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Information Literacy and Digital Literacy as Predictors of Students Cognitive Learning Outcomes in General Biology

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Abstract: The rapid digital transformation in higher education highlights the importance of literacy competencies that enable students to effectively access, evaluate, and utilize information. This study aimed to examine the relationship between information literacy (IL), digital literacy (DL), and students' cognitive learning outcomes (CLO). A quantitative correlational design was employed involving 78 undergraduate students enrolled in a General Biology course. Data were collected using a literacy questionnaire and a cognitive test. Assumptions of normality, linearity, and multicollinearity were met prior to analysis. Multiple regression analysis revealed that IL and DL simultaneously had a significant relationship with CLO ($p < 0.05$; $R = 0.417$; $R^2 = 0.174$), while partial effects were not significant. This study demonstrates that IL and DL act as complementary rather than independent predictors of cognitive outcomes. The findings imply that integrating both literacies into instructional design is essential to enhance students' academic performance in digital learning environments. The study contributes to the growing literature on literacy integration in higher education and implies that instructional design should integrate information and digital literacy simultaneously to support meaningful learning and improve students' academic performance in digital learning environments.

Keywords: Cognitive Learning Outcomes; Digital Literacy; Information Literacy.

Introduction

The swift digital revolution in higher education requires a reassessment of the abilities vital to academic achievement, particularly in information literacy (IL) and digital literacy (DL). Research indicates that higher education institutions must adapt their curricula to equip students with the necessary skills to thrive in a digitally driven workforce, highlighting the importance of digital competence as a predictor of academic performance [1]. Therefore, developing these competences is essential for aligning educational achievements with the requirements of the 21st century. In modern biology education, students must cultivate digital scientific literacy, including the ability to access, assess, synthesize, and use scientific knowledge from diverse digital sources.

Information literacy (IL) refers to the ability to identify, evaluate, and use information effectively, while digital literacy (DL) involves the competent and responsible use of digital technologies. Although distinct, both literacies are complementary and essential for navigating information in digital environments [2][3]. The integration of these literacies is crucial, as they collectively enhance the skills needed to navigate the complexities of the digital age, where information and technology are intertwined [4]. Furthermore, the evolving nature of these literacies necessitates a flexible approach that considers socio-cultural contexts and technological advancements, ensuring that educational frameworks remain relevant and effective [5][6].

Previous studies have shown that both IL and DL are positively associated with academic performance, including critical thinking and problem-solving skills. These findings highlight the importance of literacy competencies in supporting students' academic success [7][8]. Furthermore, Rafique et al. demonstrated that IL is a significant predictor of academic motivation and performance among engineering students, underscoring its critical role in educational outcomes [9]. Additionally, Audrin and Audrin's systematic review identifies DL as a key factor in educational success, linking it to essential 21st-century skills [4]. Collectively, these findings underscore the importance of fostering both information and DL to enhance academic achievement.

The existing literature on literacies in educational contexts often examines them in isolation, focusing primarily on students' perceptions and technology-use behaviors rather than their direct impact on cognitive learning outcomes (CLO). For instance, studies on new literacies reveal significant positive correlations between students' perceived benefits of these literacies and their academic achievements, particularly in collaborative settings [10]. Furthermore, the development of integrated assessment tools for information, media, and data literacy also underscores the necessity of a holistic approach to literacy education, which could enhance CLO by addressing interrelated competencies [11]. Thus, a more comprehensive examination of these literacies in relation to cognitive outcomes is essential for advancing educational practices.

Despite the growing recognition of literacy competencies as critical determinants of academic success in higher education, empirical studies examining the simultaneous contribution of information literacy (IL) and digital literacy (DL) to cognitive learning outcomes (CLO) remain limited. Previous research has predominantly focused on students' technological engagement or perceived

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readiness, often overlooking how these competencies translate into measurable academic performance. Unlike prior studies that tend to examine IL and DL separately, this study provides a novel contribution by simultaneously analyzing their predictive roles on CLO within a science education context.

Therefore, this study aims to investigate the relationship between IL, DL, and students' CLO in a higher education setting. Specifically, it examines whether IL and DL significantly influence cognitive learning outcomes, both individually and simultaneously, using a correlational analytical approach. The findings are expected to provide empirical evidence that clarifies the role of these literacy competencies as complementary factors in shaping academic performance. In addition, this study offers practical implications for instructional design and curriculum development, particularly in integrating literacy-based approaches to enhance meaningful learning in digitally mediated higher education environments. This integrative approach provides a more comprehensive understanding of how literacy competencies interact to influence students' cognitive achievement.

Research Methods

Study Design

This study utilized a quantitative correlational research strategy to investigate the relationships among the independent variables IL and DL and the dependent variable CLO among students. The study was conducted at the Department of Mathematics and Natural Sciences Education at the University of Mataram, involving 78 undergraduate students enrolled in the General Biology course. The sampling technique used in this study was purposive sampling, as participants were selected based on their enrollment in the General Biology course, which requires engagement with digital and information resources. Participation in the study was voluntary, and all students were informed of the research's purpose prior to data collection.

Instrument of The Study

Data in this study were collected using both non-test and test instruments. IL and DL were measured using a questionnaire sheet. The IL instrument consisted of four indicators that reflected students' ability to identify, access, evaluate, and utilize information sources effectively. The DL instrument included five indicators that measured students' ability to use digital tools, access online resources, evaluate digital information, communicate through digital platforms, and apply digital technologies for learning purposes.

Students' CLO were measured using a 40-item multiple-choice test developed based on the learning objectives of the General Biology course. IL and DL were measured using a 72-item questionnaire. The IL and DL questionnaire used a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total scores were categorized into low, moderate, and high levels based on percentage intervals. The cognitive test was scored dichotomously (1 for correct answers, 0 for incorrect), then converted to a percentage score.

Before data collection, all items were assessed for validity and reliability. The items' validity was assessed using Pearson's product-moment correlation; all items demonstrated p-values below 0.05, indicating satisfactory validity. Reliability analysis using Cronbach's alpha produced coefficients of 0.980 for the literacy questionnaire and 0.874 for the CLO test, indicating excellent and good reliability, respectively. Therefore, the instruments were considered appropriate for use in this study.

Data Collection and Analysis

Data collection was carried out during the implementation of the General Biology course at the Department of Mathematics and Natural Sciences Education, University of Mataram. Data on students' IL and DL were collected using a 72-item questionnaire. The questionnaire was administered to participants to assess their ability to access, evaluate, and use information, as well as their competence in using digital technologies for learning. Meanwhile, students' CLO were measured using a 40-item multiple-choice test developed based on the learning objectives of the General Biology course. The test was administered to students after the learning session. The use of both instruments enabled the researcher to obtain data on students' literacy competencies and their CLO.

Prior to conducting the regression analysis, several prerequisite tests were performed to ensure that the data met the assumptions of parametric analysis. The Kolmogorov–Smirnov test indicated that the residuals were normally distributed ($p = 0.200 > 0.05$). Linearity tests showed that the relationships between IL and CLO ($p = 0.220$) as well as between DL and CLO ($p = 0.363$) were linear. In addition, multicollinearity diagnostics indicated that the highest condition index was 22.008, which is below the critical threshold of 30, suggesting no serious multicollinearity among the independent variables. These results confirm that the data satisfied the assumptions required for multiple regression analysis.

Results and Discussion

This study examines the relationship between information literacy (IL), digital literacy (DL), and students' cognitive learning outcomes (CLO) in higher education, revealing several important patterns. As presented in Table 1, IL and DL simultaneously have a significant effect on CLO ($p = 0.001 < 0.05$), indicating that both literacy competencies contribute to students' academic performance.

Table 1. ANOVA Analysis Result

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	238.373	2	119.186	7.790	.001[b]
Residual	1132.147	74	15.299		
Total	1370.519	76			

To further examine the strength of this relationship, Table 2 shows that the model demonstrates a moderate association ($R = 0.417$) with an explanatory power of 17.4% ($R^2 = 0.174$), indicating that IL and DL contribute to CLO, although other factors remain influential.

Table 2. Multiple Linear Regression Summary of the Correlation of IL and DL Skills to CLO

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.417[a]	.174	.152	3.91143

The contribution of each independent variable to CLO is presented in Table 3. IL contributes 6.79%**,** while DL contributes 10.61% to the explained variance in CLO. Collectively, both variables explain 17.4% of the variance in CLO**.**

Table 3. The Summary of Relative and Effective Contribution of IL and DL to CLO

Variable	Relative Contribution (%)	Effective Contribution (%)
IL	39.02	6.79
DL	60.98	10.61
Total	100	17.4

The relatively moderate contribution of IL and DL to students' cognitive learning outcomes suggests that these literacies are not the sole determinants of academic performance. This indicates that other factors may also play significant roles. Previous studies have shown that IL has a moderate positive correlation with academic performance (r = 0.33). At the same time, additional factors such as cognitive attributes, socio-economic background, and learning environment also influence learning outcomes [8][12]. Furthermore, digital competence has been associated with improved learning performance in higher education contexts, particularly when supported by effective information-processing and knowledge integration strategies [13][14]. Therefore, while IL and DL contribute to learning outcomes, they operate within a broader set of factors that shape students' academic performance.

Building on this finding, the higher contribution of DL compared to IL suggests the increasing importance of digital competencies in shaping students' cognitive learning outcomes. DL encompasses skills such as communication, problem-solving, and critical thinking, which are essential for navigating technology-driven learning environments [15][16]. Previous studies have also shown that digital competence is associated with improved learning performance, particularly in areas such as data literacy and digital content creation [13]. This indicates that students with stronger digital literacy are better equipped to engage with learning resources and perform effectively in digital learning contexts.

In contrast, information literacy supports students' CLO by enabling them to identify information needs, evaluate sources, and apply knowledge effectively in academic contexts. A meta-analysis reports a moderate positive relationship between IL and academic performance (r = 0.33), indicating its contribution to learning outcomes [8]. Furthermore, integrating IL into curricula has been shown to enhance students' self-efficacy, motivation, and academic performance [17][9]. These findings suggest that IL plays a complementary role alongside digital literacy in supporting students' academic success.

As shown in Table 4**,** neither IL ($\beta = 0.167$, $p = 0.481$) nor DL ($\beta = 0.261$, $p = 0.271$) has a statistically significant individual effect on CLO. This indicates that, when considered separately, each literacy does not significantly predict students' cognitive learning outcomes. However, consistent with the significant ANOVA result, both variables jointly contribute to the regression model, suggesting that their combined effect helps explain variations in CLO.

Table 4. Multiple Regression Equation Coefficient Analysis of IL and DL to CLO

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	68.966	1.918		35.949	.000
	IL	.044	.063	.167	.709	.481
	DL	.069	.063	.261	1.108	.271

The non-significant partial effects of IL and DL observed in Table 4 can be explained by their conceptual interdependence. Although the overall regression model is significant, the individual contributions of these literacies may be obscured by their overlapping competencies, particularly in accessing, evaluating, and utilizing digital information [18][19]. This suggests that students do not apply these literacies in isolation, but rather as integrated cognitive processes, indicating that separating IL and DL as independent predictors may oversimplify how students engage with academic tasks. Previous studies also indicate that learning outcomes are influenced by multiple factors beyond literacy, including cognitive skills and socio-economic conditions, which may further explain the limited individual effects observed in this study [8].

This interdependence highlights that IL and DL should be understood as interconnected components within a broader literacy framework, rather than as separate determinants of academic performance. In the context of biology education, where students are required to interpret scientific information, evaluate evidence, and engage with digital learning resources, the integration of these competencies becomes particularly critical. IL supports the critical evaluation and application of scientific knowledge, while DL enables students to navigate digital tools and information environments effectively [20]. This finding extends previous literature by emphasizing that the effectiveness of literacy competencies lies not in their isolated use, but in their combined application within learning processes. Therefore, these results suggest the need for integrative approaches in both research and instructional design to capture better and support the complexity of students' cognitive engagement in digital learning environments [2][21][22][23][24][25]. This finding represents a key contribution of the study, demonstrating that the effectiveness of literacy competencies lies in their combined rather than independent application, and highlighting the importance of designing learning

environments that foster information and digital literacy as integrated competencies.

Conclusion

This study concludes that information literacy and digital literacy jointly influence students' cognitive learning outcomes, although their individual effects are not statistically significant. The novelty of this study lies in demonstrating the complementary nature of these literacies in predicting academic performance. Practically, the findings suggest that educators should integrate both literacy components into instructional design, particularly through digital-based learning strategies. However, this study is limited by its sample size and the exclusion of other potential influencing variables. Future research is recommended to include additional factors such as learning motivation and digital learning environments to provide a more comprehensive understanding.

Author's Contribution

Lianto: Conceptualization, Data Collection, Data Analysis, and Writing. M.R. Adawiyah: Conceptualization, Methodology, Data Collection, and Data Analysis. T.A. Lestari: Conceptualization and Writing.

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