Confirmatory Factor Analysis of a 21st-Century Skills Instrument in Audiovisual-Assisted Problem-Based Learning

Hendrik Setiawan*, Dewi Amaliah Nafiati, Munadi

Master of Pedagogy Study Program, Postgraduate Program,
Universitas Pancasakti Tegal, Indonesia.
*Corresponding Author. Email: hendriksetiawan8823@gmail.com

Abstract: This study aims to develop and validate a performance-based assessment instrument for measuring 21st-century skills in Ilmu Pengetahuan Alam dan Sosial (IPAS) learning through audiovisual-assisted Problem-Based Learning. The instrument comprises 16 essay items designed to assess four dimensions of the 4C framework—critical thinking, creativity, communication, and collaboration—with four items allocated to each dimension. Responses were scored using a 1–4 analytic rubric. An instrument development approach was employed, with construct validation conducted through a pilot test involving 30 sixth-grade students from SDN Brebes 10. Data were analyzed using Confirmatory Factor Analysis (CFA). The results indicate that all items are valid, with standardized factor loadings ranging from 0.897 to 0.967 (CR > 22.62; p < 0.001). The measurement model demonstrates excellent goodness-of-fit indices (χ^2 = 93.997; df = 98; p = 0.596; CFI = 1.000; TLI = 1.007; RMSEA = 0.000; SRMR = 0.023). All items exhibit very strong factor loadings ($\lambda \geq$ 0.80) and coefficients of determination (R^2) ranging from 0.805 to 0.935. In addition, inter-factor correlations (–0.686 to 0.193) confirm adequate discriminant validity. Overall, these findings indicate that the developed instrument satisfies construct validity requirements and demonstrates excellent psychometric quality for assessing elementary students' 21st-century skills in audiovisual-assisted IPAS learning.

How to Cite: Setiawan, H., Nafiati, D. A., & Munadi, M. (2026). Confirmatory Factor Analysis of a 21st-Century Skills Instrument in Audiovisual-Assisted Problem-Based Learning. *Jurnal Paedagogy*, *13*(1), 43-51. https://doi.org/10.33394/jp.v13i1.18801

https://doi.org/10.33394/jp.v13i1.18801

Introduction

The transformation of 21st-century education requires the development of adaptive competencies aligned with the Framework for 21st Century Learning, which identifies four core skills: critical thinking, creativity, communication, and collaboration (Voogt & Pareja Roblin, 2022). However, findings from PISA 2022 and TIMSS 2019 reveal a substantial gap between these expected competencies and the learning outcomes of Indonesian students, particularly in higher-order thinking skills (Mullis et al., 2020). Within the Merdeka Curriculum, IPAS learning provides opportunities to cultivate 21st-century skills through the exploration of contextual phenomena. Problem-Based Learning (PBL), which situates authentic problems as the starting point of learning, encourages students' investigative and problem-solving abilities (Hmelo-Silver, 2004). Innovative approaches for strengthening higher-order thinking have been shown to be effective across learning contexts, including mathematics instruction that emphasizes creative thinking and diverse learning styles (Muminu et al., 2020). The integration of audiovisual media into PBL further enhances learning experiences by offering dual representations in accordance with dual coding theory (Paivio, 2021).

Previous studies have demonstrated that PBL improves the critical thinking of elementary students (Zuryanty et al., 2019), while combinations of PBL and audiovisual media significantly strengthen critical thinking and student participation (Ningtias et al., 2024). Wulanjani et al. (2024) reported that PBL supported by e-modules effectively develops critical thinking, communication, and creativity. Wahroni et al. (2020) also found that PBL-based module development improves students' understanding. In addition, Nafiati et al. (2024) revealed that cooperative learning strengthens communication skills, particularly in boarding school contexts. Despite these findings, most existing research concentrates on partial cognitive aspects and has not yet examined the four 4C dimensions comprehensively within an experimental learning environment.

A major methodological limitation in previous studies is the limited availability of validated instruments for assessing 21st-century skills within audiovisual-assisted Problem-Based Learning at the elementary school level. Although several studies have reported the effectiveness of innovative learning models in improving specific competencies such as communication skills in boarding school contexts (Nafiati et al., 2024) and creative thinking in mathematics learning (Muminu et al., 2020) these findings highlight a broader issue: the effectiveness of instructional approaches in elementary science and IPAS education still requires support from valid and contextually appropriate assessment instruments. Without rigorous measurement tools, evidence regarding the development of 21st-century skills in elementary education remains incomplete.

Existing instruments for assessing 21st-century skills are predominantly based on self-report questionnaires, which tend to measure students' perceptions rather than their actual performance. Such instruments are limited in capturing how elementary students demonstrate critical thinking, creativity, communication, and collaboration when responding to authentic learning problems. According to Hair et al. (2022), the assessment of complex and multidimensional constructs demands strong empirical evidence of construct validity through confirmatory factor analysis. In addition, Nafiati (2021) emphasizes that comprehensive educational assessment should integrate cognitive, affective, and psychomotor domains, particularly in elementary learning contexts where skills development is closely linked to observable performance.

Building on these gaps, the present study develops a comprehensive essay-based assessment instrument for evaluating 21st-century skills in audiovisual-assisted Problem-Based Learning. Essay-based tasks are considered more appropriate for elementary students because they allow learners to articulate reasoning processes, generate original ideas, communicate understanding clearly, and demonstrate collaborative thinking through problem-solving scenarios. Unlike selected-response formats, essay-based assessments enable the direct observation of students' 4C competencies in authentic learning situations. Therefore, this study focuses on establishing strong construct validity of the instrument using Confirmatory Factor Analysis, providing a methodologically sound measurement tool to support research and instructional evaluation in elementary IPAS education.

Research Method

This study represents the instrument development phase of a quasi-experimental research design employing a pretest–posttest structure to examine the effect of audiovisual-assisted PBL on 21st-century skills. The pilot testing involved 30 sixth-grade students from SDN Brebes 10 (14 males, 16 females; mean age = 11.7 years, SD = 0.47) who shared similar characteristics with the main study sample but were not part of the experimental group. The

pilot was conducted in the third week of implementation with approval from the school principal and parents. The selected sample size (N = 30) aligns with methodological recommendations for pilot studies. Previous literature indicates that samples of 15–30 participants are acceptable for initial instrument validation (Rahayu et al., 2023; Bujang et al., 2024). Boomsma and Hoogland (2001) further note that simple CFA models with clear factor structures and high indicator–factor ratios (4:1) may be reliably estimated using small samples, although results should be interpreted conservatively.

The instrument consisted of 16 essay items assessing four dimensions of the 4C framework, with four items for each dimension. Responses were scored using a 4-point analytic rubric (1 = Poor: incomplete/inaccurate; 2 = Fair: partially correct; 3 = Good: correct and sufficiently complete; 4 = Very Good: complete and accurate). Prior to construct validation, the instrument underwent content validation through expert judgment to ensure its theoretical and contextual adequacy. The expert panel consisted of three experts, including two professors in educational assessment and one elementary school practitioner. Each item was evaluated in terms of relevance, clarity, and representativeness of the intended 4C construct. The results of the expert review indicated that all items met acceptable Content Validity Index (CVI) criteria, confirming that the instrument was theoretically sound before being administered to students.

The construct foundation was derived from established theoretical frameworks, including Facione (1990) for Critical Thinking, Torrance as cited in Munandar (2021) for Creativity, Ruben and Stewart as cited in Mulyana (2023) for Communication, and Johnson and Johnson as cited in Trianto (2021) for Collaboration. Item development also incorporated the cognitive, affective, and psychomotor domains of learning to ensure comprehensive skill representation (Nafiati, 2021).

Table 1. Specifications of the 21st-Century Skills Instrument

Dimension	Indicators	Items	Item Numbers	Score Range
Critical Thinking	Analysis, evaluation, inference, interpretation	4	Q1–Q4	4–16
Creativity	Fluency, flexibility, originality, elaboration	4	Q5–Q8	4–16
Communication	Clarity, accuracy, completeness, responsiveness	4	Q9–Q12	4–16
Collaboration	Contribution, responsibility, interdependence, social skills	4	Q13–Q16	4–16
Total		16	–	16–64

Data collection was carried out in the classroom under the supervision of the researcher. Students were informed of the purpose of the assessment and assured that their responses would not affect academic grades. Completion time ranged from 60 to 75 minutes. Scoring was conducted by the researcher using a standardized rubric to maintain consistency. Data were collected individually after students completed one cycle of audiovisual-assisted PBL, ensuring that their responses reflected the intended learning context.

Prior to field testing, the instrument underwent content validation through expert judgment to ensure its theoretical and contextual relevance. The validation process involved three experts consisting of two professors in education assessment and one elementary school practitioner. Each item was evaluated in terms of relevance, clarity, and representativeness of the 4C constructs. The overall Content Validity Index (CVI) indicated that all items met

acceptable content validity criteria, confirming that the instrument was theoretically sound before being administered to students.

Construct validity was examined using Confirmatory Factor Analysis (CFA) with JASP (Jeffreys' Amazing Statistics Program) software. Scores for each item (1–4) served as observed variables in the model. The four-factor model specified that each item loaded on only one latent factor, all latent factors were correlated, and error terms were independent. Model fit evaluation employed the following criteria: χ^2 (p > 0.05), Comparative Fit Index (CFI ≥ 0.90), Tucker–Lewis Index (TLI ≥ 0.90), Root Mean Square Error of Approximation (RMSEA ≤ 0.08), and Standardized Root Mean Square Residual (SRMR ≤ 0.08). Item validity was assessed based on standardized factor loadings (λ ≥ 0.50) with critical ratios (CR > 1.96) or p < 0.05. Loading strength was interpreted following Hair et al. (2022): λ = 0.80–1.00 (very strong), 0.60–0.79 (strong), and 0.40–0.59 (moderate). Discriminant validity was evaluated through inter-factor correlations (< 0.85).

Results and Discussion

A bibliometric analysis of international publications from the period 2016–2025 reveals significant growth in solfeggio-based music education studies, particularly on the topics of ear training, sight singing, sight reading, and music pedagogy. Two phases of development can be identified: the early exploration phase (2016–2020), characterized by a wide distribution of topics, and the acceleration and consolidation phase (2021–2025), which shows an increase in the number of publications and thematic consistency towards the solfeggio approach in modern music education

The CFA results indicated that the four-factor model demonstrated an excellent fit to the data (Table 2). The CFI (1.000) and TLI (1.007) exceeded the recommended threshold of ≥0.90, suggesting that the model captured the covariance structure exceptionally well. The RMSEA value of 0.000 with a 90% confidence interval of [0.000–0.087] and the SRMR of 0.023 were both well below the ≤0.08 cutoff, indicating minimal model misfit

Table 2. Table 2. Goodness-of-Fit Indices of the Measurement Model

Index	Value	Criterion	Description
χ^2	93,997	-	-
df	98	-	-
p-value	0,596	>0,05	*Excellent Fit*
CFI	1,000	≥0,90	*Excellent Fit*
TLI	1,007	≥0,90	*Excellent Fit*
RMSEA	0,000	≤0,08	*Excellent Fit*
RMSEA 90% CI	[0,000-0,087]	-	*Excellent Fit*
SRMR	0,023	≤0,08	*Excellent Fit*

The chi-square statistic was nonsignificant (χ^2 = 93.997; df = 98; p = 0.596), confirming that the model did not significantly differ from the observed data, thereby providing strong evidence of model adequacy. All 16 items met the construct validity criteria, with factor loadings ranging from 0.897 to 0.967 and critical ratios between 22.62 and 65.81 (p < 0.001), as presented in Table 3.

Table 3. CFA Results of the 21st-Century Skills Instrument

Item	Dimension	E	R	p	R²	Status	Category
1	*Critical Thinking*	,959	,018	2,16	<0,001	0,920	Valid	Very Strong
2	*Critical Thinking*	,959	,018	1,83	<0,001	0,919	Valid	Very Strong
3	*Critical Thinking*	,947	,022	3,08	<0,001	0,897	Valid	Very Strong
4	*Critical Thinking*	,935	,026	6,10	<0,001	0,875	Valid	Very Strong
5	*Creativity*	,946	,025	8,18	<0,001	0,895	Valid	Very Strong
6	*Creativity*	,938	,027	4,73	<0,001	0,880	Valid	Very Strong
7	*Creativity*	,899	,039	2,93	<0,001	0,808	Valid	Very Strong
8	*Creativity*	,924	,031	9,63	<0,001	0,855	Valid	Very Strong
9	*Communication*	,967	,015	5,81	<0,001	0,935	Valid	Very Strong
10	*Communication*	,967	,015	5,81	<0,001	0,935	Valid	Very Strong
11	*Communication*	,943	,023	1,90	<0,001	0,889	Valid	Very Strong
12	*Communication*	,967	,015	5,81	<0,001	0,935	Valid	Very Strong
13	*Collaboration*	,942	,026	6,72	<0,001	0,888	Valid	Very Strong
14	*Collaboration*	,942	,026	6,72	<0,001	0,888	Valid	Very Strong
15	*Collaboration*	,897	,040	2,62	<0,001	0,805	Valid	Very Strong
16	*Collaboration*	,942	,026	6,72	<0,001	0,888	Valid	Very Strong

Note: λ = standardized factor loading; SE = standard error; CR = critical ratio; R^2 = squared multiple correlation

All items (100%) were categorized as "very strong" ($\lambda \geq 0.80$). The lowest loadings were observed for Q3, Q7, and Q15 ($\lambda = 0.897$), while the highest were found in items Q9, Q10, and Q12 ($\lambda = 0.967$). The Communication dimension displayed the highest item consistency, with three of its indicators sharing identical factor loadings ($\lambda = 0.967$; CR = 65.81). The R^2 values ranged from 0.805 to 0.935, indicating that each item's latent factor explained between 80.5% and 93.5% of its variance, far above the minimum recommended level ($R^2 \geq 0.25$). Items Q9, Q10, and Q12 (Communication) emerged as the strongest indicators of 21st-century skills, whereas Q3 (Critical Thinking), Q7 (Creativity), and Q15 (Collaboration) showed comparatively lower but still very strong loadings.
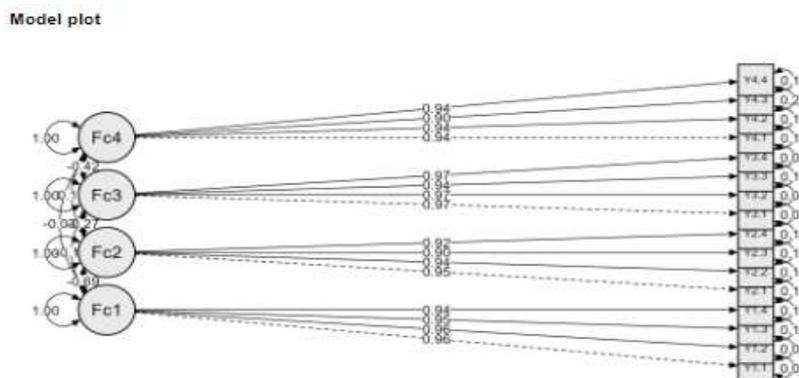
Figure 1. CFA Measurement Model Diagram of the 21st-Century Skills Instrument

Correlation analysis revealed a wide range of relationships among the four factors, from 0.686 to 0.193. The strongest negative correlation occurred between Critical Thinking and Creativity ($r = –0.686$; $p < 0.001$). Some factor pairs showed nonsignificant associations.

Table 4. Correlations Among Latent Factors

Faktor	*Critical Thinking*	*Creativity*	*Communication*	*Collaboration*
Critical Thinking	1			
Creativity	-0,686***	1		
Communication	-0,184	-0,265	1	
Collaboration	-0,026	0,193	-0,421**	1

Note: p < 0.01; *p < 0.001

Significant correlations were identified between Critical Thinking Creativity ($r = –0.686$; $p < 0.001$) and Communication Collaboration ($r = –0.421$; $p = 0.007$). These negative correlations suggest that within the context of audiovisual-supported PBL, improvement in one skill dimension may vary depending on the specific task emphasis. Other correlations Critical Thinking Communication ($r = –0.184$; $p = 0.307$), Critical Thinking Collaboration ($r = –0.026$; $p = 0.888$), Creativity–Communication ($r = –0.265$; $p = 0.129$), and Creativity Collaboration ($r = 0.193$; $p = 0.290$) were nonsignificant. All absolute values remained below 0.85, supporting strong discriminant validity.

Discussion

This study successfully developed a performance-based assessment instrument for 21st-century skills within an audiovisual-supported PBL context, demonstrating strong construct validity. Unlike self-report instruments, which assess students' perceptions, this instrument evaluates actual student performance via open-ended responses to contextual problems. The four-factor model exhibited outstanding fit (CFI=1.000; TLI=1.007; RMSEA=0.000; SRMR=0.023), outperforming recommended cutoffs (Hair et al., 2022) and aligning with the P21 framework (Voogt & Pareja Roblin, 2022). The non-significant chi-square value further strengthened the evidence for model data congruence, a condition rarely achieved in CFA studies (Wolf et al., 2013).

All items achieved very strong loadings ($\lambda \geq 0.897$) and high R^2 values (0.805–0.935), indicating highly precise measurement. Although the present study focused on construct validity, the exceptionally high loadings and item–factor relationships provide preliminary

evidence of strong internal consistency. Future research with larger samples remains necessary for formal reliability testing.

Communication emerged as the most consistent dimension, aligning with findings from Ningtias et al. (2024) and Nafiati et al. (2024), who reported that PBL and cooperative learning environments significantly enhance communication skills. Meanwhile, the lowest loadings appeared on Critical Thinking (inference), Creativity (originality), and Collaboration (interdependence) skills that involve higher-order cognitive and socio-cognitive processes (Facione, 1990; Munandar, 2021; Trianto, 2021).

The pattern of factor correlations confirmed the distinctiveness of the four constructs. The significant negative relationship between Critical Thinking and Creativity (r=–0.686) reflects their divergent cognitive orientations Critical Thinking being convergent and analytical, whereas Creativity is divergent and generative (Facione, 1990; Munandar, 2021). This non-parallel developmental pattern enriches the theoretical understanding of 4C skills.

The negative correlation between Communication and Collaboration (r = –0.421) provides an important pedagogical insight into how 21st-century skills manifest in audiovisual-supported PBL contexts. Rather than indicating a conceptual contradiction, this relationship suggests that these two skills may be differentially activated depending on task structure and assessment focus. Communication items in this instrument primarily emphasized individual expressive clarity, accuracy, and completeness of responses, whereas collaboration items emphasized interdependence, shared responsibility, and social coordination within group problem-solving scenarios.

In PBL settings, students who demonstrate strong individual communication performance,such as articulating ideas clearly and responding accurately to contextual problems may not necessarily exhibit equally strong collaborative behaviors if tasks allow individual dominance or unequal participation. Conversely, students who engage more effectively in collaborative processes may distribute roles and responsibilities in ways that reduce individual verbal prominence. This finding aligns with socio-constructivist perspectives suggesting that collaboration does not always require symmetrical verbal contribution, but rather effective coordination toward shared goals (Johnson & Johnson, as cited in Trianto, 2021).

Importantly, the observed negative correlation reflects task-dependent emphasis rather than skill incompatibility, reinforcing the argument that communication and collaboration, while theoretically related, represent distinct dimensions of performance in authentic learning environments. This empirical distinction supports the discriminant validity of the instrument and aligns with theoretical models of 21st-century competencies that conceptualize the 4C skills as complementary yet non-hierarchical constructs (Voogt & Pareja Roblin, 2022).

From a practical standpoint, this finding highlights the need for teachers to intentionally design PBL tasks that balance individual articulation and collective responsibility. Assessment strategies should ensure that students are not only evaluated on how well they express ideas individually, but also on how effectively they contribute to group processes. The availability of separate yet empirically distinct indicators for communication and collaboration in this instrument enables educators to diagnose such imbalances and adjust instructional design accordingly.

Conclusion

This study developed a 16-item performance-based assessment instrument designed to measure four dimensions of 21st-century skills critical thinking, creativity, communication, and collaboration within the context of audiovisual-assisted Problem-Based Learning. Confirmatory Factor Analysis conducted with a pilot sample of 30 students provided strong evidence of construct validity. All items demonstrated very strong standardized loadings (0.897–0.967) with significant critical ratios (CR > 22.62; p < 0.001), indicating high measurement precision. The measurement model exhibited excellent fit (χ^2 = 93.997; df = 98; p = 0.596; CFI = 1.000; TLI = 1.007; RMSEA = 0.000; SRMR = 0.023), confirming that the model accurately represented the underlying covariance structure. The coefficient of determination values (R^2 = 0.805–0.935) indicated that each item was strongly explained by its latent factor. Inter-factor correlations ranging from –0.686 to 0.193 supported strong discriminant validity, demonstrating that the four constructs were empirically distinct while still theoretically related within the 4C framework.

These findings provide robust preliminary evidence that the instrument possesses excellent construct validity and is appropriate for assessing elementary students' 21st-century skills in IPAS learning using performance-based tasks rather than self-reported perceptions. Although the pilot study employed a relatively small sample, the clarity of the factor structure and the magnitude of the loadings support the stability of the model. Overall, the validated instrument offers practical value for educators seeking to measure students' actual performance in 21st-century skills and to support instructional decision-making in audiovisual-assisted PBL implementation.

Recommendation

In light of the results obtained and the limitations encountered in this study, several directions are suggested for future development and refinement of the instrument. First, it is important to conduct additional validation studies with a larger and more heterogeneous sample so that the stability and generalizability of the factor structure can be ensured. Subsequent research should also include reliability testing whether through repeated measurements or consistency between raters to reinforce the psychometric strength of the instrument.

Further investigations are encouraged to analyze whether the instrument performs consistently across different groups, such as male and female students, learners with varying initial abilities, or diverse school settings. Future studies may also adopt longitudinal approaches to examine the instrument's capacity to detect growth in 21st-century skills over time, particularly following the implementation of PBL. Complementary qualitative analyses of student responses may offer deeper insight into the cognitive and social processes underlying the development of critical thinking, creativity, communication, and collaboration.

References

Boomsma, A., & Hoogland, J. J. (2001). The robustness of LISREL modeling revisited. In R. Cudeck, S. du Toit, & D. Sörbom (Eds.), *Structural equation modeling: Present and future* (pp. 139-168). Scientific Software International.

Bujang, M. A., Omar, E. D., & Baharum, N. A. (2024). A review on sample size determination for Cronbach's alpha test: A simple guide for researchers. *The Malaysian Journal of Medical Sciences, 25*(6), 85-99.

Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.

Facione, P. A. (1990). *Critical Thinking: A statement of expert consensus for purposes of educational assessment and instruction.* California Academic Press.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022). *Multivariate data analysis* (8th ed.). Cengage Learning.

Hadiyanti, H., Susongko, P., & Munadi, M. (2020). Pengembangan instrumen *higher order thinking skill mata pelajaran matematika dengan Rasch model. Journal of Education Research*, 5(1), 399-407.

Hmelo-Silver, C. E. (2004). *Problem-based learning: What and how do students learn? Educational Psychology Review, 16*(3), 235-266.

Muminu, M., Nugraha, R. A., & Munadi, M. (2020). *The influence of mathematical creative thinking ability in terms of learning styles on the learning of compound interest and annuities among students. Journal of English Language and Education*, 10(1), 389-397.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science.* Boston College, TIMSS & PIRLS International Study Center.

Mulyana, D. (2023). *Komunikasi efektif: Suatu pendekikan lintas budaya* (4th ed.). Remaja Rosdakarya.

Munandar, U. (2021). *Kreativitas dan keberbakatan: Strategi mewujudkan potensi kreatif dan bakat* (5th ed.). Gramedia Pustaka Utama.

Nafiati, D. A. (2021). Revisi taksonomi Bloom: Kognitif, afektif, dan psikomotorik. *Humanika: Kajian Ilmiah Mata Kuliah Umum, 21*(2), 151-172. https://doi.org/10.21831/hum.v21i2.29252

Nafiati, D. A., Rismawati, N., Azami, T., & Hendaryati, N. (2024). Cooperative learning: Alternatif untuk meningkatkan *Communication skill* pada sekolah berbasis *boarding. Jurnal Pendidikan Ekonomi (JURKAMI), 9*(2), 1-12.

Ningtias, D. R., Nurhayati, S., & Suranto, S. (2024). Pengaruh model *Problem Based Learning* berbantuan media audiovisual terhadap keterampilan berpikir kritis siswa sekolah dasar. *Jurnal Basicedu, 8*(2), 567-578.

Paivio, A. (2021). *Mental representations: A dual coding approach* (2nd ed.). Oxford University Press.

Rahayu, D. A., Supriyadi, S., & Ardhian, T. (2023). Sample size determination in nursing instrument development: A comprehensive review. *Journal of Nursing Science Update, 11*(1), 45-58.

Shi, D., Lee, T., & Maydeu-Olivares, A. (2019). Understanding the model size effect on SEM fit indices. *Educational and Psychological Measurement, 79*(2), 310-334.

Trianto. (2021). *Mendesain model pembelajaran inovatif-progresif* (5th ed.). Kencana.

Voogt, J., & Pareja Roblin, N. (2022). 21st century skills: From theory to practice in education. In *International handbook of research on teachers and teaching* (pp. 1-15). Springer.

Wahroni, W., Munadi, M., & Nasukha, M. (2020). Pengembangan modul pemrograman dasar algoritma dengan PBL siswa menjadi paham. Journal of Education Research, 5(4), 6503-6511.

Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement, 73*(6), 913-934.

Wulanjani, A. N., Pratama, R. A., & Susanti, V. D. (2024). Efektivitas model *Problem Based Learning* berbantuan e-modul dalam mata pelajaran IPAS untuk meningkatkan keterampilan berpikir kritis dan komunikasi siswa. *Jurnal Basicedu, 8*(3), 1789-1801.

Zuryanty, Kenedi, A. K., Chandra, F. H., Hamimah, & Fitria, Y. (2019). *Problem Based Learning*: A way to improve *Critical Thinking* ability of elementary school students on science learning. *Journal of Physics: Conference Series, 1321*, 022107.