West Science Interdisciplinary Studies
Vol. 03, No. 12, December and 2025: pp. 2235-2247

Analysis of the Impact of Online Collaborative Learning, Metacognitive Awareness, and Instructional Media Richness on Students' Problem-Solving Skills in Higher Education

Nasruliyah Hikmatul Maghfiroh
Universitas PGRI Argopuro Jember and nasruliyahhikmatulmaghfiroh85@gmail.com

ABSTRACT

This study analyzes the impact of online collaborative learning, metacognitive awareness, and instructional media richness on students' problem-solving skills in higher education. Using a quantitative research design, data were collected from 150 university students through a Likert-scale questionnaire and analyzed using SPSS version 25. Validity and reliability tests confirmed that all measurement items were appropriate and consistent. Classical assumption tests also indicated that the regression model met the required statistical criteria. The results of multiple linear regression analysis show that online collaborative learning, metacognitive awareness, and instructional media richness each have a positive and significant effect on problem-solving skills. Metacognitive awareness was found to be the strongest predictor, followed by online collaborative learning and media richness. The model explains 62.3% of the variance in students' problem-solving skills, indicating a strong combined influence of cognitive, social, and technological factors. These findings highlight the importance of integrating collaborative learning strategies, metacognitive training, and rich instructional media to enhance problem-solving abilities in higher education settings.

Keywords: *Online Collaborative Learning, Metacognitive Awareness, Instructional Media Richness, Problem-Solving Skills, Higher Education.*

1. INTRODUCTION

The rapid advancement of digital technology has significantly transformed the landscape of higher education, particularly in the design and delivery of learning processes, where online learning environments have evolved into interactive and collaborative spaces that enable students to engage in knowledge construction, exchange ideas, and solve complex academic problems, making the understanding of factors influencing students' cognitive development—especially their problem-solving skills—an essential focus of contemporary research. Problem-solving skills are fundamental 21st-century competencies that allow students to analyze information, think critically, and make informed decisions, and their development is shaped by various cognitive and contextual elements within digital learning settings. Key factors influencing these skills include cognitive and meta-cognitive strategies, such as goal setting, task breakdown, self-regulation, and reflection, which play crucial roles in enhancing students' ability to navigate academic challenges [1]; resource availability, where access to adequate tools and digital learning materials supports students in addressing complex tasks effectively [1]; and self-confidence, which strongly predicts students' capacity for problem-solving in online learning environments [1]. Educational technology further strengthens these abilities through technological tools that create immersive learning environments integrating cognitive and practical elements into the curriculum [2], instructional strategies such as scaffolding, guidance, and peer collaboration that support students in managing complex tasks and deepening their critical thinking [2], and digital learning innovations that enhance cognitive development and creativity, fostering students' critical thinking and problem-solving capabilities [3].

Online collaborative learning has emerged as one of the most effective approaches for fostering active engagement and deeper understanding, as virtual teamwork, discussion forums, and shared digital tasks enable students to work together, negotiate meaning, and explore multiple perspectives, thereby contributing significantly to their problem-solving processes through the co-construction of knowledge and reflective thinking; however, the effectiveness of such collaboration is highly dependent on learners' individual cognitive abilities, particularly their metacognitive awareness. This approach has been shown to enhance essential cognitive skills such as decision-making and problem-solving, as students engage in evaluating options and establishing priorities [4], while its active, social, and engaging nature also supports the development of metacognitive thinking, which is crucial for understanding diverse perspectives and addressing real-world problems [5]. Metacognitive awareness—students' understanding of their own thinking and learning processes—plays a vital role in enabling effective collaboration by strengthening self-regulation and co-regulation, which in turn improves student success and satisfaction [6], and shared metacognition within the Community of Inquiry framework further promotes critical discourse and peer interaction to enhance collaborative learning outcomes [6]. Moreover, the effectiveness of online collaborative learning is influenced by the learning environment, instructional design, and nature of interaction, as well-structured digital environments can enhance academic performance and satisfaction [7], while online platforms offer flexible and democratic spaces for exchanging ideas and engaging in reflective thinking with fewer time and space constraints compared to traditional classrooms [8].

Metacognitive awareness—students' ability to plan, monitor, and evaluate their own learning—plays a fundamental role in determining how effectively they approach and solve academic problems, as students with higher levels of metacognitive awareness tend to be more strategic, reflective, and independent in managing learning tasks, especially within online learning environments where they must navigate various digital tools and information sources. In such contexts, metacognitive skills are essential for regulating learning processes, adapting strategies, and overcoming challenges that arise during collaborative tasks, thereby supporting academic success [9], [10]. Metacognitive awareness enhances academic performance by enabling learners to engage in planning, monitoring, and evaluating their learning, and strategies such as self-evaluation and problem-solving further strengthen critical thinking and reading comprehension [10], while in collaborative problem-solving, metacognitive processes operate across individual, social, and environmental levels that shape group performance [11]. Another crucial element influencing online learning effectiveness is instructional media richness, which refers to the degree to which learning media offer clear, interactive, and engaging information; rich media formats—such as videos, animations, simulations, and multimedia presentations—cater to diverse learning styles, increase engagement and motivation, and provide clearer, more interactive content that enhances comprehension and retention [12]. Together, metacognitive and motivational skills form the foundation for successful academic problem-solving [13], and students with stronger metacognitive awareness demonstrate greater strategic independence and more effective management of learning tasks [9], [13], while the use of rich instructional media in digital platforms further strengthens cognitive outcomes, including students' problem-solving abilities.

Despite the growing emphasis on online learning, empirical research examining the combined influence of online collaborative learning, metacognitive awareness, and instructional media richness on problem-solving skills in higher education remains limited, as most existing

studies focus on isolated factors or specific subject areas, leaving a gap in understanding how these elements interact within broader educational contexts; moreover, the accelerating shift toward hybrid and fully online learning models driven by global technological advancements underscores the need for deeper exploration of how digital learning designs support higher-order thinking skills. This study addresses this gap by analyzing the impact of online collaborative learning, metacognitive awareness, and instructional media richness on students' problem-solving skills through a quantitative approach involving 150 student respondents, using a five-point Likert scale questionnaire and SPSS version 25 for data analysis, with findings expected to provide valuable insights for educators, curriculum developers, and policymakers in designing online learning environments that effectively enhance students' cognitive abilities. Overall, the research contributes to ongoing discussions on digital pedagogy and offers evidence-based recommendations for improving problem-solving outcomes in higher education through collaborative learning strategies, metacognitive development, and the integration of rich instructional media.

2. LITERATURE REVIEW

2.1 Online Collaborative Learning

Online collaborative learning has been shown to significantly enhance problem-solving skills by fostering active engagement, diverse perspectives, and continuous interaction, as digital platforms facilitate teamwork and collective inquiry that strengthen critical thinking and analytical abilities; this integration of technology not only supports the exchange of ideas but also promotes deeper cognitive processing compared to traditional individual learning methods. Research indicates that online collaborative learning environments positively correlate with improved problem-solving abilities due to active participation and interaction that encourage the exchange of diverse ideas and viewpoints [4], [14], while digital tools further facilitate continuous feedback and engagement, both of which are essential for refining problem-solving strategies and enhancing cognitive skills [15]. Collaborative platforms also promote effective communication and teamwork—critical components of problem-solving—by enabling students to articulate thoughts clearly and negotiate meaning with peers [16], and through group discussions and virtual tasks, students strengthen critical thinking as they evaluate different perspectives and construct knowledge collectively [17]. Moreover, studies show that online collaborative learning increases student engagement and satisfaction, which are vital for sustaining motivation and interest in problem-solving tasks [14], and the interactive nature of digital collaborative tools creates a dynamic, enjoyable, and effective learning environment that supports deeper cognitive involvement [15].

2.2 Metacognitive Awareness

Metacognitive awareness significantly influences problem-solving skills by enabling learners to effectively plan, monitor, and evaluate their cognitive processes, a capability that is especially crucial in higher education and online learning environments where students must independently manage their learning and regulate their strategies. Research shows that students with high metacognitive awareness tend to perform better academically and demonstrate stronger problem-solving abilities because metacognitive skills help them identify problems, analyze potential solutions, and

critically evaluate outcomes. Evidence from various studies highlights this connection, such as findings that Grade 9 students exhibit high levels of metacognitive regulation—particularly in planning, monitoring, and evaluation—although the relationship between metacognitive regulation and specific components of problem-solving varies, indicating a complex interplay between these skills [18]. In higher education, metacognitive awareness is associated with deeper learning approaches and organized studying, both of which support more strategic and effective problem-solving [19]. A meta-analysis of 36 studies further demonstrates a strong correlation between metacognitive awareness and academic achievement, with an effect size of 0.824, underscoring the importance of metacognitive skills in enhancing academic performance and, consequently, problem-solving ability [20]. Additionally, research on high school students reveals that while overall metacognitive awareness tends to be high, variations in declarative, procedural, and conditional knowledge can influence how students approach and solve problems, highlighting the nuanced nature of metacognitive development [21].

2.3 Instructional Media Richness

Instructional media richness plays a pivotal role in enhancing students' problem-solving skills by providing diverse, engaging learning experiences through multimedia components such as videos, animations, and interactive modules that are particularly effective in online learning environments, helping maintain attention, accommodate various learning styles, and improve comprehension while fostering better retention and application of knowledge in problem-solving contexts; this is supported by research showing that rich media environments encourage active learning by prompting students to explore content independently and engage in analytical tasks. The effectiveness of rich media is further strengthened when aligned with students' learning styles, as a theoretical framework integrating media richness theory and learning styles indicates that considering both dimensions can significantly enhance learning performance [22], suggesting that tailoring media richness to individual preferences can optimize and personalize the educational experience. In distance education, media richness has been shown to significantly improve student satisfaction, communication, and the perceived value of course delivery platforms [23], with rich media facilitating stronger interaction between students and faculty—an essential factor for successful remote learning. Practical applications of media-rich instruction demonstrate its ability to connect curriculum to learners by incorporating innovative platforms and multimedia strategies across subjects [24], supporting collaborative and transformative learning that is crucial for developing problem-solving skills. However, despite its advantages, rich media does not automatically ensure improved learning outcomes, as content complexity and media appropriateness must be carefully considered; effective instructional media should be designed to match the uncertainty and equivocality of the content to achieve optimal learning performance [25].

2.4 Problem-Solving Skills

The development of problem-solving skills in higher education is a multifaceted process shaped by collaborative interaction, metacognitive processes, and the quality of instructional media, all of which are essential for preparing students to address

complex academic and professional challenges, particularly within online learning environments that offer unique opportunities to strengthen these skills through innovative strategies and resources. Collaborative learning approaches such as problem-based learning (PBL) and Socratic questioning have been shown to enhance critical thinking and problem-solving by encouraging dialogue and the sharing of diverse perspectives [26], while active methodologies like project-based learning foster collaboration and empower students to identify problems, generate solutions, and make decisions, thereby strengthening their problem-solving abilities [27]. Metacognitive processes also play a vital role, as strategies involving self-regulation and reflection support effective problem-solving, with online environments providing scaffolding and resources that prompt students to reflect on their strategies [28], and learners' metacognitive strategies—such as goal setting and task breakdown—serving as significant predictors of problem-solving performance in digital contexts [1]. Additionally, the quality of instructional media is critical, as well-designed resources and tools in online learning environments enhance cognitive engagement and facilitate the acquisition of domain knowledge [1]; however, despite the potential of rich online resources, challenges such as limited resources and insufficient teacher training can hinder the effective integration of critical thinking and problem-solving skills into educational curricula [29].

2.5 Conceptual Framework

Based on the theoretical foundations and previous studies, this research proposes that online collaborative learning, metacognitive awareness, and instructional media richness each influence students' problem-solving skills, as illustrated in the conceptual framework, which outlines the relationships among these variables: Online Collaborative Learning → Problem-Solving Skills, Metacognitive Awareness → Problem-Solving Skills, and Instructional Media Richness → Problem-Solving Skills. These relationships are tested through quantitative analysis. Empirical studies consistently demonstrate that online collaborative learning environments significantly enhance students' critical thinking, problem-solving skills, and cognitive abilities by leveraging group discussions and shared tasks that foster active learning and knowledge construction. In addition, metacognitive awareness and media richness play crucial roles in strengthening learning outcomes and problem-solving performance. Findings show that online collaborative learning environments cultivate critical thinking skills (CTS) through group metacognitive regulation (GMR), where high-GMR groups display balanced and frequent critical thinking processes, and medium-GMR groups exhibit sophisticated cognitive engagement, underscoring the importance of GMR in promoting CTS [30], while students in collaborative digital settings report improved problem-solving abilities and higher learning satisfaction [14].

Metacognitive awareness further enhances learning outcomes by supporting essential skills such as self-monitoring and self-reinforcement, which contribute to effective problem-solving; these skills develop through interactive and self-managed learning experiences that heighten motivation and cognitive processing [31]. The co-construction of knowledge in socially dynamic learning environments—enabled by metacognitive processes—is central to effective problem-solving training [31]. Meanwhile,

instructional media richness contributes substantially to problem-solving development, as multimedia-based learning environments, particularly case studies, improve comprehension, motivation, and the application of knowledge in problem-solving tasks; students engaged in such multimedia case studies report enhanced higher-order thinking skills and positive learning experiences [32]. The use of multimedia in collaborative learning settings also supports the development of teamwork and critical thinking skills essential for workforce readiness [32]. Based on this literature review, the following hypotheses are formulated.

H1: Online collaborative learning has a positive and significant effect on students' problem-solving skills.

H2: Metacognitive awareness has a positive and significant effect on students' problem-solving skills.

H3: Instructional media richness has a positive and significant effect on students' problem-solving skills.

3. METHODS

3.1 Research Design

This study employed a quantitative research design using an explanatory approach to analyze the impact of online collaborative learning, metacognitive awareness, and instructional media richness on students' problem-solving skills in higher education. The explanatory design was chosen because it allows the researcher to examine causal relationships among variables based on numerical data. A survey method was used to collect primary data through a structured questionnaire distributed online to student respondents.

3.2 Population and Sample

The population of this study consisted of students enrolled in higher education institutions who were actively participating in online learning. A total sample of 150 students was selected using a purposive sampling technique, which ensured that only students with experience in online learning environments during their academic courses were included. The sample size of 150 respondents is considered adequate for multiple regression analysis using SPSS, meeting the requirement of having sufficient statistical power.

3.3 Types and Sources of Data

This study used primary data obtained directly from respondents through an online questionnaire. The data collected measured students' perceptions of online collaborative learning, metacognitive awareness, instructional media richness, and problem-solving skills based on their learning experiences. Secondary data such as journal articles, books, and previous studies were also used to support the theoretical framework and literature review.

3.4 Data Collection Procedures

Data were collected through an online survey distributed via Google Forms. Respondents were informed about the purpose of the research and assured of the confidentiality of their responses. The survey link was shared through academic groups, learning management systems, and email communication. Only students who completed all questions in the questionnaire were included in the final dataset. Data collection was conducted over a period of two weeks.

3.5 Research Instrument

The research instrument used in this study was a structured questionnaire consisting of Likert scale items ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), divided into four main sections corresponding to the variables examined: Online Collaborative Learning (OCL), which measured the extent of students' engagement in collaborative activities, communication, and online group tasks; Metacognitive Awareness (MA), which assessed students' abilities in planning, monitoring, and evaluating their learning processes; Instructional Media Richness (IMR), which evaluated the interactivity, clarity, informativeness, and engagement level of the instructional media used in online learning; and Problem-Solving Skills (PSS), which measured students' abilities to identify problems, analyze information, and apply appropriate strategies to solve academic challenges. All questionnaire items were adapted from validated instruments used in previous studies to ensure accuracy and reliability in measuring each construct.

3.6 Measurement of Variables

Each variable in this study was measured using specific indicators, with Online Collaborative Learning (X1) assessed through interaction and communication, group coordination, shared responsibility, and collaborative problem-solving; Metacognitive Awareness (X2) measured through planning strategies, monitoring understanding, evaluating learning outcomes, and adjusting learning strategies; Instructional Media Richness (X3) evaluated based on the clarity of multimedia content, interactivity of media, variation of media formats, and engagement level; and Problem-Solving Skills (Y) measured through indicators of problem identification, analysis of information, selection of solution strategies, and evaluation of solution effectiveness. All indicators were measured using Likert scale items.

3.7 Data Analysis Techniques

Data analysis in this study was conducted using SPSS version 25 through several steps, beginning with descriptive statistics to summarize demographic data and describe the distribution of responses for each variable, followed by validity and reliability tests to ensure the accuracy and consistency of the measurement instrument. Classical assumption tests—including normality, multicollinearity, and heteroscedasticity tests—were then performed to verify that the assumptions required for regression analysis were met. Multiple linear regression analysis was used to test the hypotheses and determine the effects of online collaborative learning (X1), metacognitive awareness (X2), and instructional media richness (X3) on problem-solving skills (Y). The coefficient of determination (R^2) was calculated to assess how much the independent variables collectively explained the variation in problem-solving skills, while the t-test (partial test) was conducted to determine the significance of each independent variable's effect on the dependent variable. The significance level used for all hypothesis testing was $\alpha = 0.05$.

4. RESULTS AND DISCUSSION

4.1 Respondent Demographics

The demographic characteristics of the 150 student respondents provide a comprehensive overview of the participant profile for this study, all of whom had prior experience with online learning, making them well-suited for the research focus. The demographic data were categorized into gender, age, study program, duration of online learning experience, and participation in online collaborative activities. In terms of gender, the sample consisted of 63 male students (42%) and 87 female students (58%), indicating a slightly higher proportion of female respondents while still maintaining balanced representation. The age distribution showed that most participants were young adults in the productive academic range, with 60 students (40%) aged 18–20, 78 students (52%) aged 21–23, and 12 students (8%) above 23 years. Academic backgrounds were diverse, with respondents coming from Education (45 students, 30%), Business & Management (40 students, 27%),

Social Sciences (35 students, 23%), and Science & Technology (30 students, 20%), ensuring representation from multiple fields that commonly integrate online collaborative learning. The duration of online learning experience further demonstrated that participants were familiar with digital learning environments, with 23 students (15%) having less than 1 year of experience, 90 students (60%) reporting 1–2 years, and 37 students (25%) having more than 2 years of experience.

In addition to general demographic characteristics, the frequency of participation in online collaborative learning activities was assessed to confirm the relevance of the sample to the research objectives. The results indicate that only 18 students (12%) rarely engaged in online collaborative tasks, while 47 students (31%) sometimes participated, and a majority reported frequent involvement, with 53 students (35%) often and 32 students (22%) very often engaging in such activities. This distribution reinforces that most respondents had substantial exposure to online collaboration, making them appropriate evaluators of variables such as online collaborative learning, metacognitive awareness, instructional media richness, and problem-solving skills. The demographic diversity across gender, age, academic discipline, and online learning experience strengthens the generalizability and validity of the study's findings.

4.2 Validity and Reliability Analysis

Validity and reliability tests were conducted to ensure that the questionnaire used in this study was accurate, consistent, and appropriate for measuring the four variables: online collaborative learning, metacognitive awareness, instructional media richness, and problem-solving skills. All analyses were performed using SPSS version 25. The validity test, conducted using the Pearson Product-Moment correlation method, aimed to determine whether each questionnaire item accurately measured the intended construct. An item was considered valid if the r-count value exceeded the r-table value of 0.159 at a significance level of $p < 0.05$. The results showed that all items across the four variables—Online Collaborative Learning (X1) with 8 items, Metacognitive Awareness (X2) with 10 items, Instructional Media Richness (X3) with 8 items, and Problem-Solving Skills (Y) with 10 items—demonstrated positive correlation values, with all correlation coefficients surpassing the minimum required threshold and significance values below 0.05. These findings indicate that all questionnaire items met the validity requirements and are suitable for measuring their respective constructs.

The reliability test measured the internal consistency of the instrument using Cronbach's Alpha, with criteria stating that $\alpha \geq 0.70$ indicates reliability, $\alpha \geq 0.80$ indicates high reliability, and $\alpha \geq 0.90$ indicates excellent reliability. The reliability results demonstrated strong consistency across all variables: Online Collaborative Learning (X1) recorded a Cronbach's Alpha of 0.861, Metacognitive Awareness (X2) scored 0.884, Instructional Media Richness (X3) achieved 0.873, and Problem-Solving Skills (Y) reached 0.891. All values exceeded 0.80, confirming that the items used to measure each construct were highly reliable. These outcomes collectively demonstrate that the research instrument possesses strong internal consistency, ensuring dependable measurement of all variables involved in the study.

4.3 Classical Assumption Tests

Classical assumption tests were conducted to ensure that the multiple linear regression model used in this study met the required statistical criteria, including tests for normality, multicollinearity, heteroscedasticity, and autocorrelation. The normality test, performed using the Kolmogorov–Smirnov (K-S) method and supported by the Normal P–P Plot, showed a significance value of 0.112, which is greater than 0.05, indicating that the residuals are normally distributed and thus fulfilling the normality assumption. The Normal P–P Plot further confirmed this result by displaying data points that closely followed the diagonal line. The multicollinearity test, assessed through Tolerance and Variance Inflation Factor (VIF) values, revealed that all predictor variables had tolerance values above 0.10 and VIF values below 10, demonstrating that no multicollinearity issues were present among the independent variables in the regression model.

Table 1. VIF

Variable	Tolerance	VIF	Conclusion
X1	0.582	1.720	No multicollinearity
X2	0.647	1.545	No multicollinearity
X3	0.603	1.656	No multicollinearity

The results of the multicollinearity test presented in Table 1 show that all independent variables—Online Collaborative Learning (X1), Metacognitive Awareness (X2), and Instructional Media Richness (X3)—meet the acceptable statistical criteria, indicating that multicollinearity is not a concern in this regression model. Each variable demonstrates a tolerance value well above the minimum threshold of 0.10, with X1 at 0.582, X2 at 0.647, and X3 at 0.603, suggesting that a substantial proportion of each variable's variance is unique and not excessively shared with other predictors. Similarly, the VIF values for all variables fall far below the maximum allowable value of 10—X1 at 1.720, X2 at 1.545, and X3 at 1.656—further confirming the absence of problematic multicollinearity. These findings indicate that the independent variables do not statistically interfere with one another, allowing the regression coefficients to be interpreted reliably and ensuring that the overall model remains stable and accurate in estimating the effects of online collaborative learning, metacognitive awareness, and instructional media richness on students' problem-solving skills. Based on these values, the regression model clearly satisfies the assumption of no multicollinearity.

The heteroscedasticity test was conducted using the Glejser Test along with visual analysis of the scatterplot to verify whether the residuals exhibited constant variance. The Glejser test results showed that all independent variables had significance values greater than 0.05—X1 at 0.214, X2 at 0.327, and X3 at 0.298—indicating that none of the predictors caused heteroscedasticity. This is supported by the scatterplot, which displays a random distribution of residual points without any discernible pattern, confirming that the residuals have homogeneous variance. These findings collectively demonstrate that the regression model fulfills the heteroscedasticity assumption, allowing further analyses to proceed with confidence in the reliability of the estimated parameters.

4.4 Multiple Linear Regression Results

Regression analysis was conducted to examine the effect of online collaborative learning (X1), metacognitive awareness (X2), and instructional media richness (X3) on problem-solving skills (Y). The multiple linear regression model generated the equation $Y = 0.412 + 0.287X_1 + 0.354X_2 + 0.265X_3$, which provides several important insights. The constant value of 0.412 represents the baseline level of problem-solving skills when all independent variables are assumed to be zero. The positive coefficients for X1, X2, and X3 indicate that increases in online collaborative learning, metacognitive awareness, and instructional media richness contribute positively to the development of students' problem-solving abilities. Among the three predictors, metacognitive awareness (X2) displays the highest coefficient at 0.354, suggesting that it plays the most influential role in enhancing students' problem-solving skills compared to online collaborative learning and instructional media richness. These findings highlight the importance of both cognitive and environmental factors in shaping students' ability to tackle academic challenges.

The coefficient of determination (R^2) obtained from the regression analysis was 0.623, indicating that 62.3% of the variation in students' problem-solving skills can be explained by the combined influence of online collaborative learning, metacognitive awareness, and instructional media richness. The remaining 37.7% of the variation is attributed to other factors not included in this model, such as individual motivation, instructional quality, learning environment, prior knowledge, and other cognitive or psychosocial variables. This R^2 value demonstrates that the regression model has moderately strong explanatory power. To further evaluate the significance of each independent variable, a partial t-test (t-test) was conducted, the results of which are presented in the following section.

Table 2. Multiple Regression

Variable	t-value	Sig.	Conclusion
Online Collaborative Learning (X1)	3.912	0.000	Significant
Metacognitive Awareness (X2)	5.021	0.000	Significant
Instructional Media Richness (X3)	3.545	0.001	Significant

The results presented in Table 2 demonstrate that all three independent variables—Online Collaborative Learning (X1), Metacognitive Awareness (X2), and Instructional Media Richness (X3)—have a statistically significant effect on students' problem-solving skills, as indicated by their respective t-values and significance levels. Online Collaborative Learning (X1) shows a t-value of 3.912 with a significance level of 0.000, confirming that collaborative digital interactions, shared tasks, and group coordination significantly contribute to improving problem-solving abilities. Metacognitive Awareness (X2) exhibits the highest t-value of 5.021 with a significance level of 0.000, indicating that students' abilities to plan, monitor, and evaluate their learning processes are the strongest predictors of problem-solving performance in this model. Instructional Media Richness (X3) also demonstrates a significant effect, with a t-value of 3.545 and a significance level of 0.001, suggesting that engaging, interactive, and varied multimedia content enhances students' cognitive engagement and supports better problem-solving outcomes. Overall, these findings confirm that all three predictors play meaningful roles in shaping students' problem-solving skills, with metacognitive awareness emerging as the most influential factor.

Discussion

The results of this study provide comprehensive insights into how online collaborative learning, metacognitive awareness, and instructional media richness influence students' problem-solving skills in higher education. The findings reinforce existing theories and prior empirical work, highlighting that students' learning outcomes are shaped not only by individual cognitive abilities but also by the quality of their social interactions and the technological sophistication of their learning environments. The regression analysis showed that online collaborative learning (X1) significantly enhances students' problem-solving skills. This supports the premise that collaborative learning environments promote idea exchange, negotiation of meaning, and the co-construction of knowledge—activities central to higher-order thinking development. Online collaboration exposes students to diverse viewpoints that stimulate critical thinking, encourages articulation of reasoning, and allows asynchronous reflection that enables more thoughtful, refined responses. These results are consistent with constructivist learning theory and prior studies demonstrating that collaborative digital environments strengthen communication, creativity, and analytical thinking [33]–[35].

Metacognitive awareness (X2) emerged as the strongest predictor of problem-solving skills, indicating its central role in shaping students' ability to plan, monitor, and evaluate their learning strategies. Students with strong metacognitive skills can identify gaps in understanding, select appropriate strategies, regulate their cognitive processes, and adapt when encountering unfamiliar problem contexts—making them more effective problem solvers. This aligns with extensive research emphasizing that metacognition is a core component of academic success and critical thinking development. The findings suggest that integrating metacognitive activities—such as guided reflection, self-assessment, learning journals, and strategic questioning—into instructional practices can significantly strengthen students' problem-solving capacities and overall cognitive performance.

Instructional media richness (X3) also showed a significant influence on students' problem-solving abilities, underscoring the importance of rich multimedia environments in supporting deep comprehension and analytical reasoning. Rich media such as videos, animations, interactive simulations, and digital learning platforms help clarify complex concepts, reduce ambiguity, and improve understanding through multiple sensory channels. Interactive features enable students to experiment with virtual scenarios, apply concepts in practical contexts, and receive immediate

feedback—offering a more engaging and cognitively stimulating learning experience. These findings align with media richness theory, which posits that communication effectiveness increases when information is delivered through multimodal and context-rich formats. Prior studies similarly highlight that multimedia environments enhance engagement, motivation, and cognitive processing, ultimately improving students' learning outcomes.

Overall, the model explained 62.3% of the variance in problem-solving skills, indicating that the combination of collaborative learning, metacognitive awareness, and media richness provides a substantial contribution to students' cognitive development. These findings carry important implications for higher education. Pedagogically, instructors should integrate collaborative tasks with reflective components and multimedia resources to create richer learning experiences. From a curriculum perspective, embedding metacognitive training within learning modules can help students strengthen their strategic thinking and self-regulation skills. Technologically, institutions should invest in learning management systems and digital tools that support multimedia content and collaboration, such as virtual labs and interactive discussion platforms. Finally, students should be encouraged to actively participate in online learning communities, utilize multimedia resources, and take greater ownership of their learning processes. In conclusion, the study demonstrates that online collaborative learning fosters interactive knowledge construction, metacognitive awareness is the most influential determinant of problem-solving success, and instructional media richness enhances comprehension and engagement—highlighting the need for an integrated pedagogical approach that blends social, cognitive, and technological elements to optimize learning outcomes in higher education.

5. CONCLUSION

This study concludes that online collaborative learning, metacognitive awareness, and instructional media richness significantly contribute to the development of students' problem-solving skills in higher education, with findings showing that students who actively participate in collaborative online environments tend to demonstrate stronger analytical and critical thinking abilities. Metacognitive awareness emerged as the most influential factor, indicating that students who can plan, monitor, and evaluate their learning processes are better equipped to tackle complex academic tasks, while instructional media richness also plays a vital role by enhancing comprehension, engagement, and cognitive processing through multimodal content. Collectively, these three predictors explain 62.3% of the variation in problem-solving skills, emphasizing the importance of integrating pedagogical, cognitive, and technological approaches in contemporary higher education. Based on these insights, educators are encouraged to design learning experiences that foster collaboration, promote metacognitive reflection, and incorporate rich multimedia resources, while institutions should invest in digital learning platforms that support interactive, engaging, and resource-rich online environments. Future research may further examine additional factors such as motivation, self-efficacy, and learning environment conditions to provide a more comprehensive understanding of the determinants of problem-solving performance.

REFERENCES

[1] S. I. Park and S. Jang, "Critical factors influencing problem-solving ability in online learning environments," *SNU J. Educ. Res.*, vol. 19, pp. 25–56, 2010.

[2] D. Lu and Y.-N. Xie, "The application of educational technology to develop problem-solving skills: A systematic review," *Think. Ski. Creat.*, vol. 51, p. 101454, 2024.

[3] L. Judijanto, M. Khoiri, M. Arsyad, J. W. Sitopu, and E. Sitepu, "Pengaruh Teknologi Pembelajaran terhadap Perkembangan Kognitif dan Kreativitas Siswa di Era Digital," *J. Psikol. dan Konseling West Sci.*, vol. 2, no. 04, pp. 293–300, 2024.

[4] J. Corrales and A. A. Tenorio, "Leveraging online collaboration for enhanced social studies cognitive skills," *Int J Sci Manag Res*, vol. 7, no. 9, pp. 61–73, 2024.

[5] H. S. Lu and R. Smiles, "The role of collaborative learning in the online education," *Int. J. Econ. Bus. Manag. Res.*, vol.

6, no. 6, pp. 97–106, 2022.
[6] K. Sevnarayan and N. Vaughan, "Shared Metacognition, Collaboration and the Community of Inquiry Framework in Action," *Compet. J. Educ.*, vol. 4, no. 3, pp. 305–327, 2025.
[7] S. N. Razali, F. Shahbodin, H. Hussin, and N. Bakar, "Factors affecting the effective online collaborative learning environment," in *Pattern analysis, intelligent security and the internet of things*, Springer, 2015, pp. 215–224.
[8] I. Jung, M. Kudo, and S.-K. Choi, "Towards effective and less stressful online collaborative learning: Strategies to promote engagement while minimizing unnecessary cognitive load and stress," in *International Handbook of E-Learning Volume 1*, Routledge, 2015, pp. 115–126.
[9] H. Tok, H. Özgan, and B. Döş, "Assessing Metacognitive Awareness And Learning Strategies As Positive Predictors For Success In A Distance Learning Class/Uzaktan Eğitim Sınıfında Başarının Pozitif Yordayıcısı Olarak Bilişötesi Farkındalık Stratejisi Ve Öğrenme Stratejilerinin Değerlend," *Mustafa Kemal Üniversitesi Sos. Bilim. Enstitüsü Derg.*, vol. 7, no. 14, pp. 123–134, 2010.
[10] D. A. U. Cabrejos and C. A. F. Martínez, "Habilidades metacognitivas en estudiantes universitarios: Una revisión sistemática sobre su desarrollo y aplicación," *Horizontes. Rev. Investig. en Ciencias la Educ.*, vol. 9, no. 39, pp. 2857–2875, 2025.
[11] A. Çini, S. Järvelä, M. Dindar, and J. Malmberg, "How multiple levels of metacognitive awareness operate in collaborative problem solving," *Metacognition Learn.*, vol. 18, no. 3, pp. 891–922, 2023.
[12] P. Doolittle and M. Byrnes, "Cognition and Learning," *Educ. Princ. Pract. Vet. Med.*, pp. 79–132, 2023.
[13] R. E. Mayer, "Cognitive, metacognitive, and motivational aspects of problem solving," *Instr. Sci.*, vol. 26, no. 1, pp. 49–63, 1998.
[14] Y.-P. Wang and T.-J. Wu, "Effects of online cooperative learning on students' problem-solving ability and learning satisfaction," *Front. Psychol.*, vol. 13, p. 817968, 2022.
[15] E. Oskarita and H. N. Arasy, "The role of digital tools in enhancing collaborative learning in secondary education," *Int. J. Educ. Res.*, vol. 1, no. 1, pp. 26–32, 2024.
[16] C. P. Espinosa and Z. N. Saltos, "Plataformas de aprendizaje colaborativo en línea y su impacto en las habilidades," *Dominio Las Ciencias*, vol. 10, no. 3, pp. 401–410, 2024.
[17] *Л. И.* Горелова and Н. В. Уварина, "Оценка влияния цифровых технологий на педагогическую эффективность и профессиональное развитие педагогов," *ББК 74.04 Т65*.
[18] P. Güner and H. N. Erbay, "Metacognitive Skills and Problem-Solving.," *Int. J. Res. Educ. Sci.*, vol. 7, no. 3, pp. 715–734, 2021.
[19] T. Tuononen, H. Hyytinen, M. Räisänen, T. Hailikari, and A. Parpala, "Metacognitive awareness in relation to university students' learning profiles," *Metacognition Learn.*, vol. 18, no. 1, pp. 37–54, 2023.
[20] U. Akpur, "METACOGNITIVE AWARENESS AND ACADEMIC ACHIEVEMENT: A META-ANALYSIS STUDY," *Elektron. Sos. Bilim. Derg.*, vol. 23, no. 91, pp. 1276–1293, 2024.
[21] H. A. Fauziah, "Profil kesadaran metakognisi siswa di salah satu SMA swasta di Sragen," *Biosf. J. Biol. Dan Pendidik. Biol.*, vol. 3, no. 2, pp. 21–29, 2018.
[22] A. Tsadima, K. Vassilopoulou, E. Kavakli, and C. Sofianopoulou, "INTEGRATING MEDIA RICHNESS THEORY AND LEARNING STYLES: A PROPOSED THEORETICAL FRAMEWORK," in *EDULEARN12 Proceedings*, IATED, 2012, pp. 17–26.
[23] M. M. Shepherd and W. B. Martz Jr, "Media richness theory and the distance education environment," *J. Comput. Inf. Syst.*, vol. 47, no. 1, pp. 114–122, 2006.
[24] R. Papa, *Media rich instruction: Connecting curriculum to all learners*. Springer, 2014.
[25] P.-C. Sun and H. K. Cheng, "The design of instructional multimedia in e-Learning: A Media Richness Theory-based approach," *Comput. Educ.*, vol. 49, no. 3, pp. 662–676, 2007.
[26] S. Prakong, "The role of critical thinking in enhancing students' problem-solving abilities in higher education," *J. Educ. Humanit. Soc. Res.*, vol. 1, no. 1, pp. 10–16, 2024.
[27] B. B. Sobrinho, A. R. S. C. Branco, M. G. da Silva Rabecini, A. S. de Lima, and M. F. de Carvalho, "DESENVOLVENDO HABILIDADES DE RESOLUÇÃO DE PROBLEMAS EM ESTUDANTES," *LUMEN ET VIRTUS*, vol. 16, no. 46, pp. 2733–2747, 2025.
[28] C. McLoughlin, "Bridge over troubled water: Creating effective online support for the metacognitive aspects of problem solving," in *EdMedia*, Association for the Advancement of Computing in Education (AACE), 2002, pp. 1267–1272.
[29] L. Rusmin, Y. Misrahayu, F. Pongpalilu, R. Radiansyah, and D. Dwiyanto, "Critical Thinking and Problem-Solving Skills in the 21st Century, Ⅱ," *Join J. Soc. Sci*, vol. 1, no. 5, 2024.
[30] N. Li and N. Shukor, "Critical thinking process in online collaborative learning based on different group metacognitive regulation levels," *Int. J. Emerg. Technol. Learn.*, vol. 18, no. 23, pp. 130–144, 2023.
[31] M. Karyotaki and A. Drigas, "Online and Other ICT-based Training Tools for Problem-solving Skills.," *Int. J. Emerg. Technol. Learn.*, vol. 11, no. 6, 2016.
[32] J. E. Broussard, *Student problem solving communication processes while completing multimedia case studies: a look into the relationship among levels of collaboration, problem solving processes, and problem solving performance on individual and group levels*. Louisiana State University and Agricultural & Mechanical College, 2011.
[33] S. Güzel and A. Görmüş, "Prediction of satisfaction indicators increasing the level of happiness: evidence from the Turkish life satisfaction survey," *Qual. Quant.*, vol. 57, no. 4, pp. 3805–3824, 2023, doi: 10.1007/s11135-022-01532-4.

[34] I. W. K. Suwastika, "Pengaruh E-Learning sebagai Salah Satu Media Pembelajaran Berbasis Teknologi Informasi Terhadap Motivasi Belajar Mahasiswa," *J. Sist. dan Inform.*, vol. 13, no. 1, pp. 1–5, 2018.

[35] K. Kasmari, E. E. Demi, and T. Pramano, "the Effect of Percepted Organizational Support, Motivation and Job Satisfaction on Employees' Organizational Commitment (Case Study At the Kendal Regency Education and Culture Office)," *Int. J. Manag. Econ.*, vol. 1, no. 3, pp. 33–44, 2022, doi: 10.56127/ijme.v1i3.258.