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TRANSFORMING IPAS LEARNING THROUGH COLLABORATIVE INQUIRY IN THE DIGITAL AGE

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ABSTRACT

Learning in the Natural and Social Sciences (IPAS) within the Independent Curriculum has strategic potential to develop students' 4C skills. However, practice in the field remains teacher-centred, oriented towards information transfer and memorisation, and uses digital technology that is not yet optimal. Previous studies have discussed collaborative inquiry, science learning, and digital transformation separately. This research employs a library-based study with a qualitative-descriptive analytical approach to critically analyse and reconstruct the concept of collaborative inquiry to make it adaptive to science and science learning in the digital era. Analysis was conducted on primary and secondary literature from reputable academic databases using content and *critical-thematic analysis techniques*. The results show that conventional collaborative inquiry models need to be reconstructed by incorporating digital exploration activities and curation of online sources, expanding collaboration spaces through *interactive platforms*, and combining synchronous and asynchronous modes. This reconstruction also demands a shift in teachers' roles from instructors to digital facilitators, supported by pedagogical readiness and continuous training.

Keywords: *Reconstruction, Collaborative Inquiry, Science Learning, Digital Age*

INTRODUCTION

Natural and Social Sciences (IPAS) is an integrative subject that integrates science and social studies within the Independent Curriculum at the elementary education level. This approach is designed so that students understand natural and social phenomena in an integrated and contextual manner, as well as develop the 4C skills of critical thinking, creativity, communication, and collaboration that are the demands of 21st-century education (Nurhayati et al., 2024). Thus, IPAS plays a strategic role not only in transferring factual knowledge but also in fostering students' reasoning power and sensitivity to cross-disciplinary issues in their environment.

Despite its great potential, IPAS learning in the field still faces real limitations. Widodo criticised social studies learning as part of IPAS formation for still being oriented towards information transfer and memorisation, thereby failing to facilitate students' high-level thinking and productive collaboration (Widodo et al., 2020). Similar conditions were observed after integration, with learning remaining teacher-centred and low student involvement in active investigation. This problem is exacerbated by the use of suboptimal digital technology, creating

a wide gap between the ideal characteristics of contextual integrative IPAS and the realities of conventional practices.

To address these gaps, a learning model is needed that systematically positions students as active investigators and learning partners with one another. Collaborative *inquiry* is present as a pedagogical approach that is relevant to this purpose (Afdal, 2025). Chen defines collaborative inquiry as an instructional approach that encourages groups of students to ask questions, investigate phenomena scientifically, discuss, and build knowledge by jointly formulating hypotheses, collecting evidence, compiling arguments, and finding solutions to problems studied through group collaboration (Chen et al., 2022). This approach is based on the principle of social constructivism, which views knowledge as the result of active construction through social interaction, rather than merely a one-way transmission from teacher to student. The advantage of collaborative inquiry lies in its ability to simultaneously stimulate high-level thinking skills and social skills, making it ideal for addressing the challenges of IPAS learning that demand cross-disciplinary understanding and active student involvement in a sustainable manner.

The relevance of collaborative inquiry is getting stronger as digital transformation reshapes global education. Bui Trong explained that the need for a collaborative, interactive education system has prompted teachers to change their learning strategies, using digital platforms, learning resources, and interactive media (Bui Trong Tai, 2023). In the context of collaborative inquiry, digital technology expands students' investigative space, ranging from access to richer sources of information and the simulation of scientific phenomena to cross-group and cross-space discussions. This change has also changed the role of teachers from informants to facilitators who guide the construction of independent and collaborative knowledge (Wohlfart et al., 2023). Thus, collaborative inquiry and digital transformation reinforce each other in delivering a more meaningful and contextual learning experience.

The quality of teacher facilitation remains a determining factor in the successful integration of collaborative inquiry and digital technology, as the effectiveness of technology-supported inquiry depends on teacher facilitation rather than solely on the availability of digital tools (Heppt et al., 2023). Digital transformation in social studies learning concerns teachers' pedagogical readiness and changes in the learning culture that position students as active subjects, while demanding the reconstruction of the concept of collaborative inquiry to be adaptive to the digital era. Conventional models designed for face-to-face interactions in small groups need to be expanded to accommodate cross-spatial collaboration through *digital platforms*, *Google Classroom, Google Meet, Quizizz, Kahoot*, *Augmented Reality (AR)* applications, and many more

interactive learning resources that are not limited by space and time (Yun et al., 2024). Without this reconstruction, the application of collaborative inquiry risks lagging behind technological developments and failing to meet the needs of contextual science learning in the digital era, potentially losing relevance amid a fast-moving educational landscape.

The quality of teacher facilitation remains a determining factor in the success of integrating collaborative inquiry and digital technology. Heppt et al. (2023) show that the quality of teacher instructional support in inquiry-based science classes in elementary schools is closely related to the mastery of science content as well as the academic language skills of students, which indicates that the effectiveness of inquiry, including technology-supported, is highly dependent on the quality of teacher facilitation, not solely on the availability of digital tools. These findings confirm that digital transformation in IPAS learning is not only a matter of providing technological infrastructure but also concerns teachers' pedagogical readiness and changes in learning culture that position students as active subjects in the process of investigating and constructing common knowledge.

The shift in the pedagogical paradigm of the 21st century requires a reconstruction of the concept of collaborative inquiry to better align with the characteristics of the digital era. Conventional collaborative inquiry models, which are generally designed for face-to-face interactions in small groups in physical classrooms, need to be expanded in scope to accommodate new dimensions such as cross-spatial collaboration through digital platforms, the use of interactive learning resources, and patterns of student interaction that are no longer limited by space and time (Yun & Crippen, 2024). Without this kind of reconstruction, the application of collaborative inquiry risks lagging behind development in learning technology and failing to meet the needs of contextual social studies learning in the digital era, potentially losing its relevance amid a rapidly changing educational landscape.

Previous studies have discussed collaborative inquiry, IPAS learning, and digital transformation, but these areas are still studied separately. International research on technology-based collaborative inquiry primarily focuses on K-12 science and does not address the characteristics of IPAS as an integrated subject or the context of the Indonesian curriculum (Chen & Chen, 2024; Yun & Crippen, 2024). On the other hand, research on the IPAS Independent Curriculum in Indonesia highlights obstacles to policy implementation stemming from limited teacher training (Khairunnisa & Andriani, 2023). It fails to map collaborative inquiry strategies that are adaptive to the digital era. In addition, Ramadhani et al. (2024) have demonstrated the effectiveness of inquiry in improving critical thinking, but the study still relies on conventional models and does not integrate digital platforms. Given this gap, a systematic

critical examination of the implementation of collaborative inquiry in IPAS learning in the digital era is needed to gain a complete understanding of strategies, digital media, benefits, challenges, and the direction of its future development.

METHODOLOGY

This research uses a type of library *research* with a qualitative-descriptive approach that is analytical, namely the study, meaning, and in-depth reconstruction of concepts on ideas that have developed (Zed, 2025) The previous literature was chosen because the research purpose is conceptual: to conduct a critical review and reconstruction of the concept of collaborative inquiry to make it more adaptive to the characteristics of science and science learning in the digital era, rather than merely mapping empirical research trends. Still, a critical-thinking process is needed to synthesise, compare, and reconstruct the conceptual framework based on various theoretical perspectives and existing research findings.

The research data sources consist of primary sources in the form of scientific journal articles, books, and previous research results that discuss collaborative inquiry, science learning, digital transformation in education, and 21st-century pedagogy, as well as secondary sources in the form of education policy documents, reports of related institutions, and other relevant supporting literature, which are collected through documentation techniques, namely the search and collection of literature from reputable academic databases and national and international journal repositories, then read, recorded, and classified based on themes relevant to the focus of reconstruction of the concepts studied (Simanjuntak & Sosrodiharjo, 2014) The data collected is then analysed using content analysis techniques combined with critical-thematic analysis, in which content analysis is used to identify and group the main ideas from each source. In contrast, critical-thematic analysis is used to evaluate the suitability, limitations, and relevance of the concept of conventional collaborative inquiry to the demands of IPAS learning in The digital era, as well as being the basis for the formulation of reconstructive ideas that are more adaptive to the analysis process, is carried out reflexively through the comparison of findings between sources to obtain a coherent conceptual synthesis, thus producing a new framework of thought on the reconstruction of collaborative inquiry that is relevant to the transformation of pedagogy in the 21st century.

RESULT AND DISCUSSION

The Concept of Collaborative Inquiry in Conventional Perspectives

Classically, collaborative inquiry is understood as a learning process that combines scientific inquiry activities with group cooperation. In this model, students not only receive information

from teachers but are also invited to actively seek answers to problems through questioning, observation, data collection, discussion, and drawing conclusions (Peculea, 2025). Thus, collaborative inquiry positions students as the primary subjects of learning, while teachers serve as supervisors who guide the learning process.

In general, collaborative inquiry takes place through four main stages. The *first* stage is to formulate a question, during which students are invited to identify the problem or phenomenon to be studied. The *second* stage is investigation, namely activities such as seeking information, making observations, reading learning resources, or collecting data related to the question. The *third* stage is discussion, when students exchange opinions, compare findings, and compile explanations together. The *fourth stage* is to conclude, which is to formulate the final results based on data, evidence, and the results of group discussions (Pedaste et al., 2015). These four stages show that learning is oriented not only to the final result but also to the scientific thinking process that students go through.

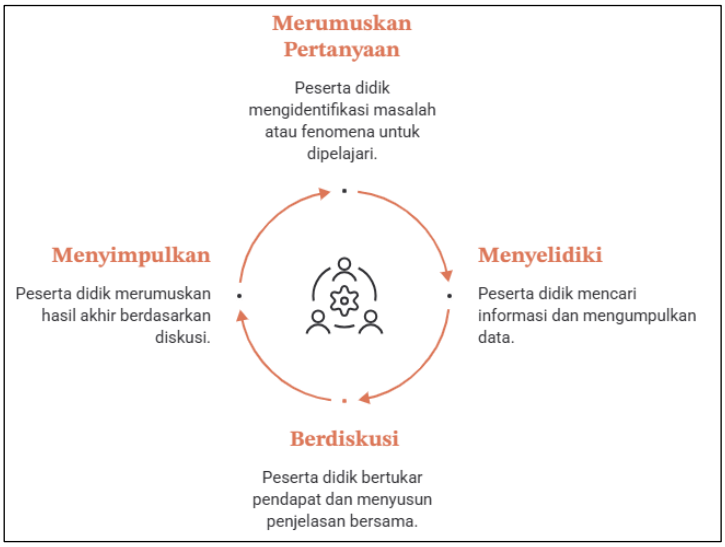

Figure 1. Stages of Collaborative Inquiry

In conventional learning practice, the four stages are usually conducted face-to-face in the classroom. Students are divided into small groups, then work together at the same time and place. Interaction between students occurs directly through conversations, questions and answers, and group work. Teachers are physically present to observe, give directions, correct misconceptions, and help groups that are experiencing difficulties. This pattern makes the classroom the central hub for inquiry and collaboration.

The main theoretical underpinning of the collaborative inquiry model is the social constructivism put forward by Vygotsky. According to Vygotsky, knowledge is not built separately by individuals, but is formed through social interactions with others. Students can

achieve better cognitive development when they learn alongside more capable teachers or peers. This concept is known as *the zone of proximal development* (ZPD), which is the distance between what students can achieve independently and what they can achieve with the help of others. The assistance is called scaffolding, which is temporary support provided by teachers or peers until students can understand concepts independently (Shabani, 2010).

Dewey views learning as an active process that departs from real experiences and problems. According to Dewey, students will understand a concept better if they are directly involved in the process of research and reflection on the experience (Bell et al., 2010). This view aligns with IPAS learning, as IPAS requires students to understand natural and social phenomena through observation, questioning, simple experiments, and the connection of concepts to daily life.

Collaborative inquiry is also strengthened by Bruner's *discovery learning* theory in Khairiyah's research. Bruner stated that learning is more meaningful when students discover concepts through exploration rather than simply receiving direct explanations from the teacher (Khoiriyah et al., 2021). In this context, questioning, investigating, and concluding activities are an important part because they help students develop critical thinking skills, solve problems, and understand the relationships between concepts. Teachers still have an important role, but it is more that of a facilitator who helps students find meaning in the learning process.

In terms of group cooperation, collaborative inquiry is closely related to cooperative learning theory. Johnson explained that cooperative learning can be effective if there is positive interdependence between group members, individual responsibility, direct interaction, social skills, and evaluation of group processes (Johnson et al., 2018). This means that the group's success is determined not only by the most capable learner but also by the involvement of all members in contributing ideas, listening to others' opinions, and completing tasks together. This principle is important in learning social studies because many social science concepts require discussion, joint observation, and evidence-based reasoning.

In conventional models, collaborative inquiry generally assumes three main things. *First*, all group members are physically present at the same time and place so that they can discuss directly. *Second*, the learning resources used are relatively limited to textbooks, teacher explanations, simple teaching aids, and the school environment. *Third*, teachers are the main controllers of the learning process, from determining problems and regulating the course of discussions to providing direction and assessing the results of group work. *These three* assumptions align with traditional learning conditions but need to be reviewed as learning enters the digital era.

However, in the context of social studies learning in the digital era, this model needs to be critically analysed because the way students access information, interact, and build knowledge has changed. The presence of digital technology opens new possibilities for collaborative inquiry, including online learning resources, interactive simulations, virtual discussions, and collaboration on digital platforms. Therefore, understanding conventional models is an important basis for assessing their suitability for today's IPAS learning needs.

Characteristics of Social Science Learning and Competency Demands in the 21st Century

IPAS is an integrative subject resulting from the combination of science and social studies content in the Independent Curriculum, which is designed so that students not only master concepts, but also can relate them to the surrounding environment functionally and meaningfully (Widyastuti et al., 2024). A pedagogical *content knowledge study* of IPAS teachers' books emphasises that this subject requires the ability of teachers to design cross-disciplinary learning that develops students' inquiry skills from the stage of problem identification to their solution through real action (Almonacid-Fierro et al., 2023).

These integrative characteristics align with the demands of 21st-century competencies known as the 4C framework: *critical thinking*, *creativity*, *communication*, and *collaboration*. Collaboration in this context is not just working together, but the ability to solve problems collectively, which the OECD categorises as a measurable competence in international assessments of *collaborative problem solving* (Scoular et al., 2020). These four competencies complement each other and cannot be developed in isolation, so the learning model that fosters one competency ideally also stimulates the other three simultaneously. With its integrative characteristics and the demands of 21st-century competencies, IPAS is the most promising subject for the optimal application of collaborative inquiry. However, this potential can only be realised if the collaborative inquiry model used is truly responsive to the learning context of today's students, which is already closely intersecting with the digital environment.

Digital Transformation and Paradigm Shift in Pedagogy

Digital transformation has fundamentally changed how learning strategies are designed, how teachers carry out their roles, how learning culture is formed, and how students interact. Bates emphasised that the digital age demands that educators redesign the learning experience by considering the availability of online resources, the diversity of communication modes, and the flexibility of learning time, which is no longer entirely tied to the classroom (Bates, 2015).

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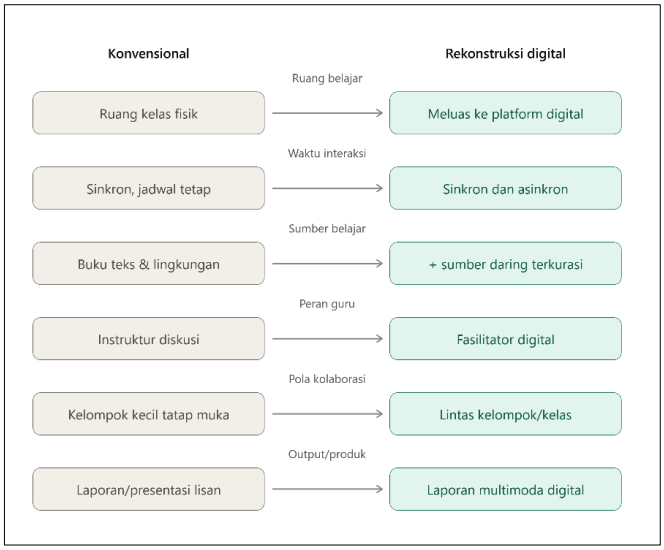
This shift also has implications for the teachers' readiness. Ertmer and Ottenbreit-Leftwich explain in their article that changes in teaching practices due to technology do not occur automatically, but depend on teachers' pedagogical beliefs, technical skills, and adequate institutional support (Ertmer et al., 2012). This means that digital transformation is not just the addition of teaching aids but a shift in the pedagogical paradigm as a whole, from a teacher-centred learning model that treats the teacher as the sole source of information to a more decentralised model in which students have direct access to various sources of knowledge. This broader context underscores the need to review conventional pedagogical models, including collaborative inquiry, to remain relevant to learners' characteristics and today's learning ecosystem.

The Limitations of the Concept of Conventional Collaborative Inquiry in the Digital Era

When conventional collaborative inquiry models are confronted with the learning characteristics of the digital age, several fundamental inconsistencies emerge. First, conventional models assume the uniformity of space and time, whereas digital transformation demands flexibility in both. Second, the conventional model limits learning resources to what is physically available in schools, even though today's students are used to accessing information across platforms independently. Third, the pattern of face-to-face small group interaction in the conventional model has not accommodated the asynchronous interaction mode that is characteristic of digital communication (Novitra et al., 2024). A systematic comparison of the three points of inconsistency is summarised below.

Table 1. Comparison of Dimensions of Conventional Collaborative Inquiry and Digital Adaptive Reconstruction



The comparison chart above shows six lines illustrating the shift from the conventional model (grey) to digital adaptive reconstruction (teal) across the following dimensions: learning

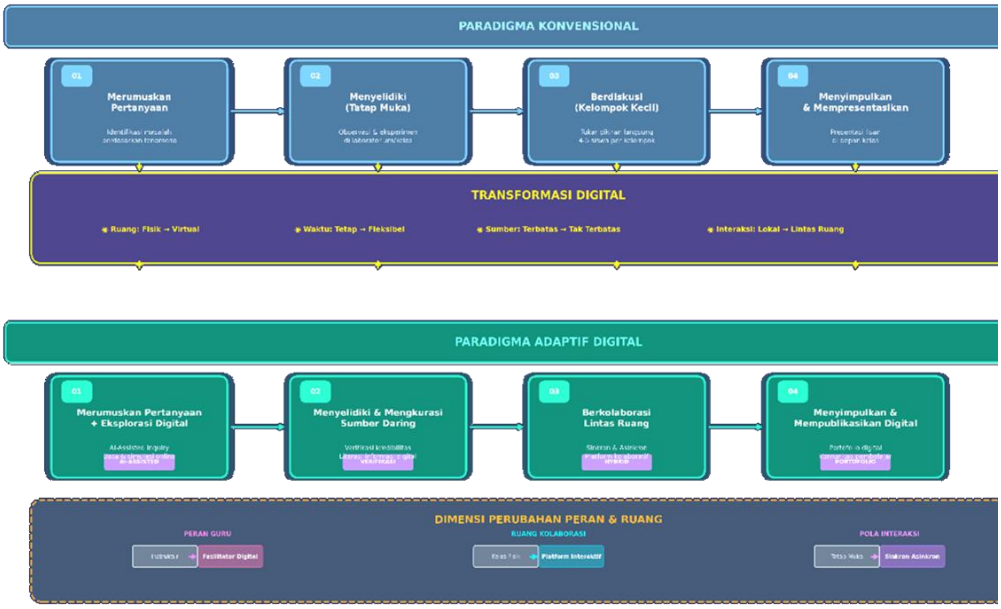
space, interaction time, learning resources, teacher roles, collaboration patterns, and product output. This inequality is exacerbated by the digital divide that many basic education units in Indonesia still face, especially in areas with limited infrastructure. James, Blankson, and Efanga remind that the digital divide has a direct impact on the quality and equity of education, because not all students have equal access to devices and connectivity (Meinrath et al., 2013). The findings of a systematic review in the research conducted by Fardila explain that limited resources in disadvantaged, frontier, and outermost (3T) areas are a real obstacle in adopting digital-based learning approaches, including collaborative models that rely on connectivity (Fardila et al., 2024). The limitations of the concept of conventional collaborative inquiry in the digital era are not only conceptual-theoretical, but also intersect with the structural problem of equal access distribution. These two aspects are important footholds for reconstructing the concept in the next section.

Reconstruction of the Concept of Collaborative Inquiry Adaptive to the Digital Era

Based on the above critical analysis, this study proposes a reconstruction of the concept of collaborative inquiry that retains its investigative and collaborative essence. Still, it expands it to be adaptive to the digital era by incorporating digital exploration activities and the curation of online sources into the investigation phase, so that students not only rely on direct observation but are also trained to trace, filter, and evaluate the credibility of digital sources. This is in line with the finding that these skills can be gradually trained at the elementary level with clear teacher guidance (Lai et al., 2023). This reconstruction also demands a shift in the role of teachers from instructors to digital facilitators who design search signs, moderate cross-modal discussions, and provide structured feedback, thus requiring teachers' pedagogical readiness as well as institutional support and ongoing training so that this shift does not stop at discourse.

Students' collaboration spaces also need to be expanded beyond physical classrooms through *interactive platforms* so that collaboration can take place across classes, even with partners outside the school, to ensure equal opportunities in the midst of the digital divide, which is still a structural challenge (Oskarita & Arasy, 2024). The final dimension of this reconstruction is an interaction pattern that combines synchronous and asynchronous modes: face-to-face discussions are maintained for crucial moments that require *direct scaffolding*, while data collection and resource curation can be carried out asynchronously according to the learning rhythm of students, thus providing flexibility without eliminating the social essence of inquiry (Bates, 2015).

Gambar 2. Paradigma Inkuiri Kolaboratif dalam Pembelajaran IPAS



The chart visually illustrates the fundamental transformation in the collaborative inquiry learning approach from the conventional paradigm to the digital adaptive paradigm (Afdal, 2025). At the conceptual level, this reconstruction is not just a translation of face-to-face activities onto digital platforms, but an epistemological reconfiguration of how knowledge is constructed. In the conventional paradigm, inquiry takes place linearly from question formulation, physical laboratory-based investigation, small group discussions, to conclusions and oral presentations (Pedaste et al., 2015). Each stage has clear spatial and temporal limitations, with learning resources limited to textbooks and classroom materials. The chart shows that in this model, collaboration occurs in the same physical space, at the same time, and with direct and limited interaction among group members who are in the same room.

The digital transformations depicted in the chart indicate an ontological shift towards space, time, resources, and modes of interaction in learning from physical to virtual, from fixed to flexible, from finite to finite, and from local to cross-space that collectively changes the fundamental character of collaborative inquiry, not simply replacing conventional stages, but expanding and complexifying them; the stage of "Investigating & Curating Online Resources" for example adding a dimension of digital information literacy in the form of verifying the credibility of sources, while the "Collaborating Across Spaces" stage introduces synchronous and asynchronous modes that allow collaboration across geographical boundaries and time zones. However, it poses new challenges related to coordination and group cohesion (Bygstad et al., 2022).

This chart also reveals fundamental role changes, especially the transformation of teachers from instructors to digital facilitators that require different pedagogical and technological competencies to design digital learning environments, manage asynchronous interactions, and evaluate learning outcomes through digital portfolios in line with the change in collaboration spaces from physical classrooms to interactive platforms that also change the social dynamics of learning, where the interaction originally rested on Physical presence and non-verbal signals must now be compensated through interface design and digital communication protocols. Overall, this chart conveys that the reconstruction of collaborative inquiry in the digital age is not a simple process of substitution but rather a systemic reconfiguration that entails transformations in activity, role, space, and the epistemology of learning.

Implications of Reconstruction on Social Science Learning Practices in Elementary Schools

The reconstruction of the concept of collaborative inquiry has important consequences for the design of science learning in elementary schools. Collaborative inquiry is no longer enough to be understood as an activity of questioning, investigating, discussing, and concluding that only takes place face-to-face in the classroom, but needs to be expanded to include the use of digital technology as part of the learning process, so that students learn not only through direct observation, but also through information search, digital media, learning videos, simulations, and relevant online learning resources(Numan et al., 2025). This change is important because IPAS learning aims to help students understand natural and social phenomena that are close to daily life.

The first implication of this reconstruction is that teachers need to design inquiry activities that combine digital exploration with hands-on observation; for example, before students observe the school environment, weather changes, plant growth, or waste management, teachers can first direct them to access age-appropriate digital materials in the form of short videos, images, infographics, or simple readings as an initial overview of the topic. Before then, conduct direct observations to compare digital information with reality in the surrounding environment, in line with the purpose of IPAS, which emphasises the relationship between the concept of learning and the reality of daily life. The second implication relates to the assessment system, which should not only focus on the outcome of the discussion or written answer, but also assess the learning process, including the skills of searching, selecting, comparing, and using digital information, as well as the ability to work together in various modes, both face-to-face and digital, so that the assessment includes the ability of learners to ask questions, collect data, and

sort out relevant information. Express opinions, respect the views of friends, and draw conclusions based on evidence.

The third implication is the need to develop a science teaching module that explicitly integrates digital literacy into the inquiry stage, not only containing learning objectives, materials, activity steps, and assessments, but also explaining how digital resources are appropriately used in the learning process. For this reason, teachers need to have *pedagogical content knowledge*, namely the ability to combine understanding of science subjects, teaching strategies, student characteristics, and the use of digital technology, in line with the study of the Independent Curriculum Science teacher's book which emphasizes the importance of learning design that is oriented not only to the content of the material, but also the way of delivery, learning activities, and strengthening students' literacy (Sarah et al., 2026). Thus, the reconstruction of the concept of collaborative inquiry is not only a theoretical discourse but also a framework that can be applied directly to the design of IPAS learning in elementary schools.

Although it offers a more adaptive framework, the reconstruction of this concept cannot be separated from several implementation constraints. First, the gap in teachers' digital literacy remains a fundamental challenge, especially for those not accustomed to designing learning activities on digital platforms. *Second*, limited infrastructure, especially in areas with unstable internet connectivity, limits the feasibility of implementing a full synchronous-asynchronous interaction pattern. *Third*, there is a risk of dehumanising social interaction if digital activities become too dominant relative to face-to-face interactions, reducing the collaborative essence at the core of social constructivism to a mere exchange of information, without the depth of social relations. Therefore, the application of this concept reconstruction needs to be accompanied by clear guidelines on the ideal balance between synchronous and asynchronous activities, tailored to the age level and the infrastructure readiness context of each educational unit.

This critical note confirms that the reconstruction of the concept of collaborative inquiry is contextual and cannot be applied uniformly across primary education units. Further studies and trials, especially through empirical research, are needed to validate the effectiveness of this reconstruction framework in supporting in-depth learning in science subjects.

CONCLUSION

First, the practice of social studies learning in elementary schools still faces a gap between its idealistic integrative-contextual characteristics and the reality in the field that is teacher-centred and oriented towards information transfer. The limitations of digital technology use widen the gap, while previous studies on collaborative inquiry, IPAS learning, and digital

transformation were still conducted separately. This emphasises the urgency of reconstructing the concept of collaborative inquiry that systematically integrates the three dimensions.

Second, through a critical review of the literature, this study reconstructs the concept of collaborative inquiry by maintaining its investigative and collaborative essence while expanding its adaptation to the digital era. The reconstruction includes the insertion of digital exploration activities and online resource curation in the investigation phase, the expansion of collaboration spaces through interactive platforms, and the blending of synchronous and asynchronous modes. This shift demands transforming the teacher's role from an instructor to a digital facilitator who can design search signs, moderate cross-fashion discussions, and provide structured feedback. Third, the implications of this reconstruction for IPAS learning practices include the design of activities that combine digital exploration with direct observation, a process assessment system that includes digital literacy and collaboration, and the development of teaching modules that explicitly integrate technology in the inquiry stage. Its implementation needs to be accompanied by guidelines on the proportion of digital-to-face-to-face activities, adjusted to age levels and infrastructure readiness, while considering the risks of the digital divide and the dehumanisation of social interaction, which still need to be monitored.

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