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Metacognitive Contribution to Biology Pre-service Teacher's Digital Literacy and Self-Regulated Learning during Online Learning

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Digital literacy development at the university level is necessary for facing Industrial Revolution 4.0. This research is ex post facto research that examines the phenomena that occur in the learning process. The study was conducted from April to August 2021, with 64 respondents from all universities with Biology Education Study Programs in Bali involved in filling out Metacognitive Ability, Self-regulated Learning, and Digital Literacy questionnaires distributed through Google Forms. The tabulated data were then analyzed using Structural Equation Modeling - Partial Least Square (SEM-PLS) SMART PLS 3.0. The results showed that the contributions of metacognitive abilities to the digital literacy skills of biology education students in Bali were 23.1%. In the other hand, contributions of metacognitive abilities to self-regulated abilities were 41.8%. Furthermore, in biology courses, metacognitive abilities have a significant contribution to digital literacy compared to self-regulated learning.

Keywords: metacognitive ability, self-regulated learning, digital literacy, biology education students, structural equation modeling, pre-service teacher

INTRODUCTION

The Covid-19 pandemic has caused massive changes in all sectors of life, including education (Alomyan, 2021; Boonroungrut et al., 2022; Calderón-Garrido et al., 2021; Makruf et al., 2022). The process of implementing instruction which has been conducted face-to-face in universities has turned into online learning. Changes in learning methods have a significant impact on the activities of lecturers and students in carrying out the

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learning process. One of the perceived impacts is how openness is to digital platforms or digital literacy owned by lecturers and students.

In response to this, the world of education in higher education packages online learning using a Learning Management System (LMS), MOOCs, social media, and even video streaming to carry out learning effectively and efficiently (Makruf et al., 2022; Rahim & Ali, 2021). In practice, not all of these facilities can be used effectively and efficiently by prospective teacher. This is due to the characteristics of online learning that cause limited interaction between lecturers and students which can reduce the quality of the learning process and results. Lecturers generally have difficulty guiding and monitoring student progress and learning difficulties due to limited communication. These limitations can also have an impact on the development of students' thinking skills, especially higher-order thinking skills which include problem-solving, critical thinking, creative thinking, and metacognition.

To continue to create a meaningful learning climate in online learning, students' independence and self-regulation skills are needed, so they can still construct their knowledge optimally. In this case, metacognitive awareness and self-regulated learning play a central role (Muijs & Bokhove, 2020). Several relevant studies related to metacognition also indicate that metacognitive abilities positively contribute to self-regulated learning abilities (Çetin, 2017; Cheng, 2011; Follmer & Sperling, 2016; Kongkar, 2021; McDowell, 2019; Muijs & Bokhove, 2020; Mustopa et al., 2020; Simpson & Nist, 1985; Thabrani, 2015). Metacognition can be defined as a person's ability to formulate various strategies to solve various problems through planning, monitoring, and evaluating student cognitive processes (Çetin, 2017; Quigley et al., 2018). Metacognitive skills refer to the individual knowledge about one or more processes and products of cognition possessed by a person (Howard, 2004). Metacognitive awareness can be divided into two main dimensions, namely Knowledge about Cognition and Regulation of Cognition (Brown in Harrison & Vallin, 2018). In simple terms, it can be interpreted that metacognition is "thinking about the way of thinking itself".

Meanwhile, self-regulated learning is a process when a student actively participates in learning metacognitively, motivationally, and behaviorally. Zimmerman (in Cheng, 2011) suggests that learning strategies can describe how self-regulated learning is owned by a student. Learning strategies can describe how a student's willingness, motivation, and metacognition are shown in the form of real behaviors. A self-regulated learning strategy is a combination of plans that will be used by students to achieve their learning goals. Through metacognitive skills and self-regulated learning, students are expected to be able to manage their learning process well even though they do not receive direct and detailed guidance from the lecturer.

On the other hand, metacognitive abilities also contribute to students' digital literacy skills (Greene et al., 2014, 2018; Zylka et al., 2015). Metacognitive abilities contribute through planning and regulatory strategies to develop students digital literacy. The cognitive aspects in digital literacy are the main aspects developed by metacognitive thinking skills. Through regulatory and digital literacy planning strategies, students can be directed to sort, search, and assess the validity of the information.

Based on this explanation, this study aims to analyze the contribution of metacognitive abilities to the digital literacy and self-regulated learning abilities of prospective biology teacher students during the implementation of online learning. After obtaining a description of metacognitive awareness, the contribution of metacognitive awareness and digital literacy and self-regulated learning is then revealed through analytical techniques using Structural Equation Modeling (SEM) which confirms the relationship between each latent variable and its manifest variable in the study.

METHOD

This study was conducted between April and August 2021. The population in this study were all Biology pre-service teachers in Bali, while the sample in this study consisted of 64 students using the purposive sampling technique. The criteria for selecting universities and students were students who are actively registered in each Biology Education Study Program in Bali such as Universitas Mahasaraswati Denpasar, IKIP Saraswati Tabanan IKIP, Universitas Mahadewa, and Universitas Pendidikan Ganesha. This criterion is used following the purpose of the study, namely to see how the contribution of metacognitive abilities contribution to self-regulated learning and digital literacy of biology education students in Bali.

This study used 3 types of questionnaire instruments, namely, digital literacy, self-regulated learning (SRL), and student metacognitive ability. The questionnaire used five-point Likert scale categories, namely Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. Metacognitive questionnaire and the SRL questionnaires were uses adapted from questionnaire developed by Jansen et al. (2017). The criteria for measuring metacognitive abilities included task definition, goal setting, strategic planning, comprehension monitoring, and strategy regulation. The criteria for the SRL questionnaire included aspects of time management, environmental structuring, persistence, and help-seeking. The measured student literacy was adapted from the Development and Validation of the Internet Skills Scale (ISS) (van Deursen et al., 2016).

The data collection in this study used survey techniques from Google Forms. The distribution of Google Forms begins with the administration or a formal letter requesting permission. The results of the data tabulation of the three research variables were analyzed using the Structural Equation Modeling-Partial Least Square (SEM-PLS) technique with Smart PLS 3.0 software.

To evaluate the SEM-PLS program, it is possible to evaluate the results of the measurement model. Evaluation of the outer model is commonly known as the validity and reliability of the model. An outer model based on reflective indicators namely convergent validity and discriminant validity, was used to analyze construct validity. The results of the convergent validity analysis must meet the loading factor > 0.7, with an average variance extracted (AVE) > 0.5 and communality value > 0.5. Furthermore, to test the convergent validity based on the criteria the AVE value must be > 0.5 and the

AVE root must be larger (Ghozali, 2011). Convergent validity is closely related to the principle that a measurement (manifest variable) of the construct should have a high correlation.

In discriminant validity, the measuring variable or manifest variable should have a high correlation. The technique for analyzing the discriminant validity is by using the cross-loading value indicator for each variable to be > 0.70. Another technique that can be used to test discriminant validity is to compare the square root of the AVE in each construct with the correlation between constructs in a model. If the square root value of AVE for each construct is greater than the correlation between constructs, then the model can be said to have good discriminant validity (Ghozali, 2011).

In addition to testing the validity of the reliability test or the accuracy of a construct in the model. In this context, the construct reliability test on the model uses composite reliability and Cronbach's Alpha. Because the use of Cronbach's Alpha gives a lower value (underestimate) so that in this study composite reliability is used. The analysis guidelines in this study can be shown in Table 1.

Table 1
Summary of convergent validity and determinant validity test

Validity	Parameter	Rule of Thumb
Convergent Validity	Loading Factor	>0.70 for confirmatory research >0.60 still acceptable for exploratory research
	Average Variance Extracted (AVE)	>0.50 for confirmatory and exploratory research
Discriminant Validity	Cross loading	>0.70 for each variable
	The Square of AVE and The Correlation between Latent Construct	The square of AVE > Correlation between latent constructs
Reliability	Cronbach's Alpha	>0.70 for confirmatory research >0.60 still acceptable for exploratory research
	Composite Reliability	>0.70 for confirmatory research 0.60 – 0.70 still acceptable for exploratory research

Adapted from: Ghozali (2011) and Hair et al. (2012)

FINDINGS

Construct Validity and Reliability

The results of the composite analysis of construct validity and reliability can be shown in Table 2.

Table 2
Construct validity and reliability

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance
Metacognitive	0.943	0.944	0.957	0.816
Digital Literacy	0.820	0.900	0.891	0.649
Self-regulated Learning	0.872	0.891	0.913	0.725

Internal consistency reliability is used to measure how capable an indicator can measure its latent construct. Following the methodology section described earlier that if the composite reliability value ranges from 0.6 – 0.7 it is considered to have good reliability (Sarstedt & Ringle, 2017), and the expected Cronbach's alpha value is above 0.7 (Latan & Ghozali, 2012).

Based on the results of the analysis in Table 2, it can be concluded that the internal consistency reliability for each latent variable includes students' metacognitive ability (0.944), digital literacy (0.900), and SRL (0.891) whose value is > 0.7. Thus, all variables in the study are reliable.

Furthermore, for the analysis of convergent validity, it can be determined using the Average Variance Extracted (AVE) indicator. Based on Table 2, it can be seen that the AVE value of students' metacognitive ability (0.816), digital literacy (0.649), and SRL (0.725) is > 0.5. Thus, it means that the construct can explain more than 50% of the item variance (Sarstedt & Ringle, 2017; Wong, 2013).

Outer Model Evaluation

The results of the convergent validity model can be seen from the loading factor and the Average Variance Extracted (AVE) value contained in Table 3.

Table 3
Convergent validity

	Digital Literacy	Metacognitive	Self-regulated Learning
C2	0.873		
CM1		0.953	
ES3			0.895
GS1		0.889	
HS3			0.874
IN2	0.206		
M2	0.869		
O2	0.906		
P3			0.899
SC2	0.930		
SP1		0.895	
SR1		0.892	
TD1		0.888	
TM3			0.725

Based on the results of the convergent validity analysis using outer loading, it can be concluded several things, namely: 1) All items or outer loading indicators of the digital literacy variable except IN2 have met the criteria because p> 0.7. By the value of the outer loading variable IN2 = 0.206 < 0.7, the manifest variable IN2 can be removed from the model because it is below the minimum value. 2) All items or outer loading indicators of metacognitive manifest variables have met the criteria because p > 0.7. 3) All items or outer loading indicators of the manifest variable SRL have met the criteria because p > 0.7.

In terms of discriminant validity, the validity of each construct can be determined by using the cross-loading value. The value of cross-loading can be shown in Table 4.

Table 4
Discriminant validity value based on cross-loading

	Digital Literacy	Metacognitive	Self-regulated Learning
C2	0.873	0.495	0.286
CM1	0.453	0.953	0.604
ES3	0.317	0.603	0.895
GS1	0.501	0.889	0.540
HS3	0.351	0.554	0.874
IN2	0.206	0.211	0.178
M2	0.869	0.347	0.284
O2	0.906	0.370	0.289
P3	0.238	0.612	0.899
SC2	0.930	0.470	0.364
SP1	0.416	0.895	0.601
SR1	0.404	0.892	0.610
TD1	0.464	0.888	0.588
TM3	0.339	0.428	0.725

The metacognitive variable with code 1 for each manifest variable such as CM1, GS1, SP1, SR1, and TD1 has a greater value in the construct than the cross-loading value and has met the requirements because it exceeds the $p>0.7$ value for each variable. Furthermore, the Digital Literacy variable with code 2, for each manifest variable, namely C2, M2, O2, and SC2, has a greater value in the construct than the cross-loading value and has met the requirements because it exceeds the p value> 0.7 for each variable. Except for the manifest variable IN2 which does not meet the criteria ($p=0,211<0,7$). In the last variable, namely the self-regulated learning variable with code 3, for each manifest variable, namely ES3, HS3, P3, and TM3 has a greater value in the construct than the cross-loading value and has met the requirements because it exceeds the p value> 0.7 for each variable.

Partial Least Square (PLS) Assumption

The prerequisite that must be met by the outer model analysis is that there is no multicollinearity with a correlation value limit of > 0.9 which is indicated by the value of the Variance Inflating Factor (VIF) at the indicator level > 5. The results of the VIF analysis at the indicator level can be described in Table 5.

Table 5
Partial least square (PLS) assumption based on variance inflating factor (VIF)

	Variance Inflating Factor (VIF)
C2	2.295
CM1	7.636
ES3	2.672
GS1	3.184
HS3	2.753
IN2	1.100
M2	3.654
O2	4.645
P3	2.947
SC2	4.832
SP1	3.985
SR1	3.634
TD1	3.495
TM3	1.596

Based on Table 5, it can be seen that the 2 latent variables, namely digital literacy and SRL each have a manifest variable that meets the VIF requirements, while for metacognitive variables there is one manifest variable that does not meet the requirements, namely CM1 (7.636>5).

Inner Model Evaluation

Inner model evaluation in this study uses 3 indicators, namely R2, predictive relevance (Q2), and goodness of fit (Gof) (Chin, 2010). The R Square value of metacognitive ability on digital literacy and SRL for Biology pre-service teachers in Bali can be shown in Table 6.

Table 6
R square value

	R Square	R Square Adjusted
Digital Literacy	0.231	0.219
Self-regulated Learning	0.427	0.418

Based on the results of the research data analysis in Table 5, it can be seen that the exogenous construct of metacognitive variables on Digital Literacy is 23.1% and for Self-regulated Learning is 41.8%. Thus, based on the results of Adjusted R Square of less than 33%, the influence of exogenous metacognitive constructs on Digital Literacy is weak (0.219) and the influence of exogenous metacognitive constructs on Self-regulated Learning is strong (0.418).

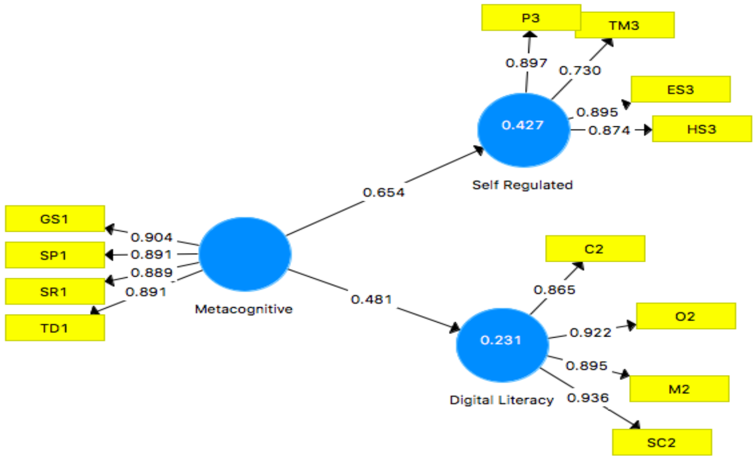

Figure 1
Structural model

For the research model to meet the model fit criteria, the SMSR value must be <0.05 (Cangur & Ercan, 2015). However, based on the explanation from the SMART-PLS website, the limitations or criteria for the fit model include RMS Theta value or Root Mean Square Theta < 0.102, SRMR, or Standardized Root Mean Square < 0.10 or < 0.08 and NFI value > 0.9. The following are the results of the analysis of the Fit Smart PLS Model (Table 7).

Table 7
Smart PLS model fit analysis

	Saturated Model	Estimated Model
SRMR	0.063	0.064
d_ULS	0.313	0.321
d-G	0.255	0.255
Chi-Square	91.352	91.344
NFI	0.857	0.857

Based on the results of the analysis of the fit model in table 4.6, it can be concluded that the model fits the data because the value of the SRMR or Standardized Root Mean Square (SRMR) p = 0.064 <0.10.

DISCUSSION

Contribution of Metacognitive Ability to Digital Literacy Ability of Biology Pre-service Teacher in Bali

The results of data analysis showed that the exogenous construct of metacognitive awareness towards digital literacy was 23.1%. This means that metacognitive goals contribute 23.1% to the digital literacy of biology pre-service teachers. Meanwhile, the remaining contribution to digital literacy is another variable not examined in this study. The results of this study are supported by previous research which explains that metacognition has a contribution to digital literacy (Greene et al., 2014, 2018; Zylka et al., 2015).

The contribution of metacognitive awareness to digital literacy is viewed from the basic principles and components of digital literacy. Digital literacy has a cognitive, technical, and socio-emotional perspective. Cognitive aspects include skills to seek, select, and critically assess information (Ng, 2012). Anthonysamy et al. (2020) also explain that digital literacy is a set of competencies consisting of knowledge, skills, and behaviors that can effectively use technology. Hague & Payton (2010) added that there are several components of digital literacy which include functional skills, creativity, critical thinking and evaluating skills, understanding socio-cultural conditions, collaboration skills, ability to find and select information, communication skills, and security on the internet.

The basic principles and components of digital literacy that have been put forward in several previous studies show the same thing, namely cognitive aspects and critical thinking skills as part of digital literacy. Cognitive aspects and critical thinking skills have relevance to metacognitive awareness which has the functions of planning, monitoring, and evaluation. In these three functions, metacognitive practice improves students' ability to critically realize their thinking and learning to improve digital literacy (Anthonysamy et al., 2020).

The critical thinking process in the context of digital literacy is the skill to select and evaluate the information obtained from digital sources. If a person can critically assess the information he gets, then he will then be aware of something he does not know and already knows and can regulate his response to the information obtained. This is closely related to metacognitive awareness, especially the monitoring and evaluation function. Several studies have also revealed a significant relationship between metacognitive awareness and critical thinking skills (Amin et al., 2020; Naimnule & Corebima, 2018).

On the other hand, the results of research showing 23.1% contribution of metacognitive awareness to digital literacy cannot be said to be high. This is because many other variables affect student digital literacy. Warno (2020) explained that several factors influence environmental literacy, including access to technology, motivation and need, and fluency of teachers/lecturers in using technology. In addition, the contribution that is not high enough is also due to the very broad component of digital literacy. Meanwhile, the relevance between metacognitive awareness and dominant digital literacy can only be studied in cognitive aspects and critical thinking skills. Therefore, further research is needed to reveal the relationship of other components of digital literacy with metacognitive awareness.

Contribution of Metacognitive Ability to Self-Regulated Learning of Biology Pre-service Teacher in Bali

The results of the SMART PLS analysis show that the contribution of metacognitive abilities to students' self-regulated learning is 64.5%. The remaining 35.5% is determined by variables outside the research variables. Metacognition is the ability of a person to evaluate and regulate his mindset (Az-zahra & Hendi, 2021). In general, metacognitive abilities can support and direct students' self-regulation in the process of planning, monitoring, evaluating, and motivating students in their learning process (Bahri & Corebima, 2015; Cazan, 2012). Several recent studies have revealed how the role of metacognitive abilities in learning to support students' self-regulated learning (Follmer & Sperling, 2016; Frazier et al., 2021; Hertel & Karlen, 2021; McDowell, 2019; Mustopa et al., 2020; Șuteu, 2021). The contribution of metacognitive ability to the self-regulated learning ability of biology pre-service teacher is supported by each descriptor of the metacognitive ability which includes task definition, goal setting, strategic planning, comprehension monitoring, and strategy regulation.

Task definition is the ability to define the tasks given by the lecturer. Each student can define the same task differently. This depends on the level of sensitivity of students to problems and students' ability to solve problems. The ability of students in defining tasks greatly affects the ability of students to manage themselves. Students who can define tasks well will have a clear picture of the relationship between the components of the task with each other, can recognize their potential effectively and efficiently in completing assignments. This will increase students' self-confidence and motivation in self-regulation. In addition, the ability to define tasks can also support students' abilities in time management which is one of the self-regulated learning descriptors for students.

The second descriptor of metacognitive ability is goal setting or designing learning goals independently (Simpson & Nist, 1985). Metacognitive ability is a form of cognition that can be used to achieve learning goals in the self-regulated learning model (Hertel & Karlen, 2021). Even though the lecturer has given the lecture objectives in detail in the semester learning plan (RPS). Lectures will be more meaningful if the students themselves can together with the lecturers in formulate the objectives of their respective lectures. The full involvement of students in designing their learning objectives will increase their participation and learning activities in the future. On a broader scale, it can be seen that the ability of students in determining their learning objectives is closely related to the ability to plan self-regulated learning. When viewed more specifically, this self-regulated planning is related to the ability of Environmental Structuring, namely structuring the learning environment and student help-seeking

Strategic Planning in metacognitive abilities is also closely related to the planning process contained in self-regulated learning. Effective strategies and metacognitive knowledge are the keys for students to succeed in developing their self-regulated learning abilities (Frazier et al., 2021). Planning for both metacognitive abilities and self-regulated learning is the first stage that determines how the learning outcomes of the subject will be achieved. Metacognitive provides a more specific definition because it emphasizes the use of the word "strategy" which describes how to achieve course learning outcomes effectively and efficiently. More specifically, strategic planning in the planning process gives students direct experience in the negotiation process. The ability to negotiate is one part of the 21st century learning needs, namely the ability to collaborate.

From the aspect of comprehension monitoring, the self-regulated learning ability of biology pre-service teachers is developed especially through monitoring understanding regularly. Comprehension monitoring is not only a part of metacognitive ability but also a part of self-regulated learning. Comprehension monitoring here means that active students periodically reflect on their understanding. Thus, the role of the lecturer as a facilitator in the lecture process is to ensure that each student has reflected on their learning abilities within a certain time interval. It also has a nurturant effect where lecturers will more easily diagnose student problems during the learning process because students have fully understood their respective abilities. More specifically, the self-regulated descriptor, namely Persistence, is also very necessary to independently carry out self-reflection consistently.

To realize strategic planning properly, it is necessary to have the right strategy regulation. Strategy regulation is the main key to supporting the success of independent learning in learning (Simpson & Nist, 1985). In this strategy student teacher candidates will be involved in problem-solving, monitoring activities and strategies during the lecture process, and evaluating their learning outcomes based on effectiveness and efficiency criteria.

CONCLUSION

Contribution of the metacognitive ability to digital literacy and SRL of Biology pre-service teachers in Bali are included in the fit model category with data because the value of SRMR or Standardized Root Mean Square (SRMR) $p= 0.064 < 0.10$. 1) The contribution of Metacognitive Ability to the Digital Literacy Ability of Biology Education Students in Bali is 23.1%. 2) Contribution of Metacognitive Ability to Self-Regulated Learning Ability of Biology Education Students in Bali is 41.8%. Based on the research results, the following suggestions can be formulated. 1) It is interesting to study how the contribution of the metacognitive ability of Biology education students in Bali is related to other research variables such as learning motivation, anxiety level, learning style, and so on. 2) To enrich research methods, similar types of research can be carried out with different methods such as multiple regression analysis and path analysis to enrich and develop research on metacognitive.

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