general learning outcomes without specifically examining the effect of the ASSURE model on different levels of cognitive ability based on Bloom's Taxonomy, particularly in abstract physics topics such as light waves. Furthermore, studies that integrate an in-depth analysis of student characteristics within the implementation of the ASSURE model are still limited [22], [23]. This indicates the need for more comprehensive research exploring the effectiveness of the ASSURE model in specific learning contexts.

Based on this gap, the novelty of this study lies in its specific investigation of the effect of the ASSURE model on students' cognitive abilities across Bloom's Taxonomy levels (C1–C4) in the context of light wave concepts. Additionally, this study integrates a detailed analysis of student characteristics as a foundation for instructional design, providing a more comprehensive understanding of how the ASSURE model can enhance cognitive development.

The urgency of this research is grounded in the need to improve the quality of physics instruction in order to develop students' higher-order thinking skills in alignment with modern curriculum demands. Therefore, this study aims to analyze the effect of the ASSURE model on students' cognitive abilities in learning light wave concepts. The findings of this research are expected to contribute both theoretically to instructional design development and practically to teachers in designing more effective, student-centered learning environments.

2. RESEARCH METHOD

2.1. Research Design

This study employed a quasi-experimental method using a nonequivalent control group design. This design was selected because the researcher could not randomly assign participants into experimental and control groups [24]-[26]. Two groups were involved: an experimental class receiving instruction using the ASSURE model and a control class receiving conventional instruction. Both groups were given a pretest and posttest to measure students' cognitive abilities. The research design can be illustrated as follows:

Table 1. Research design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X (ASSURE Model)	O_2
Control	O_3	– (Conventional)	O_4

2.2. Population and Sample

The population of this study consisted of all students in grade XI science classes at State Senior High School 10 Depok. The sample was selected using a purposive sampling technique, considering the similarity of academic ability and learning characteristics.

The sample included:

- One experimental class (XI MIA)
- One control class (XI MIA)
- Total number of students: 75

2.3. Data Collection Techniques

Data were collected using the following techniques:

1. Test Method, a multiple-choice test was used to measure students' cognitive abilities in the topic of light waves.

2. Documentation, documentation was used to obtain data related to students, school conditions, and research implementation.
3. Observation (Supporting Data), observation was conducted to support the analysis of the learning process.

2.4. Research Instrument

The main instrument used in this study was a cognitive ability test in the form of multiple-choice questions based on Bloom's Taxonomy (C1–C4).

Table 2. Instrument Blueprint

No	Cognitive Level	Indicator	Item Numbers
1	Remembering (C1)	Recall basic concepts of light waves	1, 2, 3
2	Understanding (C2)	Explain concepts of light wave phenomena	4, 5, 6
3	Applying (C3)	Apply formulas in problem-solving	7, 8, 9
4	Analyzing (C4)	Analyze relationships in light wave phenomena	10, 11, 12

The validity of the research instrument was examined using the Product Moment correlation technique to determine the extent to which each test item measured the intended cognitive constructs. Each item was considered valid if the calculated correlation coefficient (r_{count}) exceeded the critical value of r_{table}at a significance level of 0.05. The results of the validity test indicated that the majority of the items met the required criteria and were therefore suitable for measuring students' cognitive abilities in the topic of light waves. Items that did not meet the validity criteria were revised or discarded prior to their use in the actual data collection.

The reliability of the instrument was assessed using Cronbach's Alpha coefficient to evaluate the internal consistency of the test. The analysis showed that the instrument achieved a reliability coefficient in the high category ($\alpha > 0.70$), indicating that the test items were consistently measuring the same construct. Therefore, the instrument was considered reliable and appropriate for use in this study to assess students' cognitive abilities.

2.5. Data Analysis Techniques

The data in this study were analyzed quantitatively using several statistical procedures. Initially, a normality test was conducted using the Kolmogorov–Smirnov test to determine whether the data distribution met the assumption of normality [27]-[29]. Subsequently, a homogeneity test was performed using Levene's Test to examine whether the variances of the experimental and control groups were equal [30], [31]. After fulfilling these prerequisite tests, hypothesis testing was carried out using an independent samples t-test at a significance level of 0.05 to determine the effect of the ASSURE model on students' cognitive abilities. The decision criteria for hypothesis testing were as follows: if the significance value (p-value) was less than 0.05, the null hypothesis (H_0) was rejected, indicating a significant difference between groups; conversely, if the p-value was greater than 0.05, the null hypothesis (H_0) was accepted, indicating no significant difference [32]-[34].

2.6. Research Procedure

The research procedure was conducted in three main stages: preparation, implementation, and final stage. In the preparation stage, the researcher conducted a preliminary study to identify existing problems, designed lesson plans based on the ASSURE model, developed research instruments, and validated the instruments before use. In the implementation stage, both the experimental and control groups were administered a pretest to measure initial cognitive ability. The experimental group was then taught using the ASSURE model, while the control group received conventional instruction. After the treatment, a posttest was administered to both groups to measure the improvement in cognitive abilities. Finally, in the final stage, the collected data were analyzed using appropriate statistical techniques, hypotheses were tested, and conclusions were drawn based on the findings of the study.

3. RESULTS AND DISCUSSION

Descriptive statistical analysis was conducted to provide an overview of students' cognitive abilities in both the experimental and control groups before and after the treatment. The results of the pretest and posttest scores are presented in Table 3.

Table 3. Descriptive Statistics of Pretest and Posttest Scores

Group	Test	N	Mean	Min	Max	Std. Deviation
Experimental	Pretest	38	56.21	40	72	8.45
Experimental	Posttest	38	78.34	65	92	7.12
Control	Pretest	37	55.87	38	70	8.67
Control	Posttest	37	68.12	55	80	7.95

The descriptive statistics show that both the experimental and control groups had relatively similar mean scores in the pretest, with the experimental group scoring 56.21 and the control group scoring 55.87. This indicates that the initial cognitive abilities of students in both groups were comparable prior to the treatment. Such similarity suggests that the groups were homogeneous at baseline, allowing for a fair comparison of the instructional interventions.

After the implementation of the learning treatments, there was a notable increase in the posttest scores for both groups. However, the experimental group, which was taught using the ASSURE model, demonstrated a significantly higher improvement compared to the control group. The mean score of the experimental group increased to 78.34, while the control group reached only 68.12. This indicates that the ASSURE model contributed more effectively to improving students' cognitive abilities than the conventional teaching method.

In addition, the standard deviation in the experimental group decreased from 8.45 to 7.12, indicating that students' performance became more consistent after the treatment. This suggests that the ASSURE model not only improved overall cognitive achievement but also reduced the variability of student performance. In contrast, the control group showed a less pronounced improvement, indicating that conventional instruction may not sufficiently support all learners in achieving optimal cognitive development.

These findings are consistent with previous studies that highlight the effectiveness of structured instructional design models in enhancing cognitive learning outcomes. For instance, found that the ASSURE model significantly improves students' conceptual understanding and engagement in physics learning [35]. Similarly, studies have shown that instructional approaches emphasizing active learning and learner engagement lead to significantly higher cognitive achievement compared to traditional teacher-centered methods. For instance, Freeman et al. [36] demonstrated through a meta-analysis that active learning strategies substantially improve student performance in science education.

Furthermore, the improvement observed in the experimental group aligns with constructivist learning theory, which emphasizes active student involvement in constructing knowledge through meaningful experiences. The ASSURE model facilitates this process by integrating learner characteristics, appropriate media, and active participation, thereby creating a more effective learning environment. As noted by Smaldino et al. [37], instructional designs that incorporate systematic planning and active engagement can significantly enhance students' cognitive performance. Overall, the descriptive analysis indicates that the ASSURE model has a positive impact on students' cognitive abilities, particularly in understanding and analyzing complex physics concepts such as light waves.

Before conducting hypothesis testing, prerequisite analyses were performed to ensure that the data met the assumptions of parametric statistical tests, namely normality and homogeneity of variance. The normality of the data distribution was examined using the Kolmogorov–Smirnov test. The results of the normality test for both the experimental and control groups are presented in Table 4.

Table 4. Results of Normality Test

Group	Test	Sig. (p-value)	Interpretation
Experimental	Pretest	0.200	Normal
Experimental	Posttest	0.089	Normal
Control	Pretest	0.174	Normal
Control	Posttest	0.112	Normal

Based on Table 4, all significance values (p-values) for both the pretest and posttest scores in the experimental and control groups are greater than 0.05. This indicates that the data are normally distributed. Therefore, the assumption of normality required for parametric statistical analysis is satisfied. These results suggest that the distribution of students' cognitive ability scores does not significantly deviate from a normal distribution, allowing further analysis using parametric tests such as the independent samples t-test. According to statistical theory, normally distributed data ensure that hypothesis testing yields valid and reliable results, particularly in experimental research designs. The homogeneity of variance between the experimental and control groups was tested using Levene's Test. The results are presented in Table 5.

Table 5. Results of Homogeneity Test

Data	Sig. (p-value)	Interpretation
Pretest	0.327	Homogeneous
Posttest	0.214	Homogeneous

The results of Levene's Test show that the significance values for both pretest and posttest data are greater than 0.05. This indicates that the variances of the two groups are statistically equal or homogeneous. Therefore, the assumption of homogeneity of variance is fulfilled.

The fulfillment of this assumption implies that the variability of scores between the experimental and control groups is comparable, allowing for a fair comparison in subsequent hypothesis testing. Homogeneous variance is a critical requirement in independent samples t-test analysis, as it ensures that differences observed between groups are due to the treatment effect rather than unequal variability. Based on the results of the normality and homogeneity tests, it can be concluded that all prerequisite assumptions for parametric testing have been met. Therefore, the data are suitable for further analysis using the independent samples t-test to examine the effect of the ASSURE model on students' cognitive abilities.

After confirming that the data met the assumptions of normality and homogeneity, hypothesis testing was conducted using an independent samples t-test to examine the effect of the ASSURE model on students' cognitive abilities. The results of the independent samples t-test are presented in Table 6.

Table 6. Independent Samples t-test Results

Variable	Group	Mean	Std. Deviation	t-value	Sig. (2-tailed)
Posttest Score	Experimental	78.34	7.12	5.87	0.000
Posttest Score	Control	68.12	7.95		

Based on Table 6, the significance value (p-value) is 0.000, which is less than 0.05. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This indicates that there is a statistically significant difference in cognitive ability between students taught using the ASSURE model and those taught using conventional methods.

Furthermore, the mean score of the experimental group (78.34) is higher than that of the control group (68.12), suggesting that the ASSURE model has a positive effect on improving students' cognitive abilities. This result confirms that structured instructional design combined with active student participation can significantly enhance learning outcomes. The magnitude of the treatment effect was measured using Cohen's d, which represents the standardized difference between two group means. The formula is as follows:

$$d = \frac{M_1 - M_2}{SD_{pooled}} \quad ...(1)$$

where the pooled standard deviation is calculated using:

$$SD_{pooled} = \sqrt{\frac{(n_1-1)SD_1^2 + (n_2-1)SD_2^2}{n_1+n_2-2}} \quad ...(2)$$

The data used in this study were:

- Experimental group: $M_1 = 78.34, SD_1 = 7.12, n_1 = 38$
- Control group: $M_2 = 68.12, SD_2 = 7.95, n_2 = 37$

1. Calculating the pooled standard deviation

$$SD_{pooled} = \sqrt{\frac{(38-1)\,(7.12)^2 + (37-1)(7.95)^2}{38+37-2}}$$
$$= \sqrt{\frac{37(50.69) + 36(63.20)}{73}}$$
$$= \sqrt{\frac{1875.53 + 2275.20}{73}}$$
$$= \sqrt{56.86} = 7.54$$

2. Calculating Cohen's d

$$d = \frac{78.34 - 68.12}{7.54}$$
$$= \frac{10.22}{7.54}$$
$$= 1.35 \approx 1.34$$

According to Jacob Cohen (1988), effect size values can be interpreted as:

- 0.20 = small effect

- 0.50 = medium effect
- 0.80 = large effect

Thus, the obtained value of $d \approx 1.34$indicates a large effect size, meaning that the ASSURE model has a strong and practically meaningful impact on students' cognitive abilities.

The findings of this study are consistent with and extend previous research on the implementation of the ASSURE model in educational contexts. For instance, the study by Gang Lei [38] in Taylor & Francis highlights that the ASSURE model plays a crucial role in enhancing educational technology integration and supporting adaptive and interactive learning environments, although it is more conceptual and does not directly measure students' cognitive outcomes . In contrast, the study by Batir and Sadi [39] reported that ASSURE-based instructional modules effectively support students' understanding of physics concepts, particularly in energy-related topics, through structured learning activities. Additionally, Adedapo and Opoola [40], found that the level of ASSURE model integration in classroom practice significantly influences instructional effectiveness, although the study focused more on teacher implementation rather than measurable student achievement outcomes. Compared to these studies, the present research provides stronger empirical evidence by quantitatively demonstrating that the ASSURE model significantly improves students' cognitive abilities, supported by statistical testing ($p < 0.05$) and a large effect size ($d = 1.34$). Therefore, this study not only confirms prior findings but also advances the literature by offering measurable and statistically validated evidence of the ASSURE model's impact on cognitive learning outcomes in physics education.

The novelty of this study lies in its specific and measurable analysis of the effectiveness of the ASSURE model in improving students' cognitive abilities across Bloom's Taxonomy levels (C1–C4) in the context of light wave concepts. Unlike previous studies that generally focused on overall learning outcomes, this study integrates a systematic analysis of learner characteristics into each stage of instructional design and examines its impact quantitatively using statistical testing and a strong effect size ($d = 1.34$). This provides a new contribution in the form of more comprehensive empirical evidence, demonstrating that the ASSURE model not only enhances overall learning outcomes but also effectively develops students' cognitive abilities across lower to middle-order thinking levels in a more consistent and balanced manner.

The findings of this study have important theoretical and practical implications. Theoretically, the results reinforce the idea that systematic instructional design based on learner characteristics, as implemented in the ASSURE model, can effectively optimize cognitive development in physics learning. Practically, this study offers a clear recommendation for teachers to adopt the ASSURE model as an alternative instructional strategy that is more effective than conventional methods, particularly for abstract topics such as light waves. Furthermore, the integration of instructional media and active student engagement emphasized in the ASSURE model can serve as a guideline for designing more interactive, adaptive, and student-centered learning environments to improve the quality of classroom instruction.

Despite the significant findings, this study has several limitations that should be acknowledged. First, the study was conducted in a single school with a limited sample size, which may restrict the generalizability of the results to broader educational contexts. Second, the study only measured cognitive abilities up to the analysis level (C4) and did not include higher-order thinking skills such as evaluation (C5) and creation (C6). Third, the relatively short duration of the intervention may not fully capture the long-term impact of the ASSURE model on students' cognitive development. Therefore, future research is recommended to involve larger and more diverse samples, include higher levels of cognitive assessment, and implement longer intervention periods to obtain more comprehensive findings.

4. CONCLUSION

This study concludes that the ASSURE model has a significant and positive effect on students' cognitive abilities in learning light wave concepts. The experimental group showed higher posttest scores than the control group, supported by the independent samples t-test results ($p < 0.05$). In addition, the effect size ($d = 1.34$) indicates a strong practical impact of the ASSURE model. These findings demonstrate that structured instructional design combined with active student participation effectively enhances cognitive learning outcomes. Therefore, the ASSURE model can be recommended as an alternative approach to improve student-centered learning in physics. Future research is suggested to apply the ASSURE model in different subjects and educational contexts to further validate its effectiveness.

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REFERENCES

[1] D. Lombardi, "On the horizon: The promise and power of higher order, critical, and critical analytical thinking," *Educ. Psychol. Rev.*, vol. 35, no. 2, p. 38, 2023, doi: 10.1007/s10648-023-09763-z.

[2] P. Kwangmuang, S. Jarutkamolpong, W. Sangboonraung, and S. Daungtod, "The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools," *Heliyon*, vol. 7, no. 6, Jun. 2021, doi: 10.1016/j.heliyon.2021.e07309.

[3] E. G. Galimova, O. V Sergeeva, M. R. Zheltukhina, N. L. Sokolova, V. L. Zakharova, and N. N. Drobysheva, "Mobile learning in science education to improve higher-order thinking skills and communication skills: scoping review," *Front. Commun.*, vol. Volume 10-2025, 2025, [Online]. Available: https://www.frontiersin.org/journals/communication/articles/10.3389/fcomm.2025.1624012

[4] C. Cammies, J. A. Cunningham, and R. K. Pike, "Not all Bloom and gloom: assessing constructive alignment, higher order cognitive skills, and their influence on students' perceived learning within the practical components of an undergraduate biology course," *J. Biol. Educ.*, vol. 58, no. 3, pp. 588–608, May 2024, doi: 10.1080/00219266.2022.2092191.

[5] H. Hawk, "Unlocking the potential: enhancing higher-order thinking skills in accounting education," *Account. Educ.*, vol. 34, no. 6, pp. 998–1025, Nov. 2025, doi: 10.1080/09639284.2024.2375600.

[6] J. West, "Utilizing Bloom's taxonomy and authentic learning principles to promote preservice teachers' pedagogical content knowledge," *Soc. Sci. Humanit. Open*, vol. 8, no. 1, p. 100620, 2023, doi: https://doi.org/10.1016/j.ssaho.2023.100620.

[7] C. F. J. Pols, P. J. J. M. Dekkers, and M. J. de Vries, "What do they know? Investigating students' ability to analyse experimental data in secondary physics education," *Int. J. Sci. Educ.*, vol. 43, no. 2, pp. 274–297, Jan. 2021, doi: 10.1080/09500693.2020.1865588.

[8] M. I. Simeon, M. A. Samsudin, and N. Yakob, "Effect of design thinking approach on students' achievement in some selected physics concepts in the context of STEM learning," *Int. J. Technol. Des. Educ.*, vol. 32, no. 1, pp. 185–212, 2022, doi: 10.1007/s10798-020-09601-1.

[9] T. Bouchée, L. de Putter - Smits, M. Thurlings, and B. Pepin, "Towards a better understanding of conceptual difficulties in introductory quantum physics courses," *Stud. Sci. Educ.*, vol. 58, no. 2, pp. 183–202, Jul. 2022, doi: 10.1080/03057267.2021.1963579.

[10] M. V. Bøe and S. Viefers, "Secondary and university students' descriptions of quantum uncertainty and the wave nature of quantum particles," *Sci. Educ.*, vol. 32, no. 2, pp. 297–326, 2023, doi: 10.1007/s11191-021-00297-w.

[11] A.-M. Cederqvist, "An exploratory study of technological knowledge when pupils are designing a programmed technological solution using BBC Micro:bit," *Int. J. Technol. Des. Educ.*, vol. 32, no. 1, pp. 355–381, 2022, doi: 10.1007/s10798-020-09618-6.

[12] R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys. - AMER J PHYS*, vol. 66, Jan. 1998, doi: 10.1119/1.18809.

[13] S. Li and S. P. Lajoie, "Cognitive engagement in self-regulated learning: an integrative model," *Eur. J. Psychol. Educ.*, vol. 37, no. 3, pp. 833–852, 2022, doi: 10.1007/s10212-021-00565-x.

[14] H. Ruiz-Martín and R. W. Bybee, "The cognitive principles of learning underlying the 5E Model of Instruction," *Int. J. STEM Educ.*, vol. 9, no. 1, p. 21, 2022, doi: 10.1186/s40594-022-00337-z.

[15] D. Dada, O. T. Laseinde, and L. Tartibu, "Student-centered learning tool for cognitive enhancement in the learning environment," *Procedia Comput. Sci.*, vol. 217, pp. 507–512, 2023, doi: https://doi.org/10.1016/j.procs.2022.12.246.

[16] M. Altın, "Evaluation of the effectiveness of english language instruction based on the ASSURE model," *E-International J. Educ. Res.*, vol. 12, no. 5, pp. 195–211, 2021, doi: 10.19160/e-ijer.1018149.

[17] I. Damayanti and S. Rahmadonna, "Integrating quizizz and google classroom : A case study of the ASSURE model in science learning for fifth-grade digital classrooms," *Al-Ishlah J. Pendidik.*, vol. 17, no. 2, pp. 3040–3056, 2025, doi: 10.35445/alishlah.v17i2.6800.

[18] K. Nugkim and P. Onjai-uea, "The study of knowledge and understanding of the assure model in designing the planning of technology and learning media for guidance of the undergraduate students at faculty of education kasetsart university," *J. Ind. Educ.*, vol. 20, no. 3 SE-Research Articles, pp. 1–10, Aug. 2021, [Online]. Available: https://ph01.tci-thaijo.org/index.php/JIE/article/view/244534

[19] M. N. Ihsan, M. Hartati, and A. M. Rahman, "Implementing ASSURE model in islamic religious education to develop 21st century competencie," *Atthulab Islam. Relig. Teach. Learn. J.*, vol. 10, no. 1 SE-Articles, pp. 132–152, Apr. 2025, doi: 10.15575/atthulab.v10i1.43266.

[20] N. Eliana, U. A. Wati, S. Rahmadona, and U. N. Yogyakarta, "Leveraging the ASSURE model technology-based learning media for optimized information," *AL-ISHLAH J. Pendidik.*, vol. 16, no. 3, pp. 3614–3626, 2024, doi: 10.35445/alishlah.v16i3.5639.

[21] M. Özyurt and H. V. Akşab, "Use of ASSURE MODEL in ELT: Reflections on the learning and teaching process," *Int. J. Assess. Tools Educ.*, vol. 12, no. 4, pp. 1034–1054, 2025, doi: 10.21449/ijate.1571335.

[22] L. O. Nursalam *et al.*, "Exploring pre-service teacher' views of science process skills," *J. Phys. Conf. Ser.*, vol. 2165, no. 1, p. 12012, 2022, doi: 10.1088/1742-6596/2165/1/012012.

[23] G. A. Uribe, I. A. Tortajada, C. Solans Sánchez, A. Rummler, K. Y. Oyulmaz, and H. Denizli, "Graph-based algorithm for the understanding of failures in the ATLAS infrastructure," *J. Phys. Conf. Ser.*, vol. 2438, no. 1, p. 12045, 2023, doi: 10.1088/1742-6596/2438/1/012045.

[24] N. Kohan, N. Navabi, M. K. Motlagh, and F. Ahmadinia, "Designing and evaluating ECG interpretation software for undergraduate nursing students in Iran: a non-equivalent control group pretest-posttest design," *BMC Nurs.*, vol. 23, no. 1, p. 827, 2024, doi: 10.1186/s12912-024-02472-0.

[25] M. Bulus, “Sample size determination and optimal design of randomized/non-equivalent pretest-posttest control-group designs,” *Adıyaman Üniversitesi Eğitim Bilim. Derg.*, vol. 11, no. 1, pp. 48–69, Jun. 2021, doi: 10.17984/adyuebd.941434.

[26] N. Reis *et al.*, “Telerehabilitation intervention in transitional care for people with COVID-19: pre-post study with a non-equivalent control group,” 2023. doi: 10.3390/healthcare11182561.

[27] T. N. Trisahid, D. Kijkosol, and C. Corrales, “Optimization of biology learning on excretory system material through contextual teaching and learning approach,” *J. Acad. Biol. Biol. Educ.*, vol. 1, no. 2, pp. 82–91, 2024, doi: 10.37251/jouabe.v1i2.1165.

[28] A. Kamath, S. Poojari, and K. Varsha, “Assessing the robustness of normality tests under varying skewness and kurtosis: a practical checklist for public health researchers,” *BMC Med. Res. Methodol.*, vol. 25, no. 1, p. 206, 2025, doi: 10.1186/s12874-025-02641-y.

[29] Romain-Daniel Gosselin, “Testing for normality: a user’s (cautionary) guide,” *Lab. Anim.*, vol. 58, no. 5, pp. 433–437, Oct. 2024, doi: 10.1177/00236772241276808.

[30] Y. Zhou, Y. Zhu, and W. K. Wong, “Statistical tests for homogeneity of variance for clinical trials and recommendations,” *Contemp. Clin. Trials Commun.*, vol. 33, p. 101119, 2023, doi: https://doi.org/10.1016/j.conctc.2023.101119.

[31] H. M. Alakrash, N. A. Razak, and E. S. Bustan, “The effectiveness of employing telegram application in teaching vocabulary : A quasai experimental study,” vol. 6, no. 1, pp. 151–159, 2020, doi: 10.5281/zenodo.3905099.

[32] T. W. MacFarland and J. M. Yates, “Student’s t-Test for Independent Samples BT - Using R for Biostatistics,” T. W. MacFarland and J. M. Yates, Eds., Cham: Springer International Publishing, 2021, pp. 141–240. doi: 10.1007/978-3-030-62404-0_3.

[33] A. T. Hutcheson and K. G. Brown, “The Independent Samples t-Test BT - Statistics for Psychology Research: A Short Guide Using Excel,” A. T. Hutcheson and K. G. Brown, Eds., Cham: Springer Nature Switzerland, 2024, pp. 73–92. doi: 10.1007/978-3-031-60970-1_5.

[34] K. Kamid, S. Winarni, R. Rohati, W. A. Pratama, and E. Triani, “Student team achievement division learning model and student process skills,” *J. Ilm. Sekol. Dasar*, vol. 6, no. 1 SE-Articles, pp. 1–10, Mar. 2022, doi: 10.23887/jisd.v6i1.42456.

[35] Ni Putu Diana Sari, I Gusti Ayu Maritati, Putu Suwidnyana, and I Nyoman Sudiana, “The role of the ASSURE model in Indonesian and district learning planning,” *Bull. Sci. Educ.*, vol. 4, no. 3 SE-Articles, pp. 396–402, Dec. 2024, doi: 10.51278/bse.v4i3.1651.

[36] S. Freeman *et al.*, “Active learning increases student performance in science, engineering, and mathematics,” *Proc. Natl. Acad. Sci.*, vol. 111, no. 23, pp. 8410–8415, Jun. 2014, doi: 10.1073/pnas.1319030111.

[37] S. E. Smaldino, D. L. Lowther, and C. Mims, *Instructional Technology and Media for Learning*. United States: Pearson Education, Inc., 2019. [Online]. Available: https://lccn.loc.gov/2017015584

[38] G. Lei, “Influence of ASSURE model in enhancing educational technology,” *Interact. Learn. Environ.*, vol. 32, no. 7, pp. 3297–3313, Aug. 2024, doi: 10.1080/10494820.2023.2172047.

[39] Z. Batır and Ö. Sadi, “A science module designed based on the assure model: potential energy,” *J. Inq. Based Act.*, vol. 11, no. 2, pp. 111–124, 2021, [Online]. Available: https://files.eric.ed.gov/fulltext/EJ1323297.pdf

[40] A. Adedapo and B. T. Opoola, “Levels of integrating the ASSURE model in lesson delivery of selected primary school teachers in Nigeria,” *J. Lang. Teach. Res.*, vol. 12, no. 1, pp. 177–182, 2021, doi: 10.17507/jltr.1201.19.