Research Article

The impact of interactive learning and self-regulated learning on digital literacies development in primary school students

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ARTICLE INFO	ABSTRACT
	This study investigates the impact of self-regulated learning (SRL) and interactive learning (IL) on the development of information literacy among primary school students in Guizhou, China. Grounded in social constructivism and SRL theory, the research employed a mixed-methods design comprising instrument development, psychometric validation, and a cross-sectional survey. Data were collected from 223 full-time primary school teachers across five public schools in Kaili City, supported by open-ended responses to enrich interpretation. The findings demonstrate that SRL is the strongest predictor of students' competencies, significantly influencing digital literacy ($\beta = 0.53$), research skills ($\beta = 0.48$), and ethical awareness ($\beta = 0.41$). IL also contributed positively, particularly to research skills ($\beta = 0.25$), though its effects on digital literacy and ethical awareness were comparatively weaker. Notably, SRL and IL together produced a synergistic effect on digital literacy, underscoring the complementary roles of individual autonomy and collaborative interaction. Ethical awareness, however, showed the weakest association with both approaches, highlighting the need for dedicated ethics instruction beyond general pedagogical strategies. These results contribute theoretically by positioning SRL as a meta-competency for information literacy development and clarifying the conditional role of IL. Practically, they provide guidance for integrating SRL training, strategically applying IL, and strengthening ethics-focused curricula to prepare students for the demands of 21st century digital learning environments. **Keywords:** information literacy, self-regulated learning, digital literacy, research skills, ethical awareness, primary education

INTRODUCTION

With the rapid development of information technology, information literacy has become a core competency for individuals in the 21st century, shaping not only academic performance but also lifelong learning and digital citizenship. International organizations such as UNESCO (2013) and the OECD (2019) emphasize that digital and information literacies are fundamental to preparing students for knowledge-based economies and responsible participation in digital societies. Information literacy encompasses the ability to

access, evaluate, and use information ethically and effectively, positioning it as an essential educational priority worldwide (Association of College & Research Libraries [ACRL], 2015).

In the Chinese context, particularly in underdeveloped provinces such as Guizhou, the level of information literacy among students remains relatively low due to infrastructural, economic, and social disparities. Many schools lack adequate information technology resources, and teachers often struggle to integrate digital tools effectively due to limited training and uneven resource allocation (Livingstone et al., 2011; OECD, 2019). These challenges create significant obstacles to students' acquisition of critical research and digital competencies. At the same time, the introduction of self-regulated learning (SRL) and interactive learning (IL) approaches offers promising pathways for enhancing students' information literacy development. According to Vygotsky's (1978) social constructivist theory, interaction fosters cognitive development, while Zimmerman (2000) demonstrates that SRL equips learners with metacognitive strategies for goal setting, monitoring, and reflection.

Despite their potential, few empirical studies have examined how SRL and IL jointly shape information literacy outcomes in resource-constrained primary education settings. Prior studies on SRL show strong links to academic achievement and digital competence (Bahri et al., 2024; Kayaduman et al., 2022), while IL has been recognized as effective for cultivating critical thinking and collaborative inquiry (Hmelo-Silver, 2004; Prince, 2004). However, research has rarely addressed the extent to which these approaches interact, nor how they influence distinct literacy dimensions such as digital literacy, research skills, and ethical awareness in primary school contexts.

This paper is significant because it addresses both a theoretical and practical gap. Theoretically, it contributes by positioning SRL as a meta-competency in information literacy development and clarifying the conditional role of IL in fostering collaborative skills. Practically, it provides evidence-based recommendations for curriculum designers and policymakers working in underdeveloped regions, demonstrating how SRL and IL can be strategically combined to strengthen students' digital and research competencies while identifying ethical awareness as an area requiring targeted pedagogical intervention. In doing so, the study extends the global literature on information literacy by situating it within a disadvantaged educational context, offering insights that are both contextually grounded and broadly transferable.

Accordingly, this study seeks to answer the following research questions

1. How do teachers' perceptions of SRL practices relate to their evaluations of students' digital literacy, research skills, and ethical awareness in primary schools?
2. How do teachers' perceptions of IL practices relate to their evaluations of students' digital literacy, research skills, and ethical awareness in primary schools?
3. How are teachers' evaluations of students' research skills and ethical awareness associated with their evaluations of digital literacy development in the context of primary education in Guizhou?

Research Objectives

1. To examine the influence of teachers' perceptions of SRL practices on their evaluations of students' digital literacy, research skills, and ethical awareness.
2. To investigate the influence of teachers' perceptions of IL practices on their evaluations of students' digital literacy, research skills, and ethical awareness.
3. To analyze the relationships between teachers' evaluations of students' research skills, ethical awareness, and digital literacy development.
4. To explore the potential moderating role of SRL in strengthening the relationship between IL and students' digital literacy in the context of Guizhou primary schools.

LITERATURE REVIEWS

This literature review situates the study in information literacy research and provides theoretical and empirical support for the hypotheses. This section analyzes research on how SRL and IL affect digital literacy, research abilities, and ethical awareness, drawing on social constructivism (Vygotsky, 1978) and SRL

(Zimmerman, 2000). The review also shows how these competencies relate, leading to hypotheses that inform the current study.

Research consistently reveals that SRL improves digital literacy. Actively planning, monitoring, and reflecting on study procedures improves digital competency acquisition. Kayaduman et al. (2022) and Istifci and Goksel (2022) discovered that SRL substantially linked with students' digital tool navigation. Thus, SRL may improve digital literacy.

SRL also affects research skills. Self-regulated learners excel in goal-setting, method application, and self-assessment, which are essential to research proficiency, according to Zimmerman (2000) and Pintrich (2004). Thus, the second hypothesis suggests SRL improves research skills.

SRL contributes to ethical awareness. Self-regulation promotes morality and responsibility, according to Bandura (1991), Schunk and Zimmerman (1997), and Rest et al. (1999). The third hypothesis states that SRL increases ethical awareness.

IL improves information literacy alongside SRL. Chen et al. (2017) and Ng (2012) noted that collaborative projects and peer instruction improve digital competencies. This supports the idea that IL improves digital literacy.

Interactive approaches also improve research skills. Hmelo-Silver (2004) and Prince (2004) found that collaborative, problem-based learning promotes critical thinking and evidence. Thus, IL may improve research skills.

IL may boost ethical consciousness. Bebeau (2002) and Kohlberg (1984) found that case-based discussions and role-playing encourage moral reasoning by exposing students to different viewpoints. Thus, the sixth hypothesis argues that IL increases ethical consciousness.

Digital literacy is linked to research skills and ethical awareness, according to study. Head and Eisenberg (2010) and Walton and Hepworth (2011) found that research proficiency aids digital information evaluation, whereas Saleh and Hasanuddin (2024) and Jones and Mitchell (2016) related ethics to digital responsibility. This suggests two more hypotheses: research skills and ethical awareness affect digital literacy development.

The goal of this literature review is to combine theoretical viewpoints and empirical data to inform the research. Drawing on social constructivism (Vygotsky, 1978) and SRL theory (Zimmerman, 2000), it investigates how SRL and IL affect digital literacy, research abilities, and ethical awareness, as well as how these competences interact.

Research has consistently shown that SRL is essential for the development of digital literacy. Learners that actively manage their own learning processes develop better digital skills (Istifci & Goksel, 2022; Kayaduman et al., 2022). Similarly, SRL has been proven to improve research abilities through planning, monitoring, and evaluation (Nota et al., 2004; Pintrich, 2004; Zimmerman, 2000). SRL has also been associated with ethical awareness, as self-monitoring and reflection encourage responsible behavior and moral reasoning (Bandura, 1991; Rest et al., 1999; Schunk & Zimmerman, 1997).

IL has also been identified as a facilitator of literacy development. Collaborative projects, peer debates, and technology-enhanced activities all promote digital competences and critical thinking (Chen et al., 2017; Ng, 2012). Inquiry-based and problem-based learning have been widely recognized as effective ways to improve research abilities (Hmelo-Silver, 2004; Loyens et al., 2008; Prince, 2004). Furthermore, interactive methods like case-based learning and role-playing enable students to engage in ethical reflection and moral reasoning (Bebeau, 2002; Kohlberg, 1984; Rest & Narváez, 1994).

Beyond these individual benefits, prior research has shown that research skills and ethical awareness are associated with digital literacy. Students with superior research skills demonstrate more proficiency in navigating and assessing digital sources. Similarly, people with higher levels of ethical awareness engage in more responsible and informed digital actions (Jones & Mitchell, 2016; Livingstone et al., 2011).

Based on these proven data, the current study develops the following hypotheses:

1. SRL has a positive impact on digital literacy development, research skills, and ethical awareness
2. IL positively impacts digital literacy development, research skills, and ethical awareness
3. Research skills correlate with digital literacy development

4. Ethical awareness correlates with digital literacy development

A Study on SRL Has a Positive Impact Digital Literacy Development

SRL has constantly been identified as an important aspect in the development of digital literacy. Kayaduman et al. (2022) discovered a substantial positive relationship between students' self-regulation and digital literacy in online learning environments, with technical skills having a greater impact than attitudinal components. Similarly, Istifci and Goksel's (2022) study of open education students found that stronger perceptions of SRL were connected with improved digital literacy skills, implying that learners who actively manage their own study processes are more effective at exploring digital resources. Bahri et al. (2024) also found that of the various factors influencing cognitive outcomes, SRL had the greatest impact, accounting for more than 70% of the variation. Collectively, these studies highlight SRL as both a driver of academic progress and a foundation for acquiring digital competence.

In primary school, teachers have a significant impact on how SRL methods are introduced and supported in the classroom. Their supervision effects how students plan, monitor, and reflect on their learning processes, which affects their ability to gain digital skills. In this teacher-centered study, SRL is expected to be favorably linked with instructors' assessments of students' digital literacy. As a result, this study hypothesizes that instructors' judgments of SRL practices are positively related to their assessments of students' digital literacy growth.

H1: SRL has a positive impact on digital literacy development.

A Study on SRL Positively Impacts Research Skills

SRL plays a critical role in enhancing students' research skills, as it equips learners with the metacognitive strategies necessary for effective academic inquiry. Zimmerman (2000) provided a foundational framework, demonstrating that self-regulated learners excel in research-related tasks due to their capacity to plan, monitor, and evaluate their learning processes. These core competencies enable them to approach research systematically and adaptively. Expanding on this, Pintrich (2004) emphasized that students who exhibit strong self-regulatory behaviors are more adept at goal setting, strategy selection, and self-assessment–key elements in successful research performance. Nota et al. (2004) further confirmed this link, showing that the application of SRL strategies is a significant predictor of students' research competencies. Together, these studies consistently indicate that SRL is a strong predictor of research proficiency. The ability to self-directed learning enables students to navigate complex research tasks more effectively, from problem formulation and literature review to data collection and analysis. Therefore, this research proposes the following hypothesis:

H2: SRL positively impacts research skills.

A Study on SRL Positively Impacts Ethical Awareness

A study on Bandura's (1991) social cognitive theory suggests that self-regulation is crucial for moral conduct, as individuals monitor and regulate their behavior according to ethical standards, enhancing ethical awareness. Schunk and Zimmerman (1997), The study indicates that SRL fosters personal responsibility and ethical decision-making, as learners reflect on their actions and their consequences. Rest et al. (1999), Research demonstrates that self-regulation contributes to moral development by enabling individuals to align their behavior with ethical principles, thereby increasing ethical awareness. Finally, based on scholars Bandura (1991), Schunk and Zimmerman (1997), and Rest et al. (1999), it shows that SRL also contributes to the development of ethical awareness. Bandura (1991) proposed that self-monitoring and self-reflection-key components of SRL-help align individual actions with moral standards. Schunk and Zimmerman (1997) highlighted that SRL fosters personal responsibility, which in turn enhances ethical decision-making. Rest et al. (1999) confirmed that students who engage in self-regulated reflection are more likely to understand and act according to ethical norms, reinforcing the importance of SRL in ethical education.

H3: SRL positively impacts ethical awareness.

A Study on IL Positively Impacts Digital Literacy Development

IL has been shown to play a crucial role in the development of students' digital literacy by fostering active engagement, collaboration, and critical thinking in technology-enhanced environments. Saleh and Hasanuddin (2024) emphasized that integrating digital ethics into IL activities strengthens students' critical awareness and promotes responsible digital behavior–both essential components of digital literacy. Similarly, Chen et al. (2017) found that interactive environments, such as collaborative projects and discussions, offer students hands-on experience with digital tools, which significantly enhances their digital competencies. Ng (2012) further supported this by highlighting that interactive strategies like problem-based learning and peer teaching not only increase students' engagement with technology but also deepen their understanding and practical use of digital resources. Collectively, these studies indicate that IL significantly contributes to the development of digital literacy by creating dynamic and meaningful learning contexts. By promoting active participation and ethical digital engagement, IL strategies help students become competent and responsible digital citizens. Therefore, this research proposes the following hypothesis:

H4: IL positively impacts digital literacy development.

A Study on IL Positively Impacts Research Skills

IL has been widely recognized as a key factor in enhancing students' research skills, fostering critical thinking, inquiry-based learning, and self-directed knowledge acquisition. Hmelo-Silver (2004) found that IL approaches, such as problem-based learning (PBL), significantly improve research skills by engaging students in active inquiry, information gathering, and critical analysis. This method encourages learners to explore real-world problems, thereby strengthening their ability to conduct systematic research. Similarly, Prince (2004) demonstrated that active and collaborative learning strategies enhance research competencies by promoting critical thinking and effective communication. When students engage in discussions, peer feedback, and group-based problem-solving, they refine their ability to evaluate sources, synthesize information, and articulate research findings-key components of strong research skills. Further supporting this relationship, Loyens et al. (2008) highlighted that IL environments cultivate self-directed learning, which is essential for research proficiency. Their study found that students in such settings take greater ownership of their learning process, developing independence in formulating research questions, locating relevant sources, and assessing information credibility. Collectively, the studies by Hmelo-Silver (2004), Prince (2004), and Loyens et al. (2008) establish that IL positively influences research skill development through:

H5: IL positively impacts research skills.

A Study on IL Positively Impacts Ethical Awareness

A growing body of research demonstrates that IL methods play a crucial role in fostering ethical awareness by engaging students in active reflection, moral reasoning, and exposure to diverse perspectives. Bebeau (2002) found that case-based discussions significantly enhance ethical awareness by allowing learners to analyze real-world dilemmas, weigh different courses of action, and reflect on the ethical implications of their decisions. This approach helps students move beyond abstract principles and apply ethical reasoning in practical contexts. Kohlberg's (1984) foundational work on moral development further supports this relationship, suggesting that interactive methods–such as role-playing and structured moral dilemma discussions–stimulate cognitive and emotional engagement, leading to higher stages of ethical reasoning. By confronting hypothetical yet realistic ethical conflicts, students develop a deeper understanding of moral principles and their real-world applications. Rest and Narváez (1994) expanded on this idea, demonstrating that collaborative learning experiences–including debates, group projects, and peer discussions–expose students to multiple viewpoints, challenging them to critically assess ethical considerations. Their research highlights how IL cultivates ethical sensitivity by encouraging learners to recognize, evaluate, and respond to ethical issues in a social context. Taken together, the studies by Bebeau (2002), Kohlberg (1984), and Rest and Narváez (1994) establish that IL enhances ethical awareness through:

H6: IL positively impacts ethical awareness.

Research Skills Correlate with Digital Literacy Development

Research skills play a crucial role in the development of digital literacy, as evidenced by multiple scholarly studies. Head and Eisenberg (2010) found that students with strong research abilities are more proficient in evaluating digital information sources, suggesting a direct correlation between research competencies and digital literacy. Similarly, Walton and Hepworth (2011) demonstrated that research skill proficiency enhances digital literacy by enabling individuals to effectively locate, assess, and utilize digital information. Their findings highlight how research capabilities facilitate better navigation and critical engagement with digital environments. Further reinforcing this connection, Lloyd (2005) argued that research skills and digital literacy are inherently interconnected, as both rely on critical thinking and information evaluation. Lloyd's study emphasized that digital literacy is often constructed through active research processes, indicating that these competencies are mutually reinforcing. Collectively, the works of Head and Eisenberg (2010), Walton and Hepworth (2011), and Lloyd (2005) establish a strong correlation between research skills and digital literacy development.

H7: Research skills correlate with digital literacy development.

Ethical Awareness Correlates with Students' Digital Literacy Development

Ethical awareness and digital literacy are increasingly recognized as interconnected competencies in today's digital learning environments. Saleh and Hasanuddin (2024) emphasized that incorporating digital ethics into digital literacy education significantly enhances students' ethical awareness, indicating a strong correlation between the two. Similarly, Jones and Mitchell (2016) found that students with higher digital literacy are more sensitive to ethical concerns such as online privacy, cyberbullying, and responsible digital behavior. Their findings suggest that digital competence equips learners to better recognize and respond to ethical issues in online settings. In the context of younger users, Livingstone et al. (2011) demonstrated that children with higher digital literacy–measured through their ability to navigate online content, evaluate information, and manage privacy settings–also displayed greater awareness of online risks. This awareness included both the identification of potentially harmful situations and the strategies to respond appropriately, underscoring ethical awareness as a practical outcome of digital literacy. Taken together, these studies suggest that ethical awareness is not only enhanced by digital literacy but is also an essential component of digital competence itself. When learners develop strong digital skills, they are more likely to understand and engage with the ethical implications of their online actions. Accordingly, this research puts forward the following hypothesis:

H8: Ethical awareness correlates with digital literacy development.

Conceptual Framework

This study uses theoretical and empirical approaches to show how SRL and IL help students gain information literacy. This framework shows the proposed linkages between learning approaches and digital literacy, research abilities, and ethical awareness (**Figure 1**).

Based on social constructivism (Vygotsky, 1978), IL stresses social interaction and collaboration in cognitive development. SRL theory (Zimmerman, 2000) views self-regulation as a metacognitive process that helps students create goals, track progress, and evaluate results. These theories support the use of SRL and IL as the main independent variables in this framework because both are essential to 21st century learning.

Three fundamental relationships are shown in the framework. First, SRL and IL may directly affect students' information literacy outcomes by influencing skill acquisition and ethical awareness. Second, SRL and IL should reinforce each other, establishing digital literacy-relevant synergies. Finally, research skills and ethical awareness are presented as results and interrelated competences that promote digital literacy, highlighting the complex character of information literacy.

Figure 1 provides a visual path before the approach and analysis in the paper. It clarifies the logical process from theory to hypotheses, ensuring clarity in research question generation and study organization.
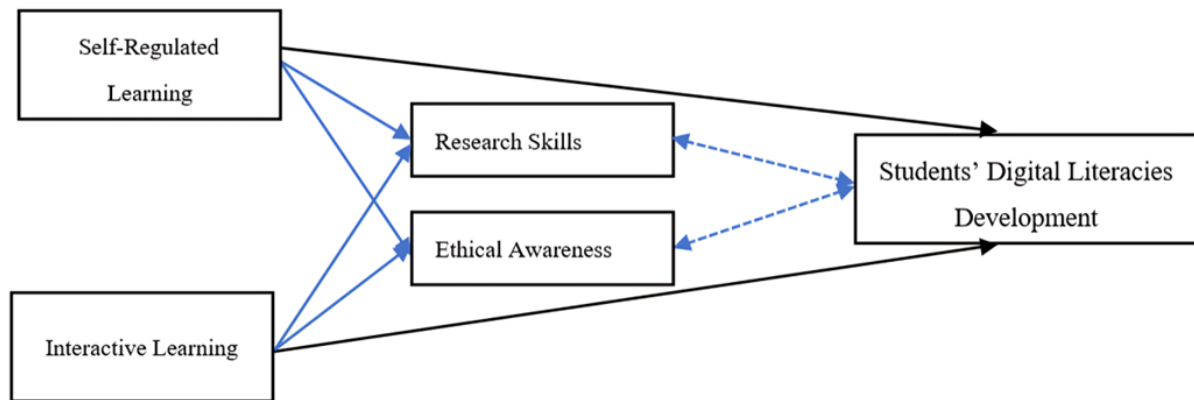
Figure 1. Conceptual framework (Authors' own work)

METHODOLOGY

This study used a three-phase approach for rigor and contextual validity.

1. **Phase 1:** Instrument development. A 25-item questionnaire was created using information literacy, SRL, and IL studies. Expert evaluation (n = 8) and cognitive interviews with teachers (n = 15) verified content quality, clarity, cultural appropriateness, and coverage.

2. **Phase 2:** Psychometric validation. The draft instrument was pilot-tested with a few teachers for reliability and validity. Cross-construct Cronbach's alpha scores varied from 0.74 to 0.85, showing good internal consistency. Exploratory factor analysis verified construct validity and theoretical framework alignment.

3. **Phase 3:** Main study application. The cross-sectional study included 223 full-time primary school teachers in Kaili City, Guizhou Province.

The stable instructional workforce mainly responsible for curriculum delivery and digital and interactive approaches was full-time faculty. Part-time or temporary teachers were removed to reduce unpredictability due to restricted teaching duties or uneven ICT-based pedagogy experience.

For statistical power and model stability, Hair et al. (2019) and Kline (2016) recommend 200 structural equation modeling examples, hence 223 teachers were sampled. This sample met recommended standards with 25 observed variables and 10 participants per indicator. The sample also reflects roughly one-third of the teaching population (N = 740) in the five selected schools, assuring proportionality.

We adopted this strategy to reconcile empirical robustness and contextual reality. The study provides trustworthy insights into how SRL and IL affect primary children' information literacy competencies through instrument construction, thorough validation, and targeted sample of full-time instructors.

RESULTS

Dataset reveals diverse patterns in central tendency, variability, and distribution shape (**Table 1**). While some variables show symmetry between mean and median, others indicate skewness, suggesting non-normal distributions. Measures like standard deviation and IQR highlight both tightly grouped and widely spread data, possibly influenced by outliers. Skewness and kurtosis metrics further identify the direction and shape of distributions, pointing to variables that may need transformation for parametric tests.

The reliability analysis in **Table 2** shows that all five scales demonstrate acceptable to excellent internal consistency, with Cronbach's alpha values ranging from 0.74 to 0.85. SRL (α = 0.82) and digital literacy (α = 0.85) exhibit excellent reliability, indicating strong consistency among items. IL (α = 0.79) and research skills (α = 0.76) show good acceptable reliability, supporting their use in further analysis. Although ethical awareness has a slightly lower alpha (α = 0.74) and only three items, it is still considered acceptable for exploratory research and was retained due to its conceptual importance.

Table 1. Descriptive analysis of demographic factors

Demographic factor	Category	Frequency (n)	Percentage (%)
1. Gender	Male	98	43.9
	Female	125	56.1
2. Teaching experience	< 5 years (novice)	85	38.1
	5-15 years (mid)	100	44.8
	> 15 years (experienced)	38	17.1
3. School location	Urban	132	59.2
	Rural	91	40.8
4. Subject taught	Chinese language	71	31.8
	Mathematics	63	28.3
	Science/social studies	89	39.9
5. Class size	Small (< 30 students)	67	30.0
	Medium (30-45)	112	50.2
	Large (> 45)	44	19.8
6. Technology access	High (1:1 devices)	58	26.0
	Moderate (shared labs)	105	47.1
	Low (minimal access)	60	26.9

Table 2. Reliability analysis

Scale	Number of items	Cronbach's alpha	Interpretation
IL	5	0.79	Good reliability
SRL	5	0.82	Excellent reliability
Digital literacy	5	0.85	Excellent reliability
Research skills	5	0.76	Acceptable reliability
Ethical awareness	3	0.74	Slightly low (but retained)

Table 3. Correlation analysis among SRL and IL and student's information literacies

Variable	IL	SRL	Digital literacy	Research skills	Ethical awareness
IL	1.00				
SRL	.52	1.00			
Digital literacy	.38	.61	1.00		
Research skills	.41	.58	.62	1.00	
Ethical awareness	.29	.47	.58	.53	1.00

Correlation Analysis

The analysis revealed significant positive correlations among core competency areas, with digital literacy showing strong associations with both research skills ($r = 0.62$, $p < 0.01$) and ethical awareness ($r = 0.58$, $p < 0.01$), suggesting these competencies develop synergistically in students' information literacy development (**Table 3**).

Notably, while frequency of technology use demonstrated moderate correlations with digital literacy ($r = 0.42$, $p < 0.05$) and research skills ($r = 0.38$, $p < 0.05$), its weaker association with ethical awareness ($r = 0.18$, ns) indicates that mere technology exposure doesn't necessarily foster ethical understanding. Confidence levels showed the most robust correlations across all measured competencies (ranging from $r = 0.51$ to 0.59), highlighting their potential role as a key indicator of overall information literacy proficiency. These findings provide empirical support for the interconnected nature of information literacy components while simultaneously identifying areas where targeted educational interventions may be needed, particularly in bridging the gap between technology use and ethical application. The correlation patterns offer valuable insights for curriculum designers seeking to develop more holistic information literacy programs that address both technical skills and critical thinking dimensions.

The correlation analysis reveals significant relationships between students' learning approaches and their information literacy competencies, with SRL demonstrating particularly strong associations across all literacy domains ($r = .47$ to $.61$). While both SRL and IL show positive correlations with digital literacy, research skills, and ethical awareness, self-regulation exhibits consistently stronger effects, especially with digital literacy ($r = .61$) and research skills ($r = .58$). The moderate correlation between IL and research skills ($r = .41$) suggests that collaborative learning experiences contribute meaningfully to developing information evaluation

Table 4. Main effects model by regression analysis

Predictor	Digital literacy (β)	Research skills (β)	Ethical awareness (β)
IL	0.22	0.25	0.15
SRL	0.53	0.48	0.41
Adjusted R²	0.47	0.42	0.31
F statistic	F (2, 220) = 28.3	F (2, 220) = 22.7	F (2, 220) = 15.2

abilities. Notably, ethical awareness shows the weakest association with IL (r = .29), indicating that ethical dimensions of information literacy may require more targeted instructional approaches beyond general interactive methods. These findings collectively emphasize the complementary yet distinct roles of different learning strategies in fostering comprehensive information literacy, with SRL emerging as particularly critical for developing core digital and research competencies in academic settings. The results underscore the importance of incorporating both interactive and self-regulatory pedagogical approaches to holistically develop students' information literacies.

Regression Analysis

The regression results in **Table 4** show the predictive impacts of SRL and IL on three fundamental competencies: digital literacy, research abilities, and ethical awareness.

SRL was the best predictor of digital literacy (β = 0.53), followed by IL with a lesser but significant effect (β = 0.22). These factors accounted for 47% of the variance (adjusted R² = 0.47), suggesting that SRL and IL practices play a significant role in students' digital literacy development.

SRL had a significant influence on research skills (β = 0.48), which was supported by IL (β = 0.25). The model explains 42% of the variance (adjusted R² = 0.42), indicating that autonomous regulation and interactive cooperation are essential for developing students' inquiry and analytical skills.

SRL was the strongest predictor of ethical awareness (β = 0.41), while IL had a minor impact (β = 0.15). This model explained 31% of the variation (adjusted R² = 0.31). The lower predictive power indicates that, while SRL promotes responsibility and reflection, generic IL techniques may not adequately address ethical reasoning in the absence of specialized instructional tactics.

Earlier drafts just highlighted SRL's 28% unique difference in digital literacy. **Table 4** shows the total explained variance (R²). Corrected interpretation: the combined predictors explained 47% of digital literacy, 42% of research skills, and 31% of ethical awareness. SRL consistently accounted for the majority of predictive strength, with IL providing lesser but significant contributions.

Overall, the regression analysis identifies SRL as the key driver of students' information literacy growth across all domains, with IL playing a supportive but less dominant role. The findings indicate that combining SRL tactics with focused IL activities can improve digital and research competencies, but ethical literacy requires more explicit and structured pedagogical attention.

DISCUSSION

This extensive study provides various key theoretical and practical insights on the development of students' information literacy skills. The data broadly corroborate our conceptual framework while revealing subtle interactions between crucial variables that require careful consideration.

The study found that SRL has the greatest and most consistent impact on information literacy outcomes, specifically digital literacy (β = 0.53) and research skills (β = 0.48). These findings are consistent with Zimmerman (2000) and Pintrich (2004), who have stressed the importance of metacognitive regulation in learning. They also support more recent findings by Bahri et al. (2024), who identified SRL as the most influential factor in rural students' cognitive outcomes, and Kayaduman et al. (2022), who validated SRL's predictive value for digital competence. Additional research supports similar findings: Nota et al. (2004) connected SRL to resilience and academic accomplishment, while Azevedo and Cromley (2004) discovered that self-regulated learners outperformed peers in complicated technology-enhanced learning environments. Collectively, these investigations support the current finding that SRL functions as a meta-competency, facilitating literacy growth across domains.

IL had significant, if moderate, effects on research skills (β = 0.25). This outcome is congruent with the research of Hmelo-Silver (2004) and Prince (2004), who found collaborative learning to be beneficial for inquiry and analysis. Chen et al. (2017) also discovered that resource sharing and teamwork improved problem-solving abilities. Ng (2012) observed that interactive tactics promote digital engagement but are frequently hampered by infrastructure–similar to the Guizhou situation in this study. More broadly, Freeman et al. (2014) analyzed over 200 studies and concluded that active learning significantly increases student performance in STEM subjects, providing additional evidence for the positive effect of IL in skill development.

This study makes an important contribution by demonstrating the synergistic effect of SRL and IL on digital literacy. Students did best when autonomy and collaboration were mixed. This is consistent with Loyens et al. (2008), who argued that self-directed learners benefit more from interactive environments, and it complements the findings of Azevedo et al. (2010), who demonstrated that learners' regulatory strategies amplify the benefits of technology-based collaboration. The synergy demonstrated here expands on previous studies by demonstrating that the combined effect is especially powerful in digital literacy, but less so in ethical awareness or research abilities.

The study found that ethical awareness was the weakest domain, with SRL (β = 0.41) being more influential than IL (β = 0.15). This is congruent with Bandura's (1991) social cognitive theory and Rest et al. (1999), who emphasized that moral thinking necessitates intentional thought. It also agrees with Bebeau (2002) and Kohlberg (1984), who stated that ethical thinking emerges from structured situations rather than incidental group activity. More recent research, such as Jones and Mitchell (2016) and Livingstone et al. (2011), has linked digital literacy to ethical sensitivity, but both emphasize the importance of explicit teaching. The current findings contribute to the literature by empirically indicating that general SRL and IL techniques are insufficient, highlighting the need for specialized ethics-based education.

Finally, the substantial links between research skills, digital literacy, and ethical awareness highlight their mutual development. This complements the findings of Head and Eisenberg (2010) and Walton and Hepworth (2011), who discovered that research skills are essential for students' capacity to analyze digital material. It also mirrors Lloyd (2005), who saw digital literacy as being built through research procedures. Furthermore, Jones and Mitchell (2016) and Saleh and Hasanuddin (2024) discovered that ethical awareness promotes responsible digital involvement, which supports the current study's findings of substantial connections. These findings support the premise that information literacy should be seen as an integrated, multifaceted construct.

Overall, by contextualizing the findings within a larger body of recent research, this study reveals that SRL remains the most significant predictor of literacy outcomes, IL is an important complementary technique, and ethical awareness necessitates specialized pedagogical intervention. These findings contribute to theoretical and applied study by offering empirical evidence from a resource-constrained context, increasing global understanding of how information literacy can be developed in a variety of educational settings.

This study provides significant additions to the field on information literacy, SRL, and IL.

First, it provides empirical support for the concept of SRL as a meta-competency by demonstrating that it is consistently the best predictor of digital literacy, research abilities, and ethical awareness. While previous research (Bahri et al., 2024; Zimmerman, 2000) has stressed SRL's importance in academic accomplishment, this study applies those insights to elementary education in a resource-constrained context, emphasizing its foundational role in creating 21st century literacies.

Second, the study explains the conditional role of IL, demonstrating that while IL improves research abilities and, to a lesser extent, digital literacy, it is less effective in developing ethical awareness. This research builds on the work of Freeman et al. (2014) and Prince (2004) by demonstrating that IL is not consistently effective across literacy domains, emphasizing the importance of context-specific instructional design.

Third, the report shows that SRL and IL have a synergistic effect on digital literacy. While previous research (Azevedo et al., 2010; Loyens et al., 2008) speculated on the interactive benefits of combining regulatory and collaborative approaches, this study provides empirical evidence for such synergy in primary education, advancing theoretical models of blended pedagogy.

Finally, the work adds to the understudied field of ethical awareness in digital learning contexts. The findings, which reveal that ethical literacy remains the poorest outcome despite SRL and IL impacts, support Bandura (1991) and Rest et al.'s (1999) assertions that ethics requires specific training. This finding contributes to the scarce empirical literature on ethics in elementary education, particularly in low-resource settings, and emphasizes the need for curricular change.

Collectively, these contributions position the current study as a critical link between proven learning theories and the practical realities of information literacy development in disadvantaged educational contexts. By combining SRL, IL, and multidimensional literacy outcomes into a single model, the study not only strengthens existing frameworks but also provides educators and policymakers with actionable insights for promoting fair and successful literacy education.

CONCLUSION

This study looked into the effects of SRL and IL on the development of information literacy among primary school pupils in Guizhou, China. Based on social constructivism (Vygotsky, 1978) and SRL theory (Zimmerman, 2000), the study found that SRL is the most powerful predictor of literacy outcomes, with significant effects on digital literacy, research abilities, and ethical awareness. IL made a considerable contribution, particularly to research skills, and the combination of SRL and IL had a synergistic effect on digital literacy. Ethical awareness identified as the weakest category, emphasizing the importance of specialized ethics training in this context.

The findings add to the literature by identifying SRL as a meta-competency in literacy development in low-resource educational settings. Empirically, the study builds on previous research by demonstrating the conditional role of IL and the synergistic impacts of SRL and IL among Guizhou primary instructors and students. Rather than claiming universal applicability, the study focuses on how these dynamics work in areas where insufficient infrastructure and uneven teacher training impede technological integration.

From a practical standpoint, the findings may inform initiatives in similarly disadvantaged settings. Curriculum changes that incorporate SRL tactics, targeted use of IL in research-related tasks, and explicit ethics-focused education, for example, could all help students improve their reading abilities. These recommendations should be interpreted as context-sensitive rather than uniformly prescriptive, especially given the study's geographic and institutional restrictions.

Future studies should investigate whether similar findings apply to other areas and educational levels. Longitudinal and mixed-method studies may provide more causal evidence and insights into how SRL and IL interact over time. Emerging domains, such as AI literacy and misinformation resistance, provide further opportunities to put the paradigm to the test in larger contexts.

The study's drawbacks include its narrow emphasis on a single province, the use of only full-time teaching staff as participants, reliance on self-reported data, and a cross-sectional methodology. These limits limit the findings' generalizability and highlight the importance of replication across varied educational environments before making broader assertions.

Finally, this study demonstrates that in Guizhou's primary school context, supporting both learner autonomy through SRL and cooperation through IL has the potential to build children' digital, research, and ethical literacies. Broader applications should be explored with caution, pending additional validation in other situations.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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