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Integrating Literacy and Numeracy Skills in Elementary Science and Social Studies Learning: A Framework Development Study

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Abstract
This research developed and validated the Literacy and Numeracy Skill Development (LNSD) framework for integrating science and social studies (IPAS) instruction in elementary schools. Employing the 4D instructional design model (Define, Design, Development, Disseminate), the study systematically addressed the absence of pedagogical frameworks combining IPAS content with explicit literacy and numeracy skill development. The Define phase revealed through literature analysis and teacher interviews that existing IPAS instruction lacked systematic literacy-numeracy integration. The Design phase produced an initial framework adapted from Willison's Research Skill Development model, comprising distinct literacy and numeracy components with associated instructional sub-stages. The Development phase engaged three subject matter experts who validated the framework using Content Validity Index methodology, resulting in consensus on ten instructional sub-stages: four literacy components (Morning Message, Let's Read, Let's Write, Let's Practice) and six numeracy components (Read, Let's Compare, Let's Observe, Let's Try, Let's Practice, Reflection). The Disseminate phase implemented the validated framework with 18 sixth-grade elementary students in Garut Regency, Indonesia. Pre-test and post-test assessments demonstrated moderate effectiveness, with average scores increasing from 46.53 to 82.64 (gain = 36.1, N-Gain = 0.66). These findings confirm the framework's validity and effectiveness in simultaneously developing content understanding and foundational competencies, offering educators a systematic approach for integrated elementary instruction that addresses twenty-first-century learning demands.

INTRODUCTION

Literacy and numeracy competencies represent foundational pillars of educational development, increasingly recognized as essential components across all disciplinary domains in contemporary education systems (Shanahan & Shanahan, 2012; Snow & Uccelli, 2009). In developed nations, the integration of literacy and numeracy has extended beyond traditional language and mathematics instruction to permeate science and social studies education, reflecting a broader understanding of these competencies as cross-curricular necessities rather than isolated skill sets (Pearson et al., 2010; Yore et al., 2007). The emergence of Science, Technology, Engineering, Art, and Mathematics (STEAM) studies has catalyzed significant scholarly attention toward literacy and numeracy integration (Babaci-Wilhite, 2019; Kobayashi, 2019; Quigley et al., 2017). Within this framework, the arts component can meaningfully represent local culture as an integral aspect of social studies, suggesting natural synergies between natural sciences and social studies. This interconnection stems from the overlapping study objects of these disciplines, both of which examine nature and its complex interactions with human societies.

Despite the recognized importance of integrating literacy and numeracy across disciplines, a significant gap exists in pedagogical frameworks that systematically combine science and social studies (IPAS) instruction with deliberate literacy and numeracy skill development (Furner & Kumar, 2007; Lederman & Niess, 1997). Current educational approaches typically treat these elements as separate instructional objectives, failing to capitalize on the inherent connections between content knowledge and foundational skills (Czerniak et al., 1999). This fragmentation limits opportunities for

students to develop integrated competencies that reflect real-world problem-solving demands characteristic of twenty-first-century challenges (Trilling & Fadel, 2009; Binkley et al., 2012). The absence of cohesive instructional designs that simultaneously address content mastery and skill development represents a critical deficiency in elementary education, where establishing these foundational connections proves most impactful.

To address this pedagogical gap, this research proposes the Literacy and Numeracy Skill Development (LNSD) framework as an innovative approach to integrated IPAS instruction. The LNSD framework builds upon the Research Skill Development (RSD) model developed at the University of Adelaide, Australia (Willison, 2020; Willison & O'Regan, 2007), adapting its core principles to elementary education contexts. The original RSD framework comprises two interconnected continuums: facets of inquiry and student autonomy (Willison, 2012). The inquiry facets encompass six dimensions of student activities including embark and clarify, find and generate, evaluate and reflect, organize and manage, analyze and synthesize, and communicate and apply. Meanwhile, the autonomy continuum delineates five developmental levels from prescribed through bounded, scaffolded, and student-initiated to open research, reflecting progressive independence in learning activities (Willison et al., 2017).

The adaptation of RSD into LNSD involves strategic modifications to align with elementary students' developmental capabilities and educational objectives (National Research Council, 2012; Vygotsky, 1978). Specifically, the LNSD framework refocuses the inquiry facets toward explicit literacy and numeracy skill development while maintaining the original structure's emphasis on progressive skill acquisition. Recognizing the cognitive and developmental characteristics of elementary students, the student autonomy continuum in LNSD encompasses only the first three levels—prescribed, bounded, and scaffolded—thereby providing appropriate support structures while encouraging emerging independence (Wood et al., 1976).

Several compelling rationales support adopting RSD as the foundation for LNSD development. First, RSD has demonstrated remarkable versatility and adaptability across diverse educational levels, from primary through tertiary education, establishing its robust theoretical foundation (Willison, 2012). Second, empirical studies have validated RSD's effectiveness in developing various cognitive competencies, including digital literacy skills, demonstrating its capacity for expansion beyond original applications. Third, the inquiry facets inherent in RSD align conceptually with literacy and numeracy competencies, facilitating natural integration of skill development with content instruction (Wellington & Osborne, 2001). Fourth, the autonomy continuum provides students with structured opportunities to explore and develop literacy and numeracy capabilities progressively, supporting differentiated learning pathways (Drake & Burns, 2004).

This study addresses two critical research questions: First, what is the validity of the integrated literacy and numeracy science learning design developed through the LNSD framework? Second, how effective is this integrated learning design in improving literacy and numeracy skills among elementary school students? These questions guide the systematic development and evaluation of a pedagogical framework that bridges the identified gap between content instruction and foundational skill development.

The significance of this research extends beyond theoretical contributions to practical implications for elementary education (English, 2016; Stohlmann et al., 2012). By establishing a validated framework for integrated IPAS instruction that simultaneously develops literacy and numeracy competencies, this study offers educators a systematic approach to addressing multiple learning objectives within cohesive instructional designs. Furthermore, this research responds to the growing recognition that twenty-first-century education requires integrated approaches that prepare students for complex, interdisciplinary challenges (Voogt & Roblin, 2012; Honey et al., 2014). The LNSD framework represents a promising direction for elementary education reform, potentially enhancing both content understanding and fundamental skill development through purposefully designed, integrated learning experiences.

METHODS

This study employed a Research and Development (R&D) methodology (Richey & Klein, 2014) utilizing the 4D instructional design model comprising Define, Design, Development, and Disseminate phases (Thiagarajan, 1974). This systematic approach facilitated comprehensive framework development from initial needs analysis through classroom implementation, ensuring alignment between theoretical foundations and practical applications in elementary science and social studies education.

The Define phase initiated with dual-method needs analysis combining literature review and field investigation. Literature analysis utilized Publish or Perish software to identify existing research on IPAS learning, followed by VOSviewer visualization to map relationships between key variables. Complementing this, structured interviews with two fifth-grade elementary school teachers explored four dimensions: student interest in IPAS learning, instructional media usage, literacy-numeracy integration practices, and pedagogical challenges. Interview transcripts underwent qualitative descriptive analysis involving systematic data reduction, presentation, and interpretation (Hashimov, 2015). Building upon these findings, the Design phase synthesized needs analysis results into an initial IPAS learning framework structured around distinct literacy and numeracy components with associated instructional sub-stages.

The Development phase engaged three subject matter experts representing science education, social studies education, and elementary pedagogy, selected via purposive sampling (Moniruzzaman Sarker & AL-Muaalemi, 2022) based on disciplinary expertise and professional experience. Expert validation employed Content Validity Index (CVI) methodology (Shrotryia & Dhanda, 2019), applying established acceptance thresholds: CVI = 1.0 for panels of 2-5 experts, minimum 0.83 for 6-8 experts, and minimum 0.78 for panels exceeding 9 experts (Lynn, 1986). Each expert independently evaluated framework components, with convergent judgments retained and divergent assessments prompting iterative refinement. This validation process yielded consensus on framework validity, producing the finalized design ready for empirical testing.

The Disseminate phase implemented the validated framework with 18 sixth-grade students from one public elementary school in Garut Regency, Indonesia, selected through purposive sampling considering institutional accessibility and administrative cooperation. Although modest in size, this purposive sample provided adequate preliminary data for effectiveness evaluation in authentic educational contexts. The research instrument comprised an eight-item learning outcome assessment measuring students' comprehension of integrated IPAS content incorporating literacy and numeracy elements. The instrument demonstrated content validity through expert review during the Development phase, ensuring alignment with framework objectives and cognitive demands appropriate for elementary students.

Data collection followed a pre-test post-test design, with assessments administered before and after framework implementation. Learning outcome data underwent quantitative analysis using gain scores and normalized gain (N-Gain) calculations (Christman et al., 2024), computed as N-Gain = (posttest score - pretest score)/(maximum score - pretest score). N-Gain values were interpreted according to standard criteria: high effectiveness ($g > 0.70$), moderate effectiveness ($0.30 \leq g \leq 0.70$), and low effectiveness ($g < 0.30$). This analytical approach enabled objective evaluation of framework effectiveness while controlling for baseline performance variability across participants.

RESULTS AND DISCUSSION

Results

Define Stage

The first stage of this research is the define stage which is the analysis stage. This stage is an analysis of the needs of the target group (Spatioti et al., 2022) which aims to identify whether or not there is a gap between the existing conditions in the field and the expected ideal conditions. This analysis was carried out in two ways, namely literature study analysis and field study.

Literature Study The literature study in this research regarding science and science learning was carried out using publish or perish software. The results of search data regarding previous research articles are shown in the table below:

Table 3 Article Search Data on Publish of Perish

Cites	Authors	Title	Publisher	Year
8	(Maun et al., 2022)	Multimedia Application for Learning IPAS Project at Christian Vocational School 3 Tomohon	ejurnal.unima.ac.id	2022
22	(Umi Isrotun, 2022)	Initial Needs for Development of Differentiated Learning Teaching Materials Based on Local Wisdom in Pekalongan Regency for Class IV School	prosiding.stekom.ac.id	2022
15	(Friska Dewi & Surya Abadi, 2022)	Contextual Teaching and Learning Based on Tri Hita Karana Used as an Elementary School IPAS Learning	ejournal.undiksha.ac.id	2022
31	(Kresnadi et al., 2023)	Utilization of Chromebooks in Social IPAS Learning at State Elementary School 18 Sungai Kakap	jurnal.stkippersada.ac.id	2023
35	(Rani & Mujianto, 2023)	Improving IPAS Learning Outcomes On Energy Transformation Materials Through Problem Based Learning Models In Class IV	journal.unpas.ac.id	2023
40	(Lestari et al., 2023)	Development of Video-Based Media in IPAS Learning on Environmental Issues in Class V Elementary School	jurnal.umj.ac.id	2023
8	(Dani et al., 2023)	Implementation of Problem Based Learning (PBL) Learning Model to Improve Student Learning Outcomes in the IPAS Subject Topic of Unique Habits of the Community Around Me, Grade IV SDN Sukowati Kapas Bojonegoro	jonedu.org	2023
24	(Afifa & Astuti, 2024)	The Effect of Digital Learning Media on Motivation and Learning Outcomes of IPAS	jppipa.unram.ac.id	2024
6	(Adhana & Andriani, 2024)	Development of Interactive Multimedia based on Problem-Based Learning to Improve IPAS Learning Outcomes	jppipa.unram.ac.id	2024
1	(Kause et al., 2025)	Improving IPAS Learning Outcome using the Problem-Based Learning Model in Elementary School	jurnalfkip.unram.ac.id	2025
1	(Sofwan Roif Ubaidillah et al., 2025)	Transformation of IPAS Learning in Elementary Schools: The Strategic Role of Digital Media in Improving Students' Understanding	Journal of Elementary Education Research and Practice	2025
2	(Rosmawati et al., 2025)	Feasibility Study of Daily Test Items for 5th Grade IPAS Based on Bloom's Taxonomy in Elementary School	Journal of Innovation and Research in Primary Education	2025
1	(Rahmawati et al., 2025)	Improving Student Learning Outcomes in Natural and Sosial Science subjects Through Inquiry Learning Models in Grade V of Elementary School	Journal of Innovation and Research in Primary Education	2025
5	(Tsaniyyati & Andriani, 2024)	Development of Mobile Learning based on Problem Solving to Improve IPAS Learning Outcomes	jppipa.unram.ac.id	2024

To determine the position and existence of science research in learning, all articles obtained were then analyzed using VOSviewer software. The visualization results of this software can be seen in

Figure 1. Basically, VOSviewer positions variable nodes in a two-dimensional spatial network, where the strength between nodes is related to the proximity of the locations of the nodes (van Eck & Waltman, 2014). The closer the relationship between two nodes, the stronger the relationship between the nodes or the more research related to these two variables is carried out and vice versa.

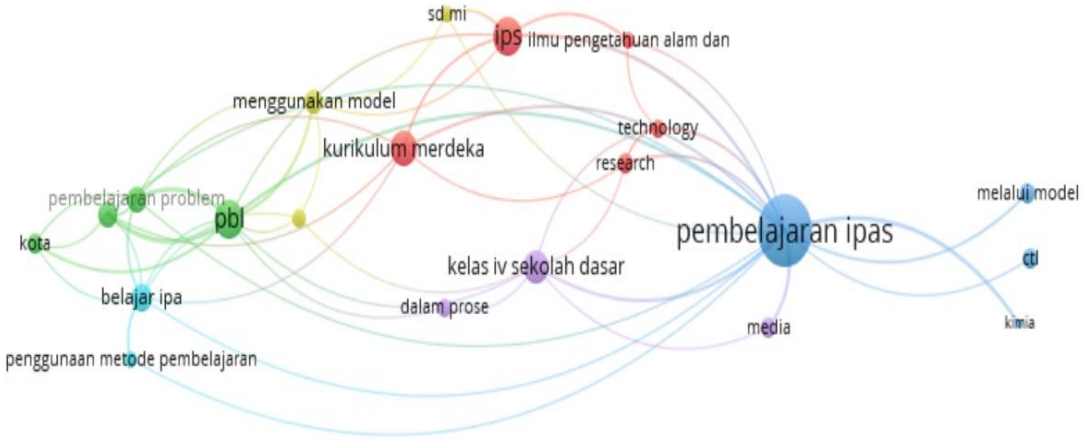

Figure 1 VOSviewer in Science Learning

Based on Figure 1, it shows that the IPAS node is not connected to the literacy and numeracy node. In this case, combining literacy and numeracy frameworks in science and science lessons is a novelty in this research.

Apart from analysis using literature studies, analysis at this stage also uses field studies conducted through interviews with two teachers. Table 4 explains the results of interviews with teachers regarding the implementation of science and technology learning that has been carried out in elementary schools.

Table 4. Recapitulation of Interview Results

Interview questions	Responses of the teachers	
	Teacher-1	Teacher-2
What is students' interest in participating in science learning activities?	Some students are enthusiastic about learning science and technology while others tend not to be enthusiastic.	Most students are very enthusiastic about science learning activities, and they tend to want project-based learning.
What learning media do you often apply in science learning activities?	Some teachers only use subject books.	The media that is often used is subject books from the ministry
Do the science and science learning activities that you implement integrate literacy and numeracy?	Have not implemented literacy and numeracy and still tend not to know this.	Not yet implementing literacy and numeracy
What are your difficulties in facilitating science learning activities?	Lack of references in science and science learning	Reference sources are still limited

Based on the define stage, both through literature studies and field studies, it can be seen that so far, science and technology is a new learning and teachers in the field have difficulty implementing science and science learning ideally, this is because there are not many references regarding science and science learning, there has been no research linking science and science learning specifically with literacy and numeracy. Therefore, further development of integrated science and science learning in literacy and numeracy is needed.

Desain Stage

At this stage, an initial design for science and science learning integrated with literacy and numeracy at elementary school level is carried out as shown in table 5.

Table 5 The initial design of science and science learning integrated literacy and numeracy.

Stage	Sub-Stages
Literacy	1. Morning Message
	2. Let's Read
	3. Let's Write
	4. New Word
	5. Let's Practice
	6. Reading Journal
	7. Reflection
Numeracy	1. Read
	2. Let's Compare
	3. Let's Observe
	4. Let's try
	5. Let's Practice
	6. Reflection

Apart from creating an integrated science and science learning design for literacy and numeracy at this stage, learning outcomes instruments are also designed. The instrument used in this research consisted of two questions.

Development Stage

At this stage, the integrated literacy and numeracy science learning design that has been prepared is validated by three experts, namely science and social studies experts. The expert validation results are shown in table 6.

Table 6. Validation of the Initial Science Learning Design

Stage	**Sub-Stages**	**Judgment result**			**Number**	**Value**
		Expet 1	**Expet 2**	**Expet 3**		
Literacy	Morning Message	√	√	√	3	1
	Let's Read	√	√	√	3	1
	Let's Write	√	√	√	3	1
	New Word	√	√	√	3	1
	Let's Practice	√	√	√	3	1
	Reading Journal	√	x	x	1	0.33
	Reflection	√	√	√	3	1
Numeracy	Read	√	√	√	3	1
	Let's Compare	√	√	√	3	1
	Let's Observe	√	√	√	3	1
	Let's try	√	√	√	3	1
	Let's Practice	√	√	√	3	1
	Reflection	√	√	√	3	1

Table 6 shows that there has been a revision of the integrated literacy and numeracy science learning design, namely the deletion of the reading journal because there were two experts who did not agree on the stages and the let's write and new words stages were combined in 1 stage and the reflection stages were combined so that the design The end of integrated science and science learning in literacy and numeracy is shown in table 7.

Table 7 Final Design of IPAS Learning Integrated with Literacy and Numeracy

Stage	Sub-Stages
Literacy	1. Morning Message
	2. Let's Read
	3. Let's Write
	4. Let's Practice
Numeracy	5. Read
	6. Let's Compare
	7. Let's Observe
	8. Let's try
	9. Let's Practice
	10. Reflection

Disseminate Stage

The validated science and numeracy integrated literacy and numeracy learning design was then implemented on 18 students in one of the schools in Garut district. Implementation results are shown in table 8 below

Table 8. Implementation data

Name	Pretest	Posttest	Gain	N-gain
S1	50	87.5	37.5	0.75
S2	37.5	87.5	50	0.8
S3	37.5	87.5	50	0.8
S4	37.5	75	37.5	0.6
S5	50	100	50	1
S6	50	100	50	1
S7	37.5	87.5	50	0.8
S8	37.5	87.5	50	0.8
S9	37.5	87.5	50	0.8
S10	50	75	25	0.5
S11	50	75	25	0.5
S12	50	75	25	0.5
S13	50	75	25	0.5
S14	62.5	87.5	25	0.67
S15	62.5	75	12.5	0.33
S16	50	75	25	0.5
S17	37.5	75	37.5	0.6
S18	50	75	25	0.5
Average	**46.53**	**82.64**	**36.1**	**0.66**

Based on table 6, the average value of student learning outcomes increased by 36.1 from the pretest value before implementing the integrated literacy and numeracy science and science learning design of 46.53 to an average posttest value of 82.64. The N-gain value of 0.66 is included in the medium category.

Discussion

This study developed and validated the Literacy and Numeracy Skill Development (LNSD) framework for integrated science and social studies (IPAS) instruction in elementary schools, yielding three principal findings that advance understanding of cross-curricular skill integration. First, needs analysis revealed a significant research gap wherein IPAS learning has not systematically incorporated

literacy and numeracy development despite their recognized importance as foundational competencies (Shanahan & Shanahan, 2012; Pearson et al., 2010). Second, expert validation confirmed the framework's content validity, with final consensus achieved on ten instructional sub-stages spanning literacy and numeracy domains. Third, implementation demonstrated moderate effectiveness (N-Gain = 0.66) in improving student learning outcomes, indicating the framework's practical viability in authentic classroom contexts.

The identified research gap aligns with broader concerns articulated in STEM integration literature. Furner and Kumar (2007) and Lederman and Niess (1997) documented persistent challenges in creating coherent interdisciplinary frameworks, while Czerniak et al. (1999) highlighted the tendency toward fragmented instructional approaches that treat content knowledge and foundational skills as separate objectives. The present findings extend these observations specifically to IPAS contexts, demonstrating through VOSviewer analysis that literacy and numeracy nodes remained disconnected from IPAS research networks. This disconnection substantiates the novelty of integrating these elements within a unified framework, addressing what Drake and Burns (2004) characterized as the absence of cohesive instructional designs capable of simultaneously developing content mastery and transferable skills.

The successful adaptation of Willison's (2020) RSD framework to elementary contexts represents a significant theoretical contribution. While the original RSD framework has demonstrated versatility across educational levels (Willison, 2012), its application to integrated elementary science and social studies instruction required substantial modifications. Specifically, limiting student autonomy to prescribed, bounded, and scaffolded levels reflects developmentally appropriate practice consistent with Vygotsky's (1978) zone of proximal development and Wood et al.'s (1976) scaffolding principles. This adaptation demonstrates that sophisticated inquiry frameworks can be successfully scaled for younger learners when appropriately adjusted for cognitive developmental stages, as recommended by the National Research Council (2012) in their K-12 science education framework.

The moderate N-Gain value (0.66) warrants careful interpretation within broader effectiveness research. Hake (1998) established that moderate gains indicate meaningful learning improvements, while Christman et al. (2024) emphasized that normalized gain metrics provide robust indicators of instructional effectiveness when controlling for baseline performance variability. The present results compare favorably with similar integrated learning interventions reported in STEM education literature. Stohlmann et al. (2012) and English (2016) documented comparable effect sizes in integrated STEM implementations, suggesting that cross-curricular approaches may inherently require extended timeframes to achieve high-level gains as students develop facility with multiple skill domains simultaneously.

The framework's emphasis on progressive skill development through structured sub-stages reflects contemporary understanding of literacy and numeracy as disciplinary practices rather than generic skills (Yore et al., 2007; Wellington & Osborne, 2001). By embedding literacy activities (Morning Message, Let's Read, Let's Write, Let's Practice) and numeracy activities (Read, Let's Compare, Let's Observe, Let's Try, Let's Practice, Reflection) within IPAS content, the framework operationalizes Pearson et al.'s (2010) proposition that literacy and science should function "each in the service of the other." This integration addresses Trilling and Fadel's (2009) call for instructional designs that prepare students for twenty-first-century challenges requiring simultaneous application of content knowledge and foundational competencies.

Several limitations merit acknowledgment. The modest sample size (n=18) and single-school implementation limit generalizability, necessitating replication across diverse educational contexts. Future research should examine differential framework effectiveness across varying student populations and investigate long-term retention of integrated skills. Additionally, while expert validation established content validity, psychometric analysis of the learning outcome instrument would strengthen claims regarding assessment reliability. Despite these limitations, this study provides

empirical evidence supporting integrated IPAS instruction as a viable approach for simultaneously developing content understanding and literacy-numeracy competencies in elementary education.

CONCLUSION

This research successfully developed and validated the Literacy and Numeracy Skill Development (LNSD) framework for integrated science and social studies (IPAS) instruction in elementary schools through systematic application of the 4D instructional design model. The framework comprises ten instructional sub-stages organized across literacy (Morning Message, Let's Read, Let's Write, Let's Practice) and numeracy (Read, Let's Compare, Let's Observe, Let's Try, Let's Practice, Reflection) domains, demonstrating content validity through expert consensus (CVI = 1.0 for retained components) and moderate effectiveness in improving student learning outcomes (N-Gain = 0.66).

This study contributes theoretically by adapting Willison's Research Skill Development framework to elementary contexts, demonstrating that sophisticated inquiry-based models can be successfully scaled for younger learners through developmentally appropriate modifications. Methodologically, it addresses the identified research gap by establishing an empirically validated approach for simultaneously developing content understanding and foundational competencies within integrated instruction. The framework operationalizes contemporary perspectives on literacy and numeracy as disciplinary practices embedded within content learning rather than isolated skill sets.

Practical implications suggest that elementary educators can employ this framework to design coherent IPAS lessons that systematically cultivate literacy and numeracy competencies while teaching science and social studies content, potentially addressing curriculum integration challenges documented in prior research. However, several limitations warrant consideration. The modest sample size (n=18) and single-school implementation restrict generalizability, while the short intervention duration may underestimate long-term effectiveness. Future research should examine framework effectiveness across diverse student populations, extended implementation periods, and varied IPAS content domains. Additionally, investigating specific mechanisms through which integrated instruction influences literacy and numeracy development would enhance theoretical understanding. Longitudinal studies examining skill retention and transfer to other academic contexts would provide valuable evidence regarding sustained learning impacts. Despite these limitations, this study provides foundational evidence supporting integrated IPAS instruction as a promising approach for elementary education reform.

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REFERENCES

Adhana, H. M., & Andriani, A. E. (2024). Development of interactive multimedia based on problem-based learning to improve IPAS learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6737–6745. https://doi.org/10.29303/jppipa.v10i9.7588

Afifa, K., & Astuti, T. (2024). The effect of digital learning media on motivation and learning outcomes of IPAS. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3155–3165. https://doi.org/10.29303/jppipa.v10i6.7513

Babaci-Wilhite, Z. (2019). Educational tools to teach STEAM subjects integrating linguistic rights, collaboration, and critical thinking. In *Promoting language and STEAM as human rights in education* (pp. 3–15). Springer. https://doi.org/10.1007/978-981-13-2880-0_1

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills* (pp. 17–66). Springer. https://doi.org/10.1007/978-94-007-2324-5_2

Christman, E., Miller, P., & Stewart, J. (2024). Beyond normalized gain: Improved comparison of

physics educational outcomes. *Physical Review Physics Education Research*, *20*(1), Article 010123. https://doi.org/10.1103/PhysRevPhysEducRes.20.010123

Czerniak, C. M., Weber, W. B., Sandmann, A., & Ahern, J. (1999). A literature review of science and mathematics integration. *School Science and Mathematics*, *99*(8), 421–430. https://doi.org/10.1111/j.1949-8594.1999.tb17504.x

Dani, D. K., Paksi, H. P., & Sutaji, S. (2023). Penerapan model pembelajaran problem based learning (PBL) untuk meningkatkan hasil belajar siswa pada mata pelajaran IPAS topik keunikan kebiasaan masyarakat di sekitarku kelas IV SDN Sukowati Kapas Bojonegoro. *Journal on Education*, *6*(1), 1174–1187. https://doi.org/10.31004/joe.v6i1.3063

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. Association for Supervision and Curriculum Development.

English, L. D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM Education*, *3*(1), Article 3. https://doi.org/10.1186/s40594-016-0036-1

Friska Dewi, L. P. A., & Surya Abadi, I. B. G. (2022). Contextual teaching and learning berbasis tri hita karana dijadikan sebagai model pembelajaran IPAS di SD. *Jurnal Pendidikan Multikultural Indonesia*, *5*(2), 80–92. https://doi.org/10.23887/jpmu.v5i2.55993

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: A stand for teacher education. *Eurasia Journal of Mathematics, Science and Technology Education*, *3*(3), 185–189. https://doi.org/10.12973/ejmste/75397

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

Hashimov, E. (2015). Qualitative data analysis: A methods sourcebook and the coding manual for qualitative researchers. *Technical Communication Quarterly*, *24*(1), 109–112. https://doi.org/10.1080/10572252.2015.975966

Honey, M., Pearson, G., & Schweingruber, H. (Eds.). (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press. https://doi.org/10.17226/18612

Isrotun, U. (2022). Analisis kebutuhan awal pengembangan bahan ajar pembelajaran berdiferensiasi berbasis kearifan lokal Kabupaten Pekalongan mata pelajaran IPAS kelas IV sekolah dasar. *Seminar Nasional Teknologi dan Multidisiplin Ilmu (SEMNASTEKMU)*, *2*(2), 341–352. https://doi.org/10.51903/semnastekmu.v2i1.188

Kause, M. C., Sunbanu, H. F., Selan, Y. A., & Maulana, R. (2025). Improving IPAS learning outcome using the problem-based learning model in elementary school. *Jurnal Pijar Mipa*, *20*(3), 539–543. https://doi.org/10.29303/jpm.v20i3.8930

Kobayashi, V. N. (2019). Reflections on STEAM in education. In *Promoting language and STEAM as human rights in education* (pp. 177–187). Springer. https://doi.org/10.1007/978-981-13-2880-0_12

Kresnadi, H., Halidjah, S., Pranata, R., & Syahrudin, H. (2023). Pemanfaatan chromebook dalam pembelajaran IPAS di Sekolah Dasar Negeri 18 Sungai Kakap. *JURNAL PENDIDIKAN DASAR PERKHASA: Jurnal Penelitian Pendidikan Dasar*, *9*(1), 1–15. https://doi.org/10.31932/jpdp.v9i1.2028

Lederman, N. G., & Niess, M. L. (1997). Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics? *School Science and Mathematics*, *97*(2), 57–58. https://doi.org/10.1111/j.1949-8594.1997.tb17339.x

Lestari, R., Jasiah, J., Rizal, S. U., & Syar, N. I. (2023). Pengembangan media berbasis video pada pembelajaran IPAS materi permasalahan lingkungan di kelas V SD. *Jurnal Holistika*, *7*(1), 34–43. https://doi.org/10.24853/holistika.7.1.34-43

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing Research*, *35*(6),

382–385. https://doi.org/10.1097/00006199-198611000-00017

Maun, R. T., Togas, P. V., & Pratasik, S. (2022). Aplikasi multimedia pembelajaran proyek IPAS di SMK Kristen 3 Tomohon. *Edutik: Jurnal Pendidikan Teknologi Informasi dan Komunikasi*, *2*(3), 438–448. https://doi.org/10.53682/edutik.v2i3.5347

Moniruzzaman Sarker, & AL-Muaalemi, M. A. (2022). Sampling techniques for quantitative research. In *Principles of social research methodology* (pp. 221–234). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5441-2_15

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. https://doi.org/10.17226/13165

Pearson, P. D., Moje, E., & Greenleaf, C. (2010). Literacy and science: Each in the service of the other. *Science*, *328*(5977), 459–463. https://doi.org/10.1126/science.1182595

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics*, *117*(1-2), 1–12. https://doi.org/10.1111/ssm.12201

Rahmawati, R., Surahman, S., Rizal, R., Pahriadi, P., & Lapasere, S. (2025). Improving student learning outcomes in natural and social science subjects through inquiry learning models in grade V of elementary school. *Journal of Innovation and Research in Primary Education*, *4*(3), 565–575. https://doi.org/10.56916/jirpe.v4i3.1459

Rani, N., & Mujianto, G. (2023). Peningkatan hasil belajar IPAS materi transformasi energi melalui model pembelajaran problem based learning pada kelas IV sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *8*(1), 1529–1543. https://doi.org/10.23969/jp.v8i1.8056

Richey, R. C., & Klein, J. D. (2014). *Design and development research*. Routledge. https://doi.org/10.4324/9780203826034

Rosmawati, E., Wulandari, B. A., & Widowati, A. (2025). Feasibility study of daily test items for 5th grade IPAS based on Bloom's taxonomy in elementary school. *Journal of Innovation and Research in Primary Education*, *4*(2), 94–102. https://doi.org/10.56916/jirpe.v4i2.1197

Shanahan, T., & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Topics in Language Disorders*, *32*(1), 7–18. https://doi.org/10.1097/TLD.0b013e318244557a

Shrotryia, V. K., & Dhanda, U. (2019). Content validity of assessment instrument for employee engagement. *SAGE Open*, *9*(1), Article 2158244018821751. https://doi.org/10.1177/2158244018821751

Snow, C. E., & Uccelli, P. (2009). The challenge of academic language. In D. R. Olson & N. Torrance (Eds.), *The Cambridge handbook of literacy* (pp. 112–133). Cambridge University Press. https://doi.org/10.1017/CBO9780511609664.008

Spatioti, A. G., Kazanidis, I., & Pange, J. (2022). A comparative study of the ADDIE instructional design model in distance education. *Information*, *13*(9), Article 402. https://doi.org/10.3390/info13090402

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, *2*(1), 28–34. https://doi.org/10.5703/1288284314653

Thiagarajan, S. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. Indiana University. https://files.eric.ed.gov/fulltext/ED090725.pdf

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.

Tsaniyyati, L., & Andriani, A. E. (2024). Development of mobile learning based on problem solving to improve IPAS learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 7086–7094. https://doi.org/10.29303/jppipa.v10i9.7757

Ubaidillah, S. R., Balqis, A. E., Jannah, B., Maimuna, S., Mu'alimin, & Fatmawati, E. (2025). Transformation of IPAS learning in elementary schools: The strategic role of digital media in

improving students' understanding. *Journal of Elementary Education Research and Practice*, *1*(2), 92–101. https://doi.org/10.70376/e44mz803

van Eck, N. J., & Waltman, L. (2014). Visualizing bibliometric networks. In *Measuring scholarly impact* (pp. 285–320). Springer. https://doi.org/10.1007/978-3-319-10377-8_13

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321. https://doi.org/10.1080/00220272.2012.668938

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. Open University Press.

Willison, J. (2012). When academics integrate research skill development in the curriculum. *Higher Education Research & Development*, *31*(6), 905–919. https://doi.org/10.1080/07294360.2012.658760

Willison, J. (2020). *The models of engaged learning and teaching*. Springer. https://doi.org/10.1007/978-981-15-2683-1

Willison, J., & O'Regan, K. (2007). Commonly known, commonly not known, totally unknown: A framework for students becoming researchers. *Higher Education Research & Development*, *26*(4), 393–409. https://doi.org/10.1080/07294360701658609

Willison, J., Sabir, F., & Thomas, J. (2017). Shifting dimensions of autonomy in students' research and employment. *Higher Education Research & Development*, *36*(2), 430–443. https://doi.org/10.1080/07294360.2016.1178216

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, *17*(2), 89–100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

Yore, L. D., Pimm, D., & Tuan, H. L. (2007). The literacy component of mathematical and scientific literacy. *International Journal of Science and Mathematics Education*, *5*(4), 559–589. https://doi.org/10.1007/s10763-007-9089-4