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Self-regulated Learning and Digital Literacy: Relationship with Conceptual Understanding of Excretory System

Rusdi[1*], Rizhal Hendi Ristanto[1], Gabriellia Oktaviani Prabowo[1], Edi Sarwono[2]

[1]Biology Education, Faculty of Mathematics and Natural Science, State University of Jakarta, Indonesia
[2]6 Jakarta State High School, Indonesia

*Corresponding author: rusdi@unj.ac.id

ABSTRACT Biology learning in the 21st century makes students understand concepts, including excretory system learning. Self-regulated learning is how students learn independently, with digital literacy skills, which should be maintained as students must control their use of technology and information in learning. This research aimed to analyze the relationship between self-regulated learning with the conceptual understanding of the excretory system and digital literacy with the conceptual understanding of the excretory system. Then also, the relationship between self-regulated learning and digital literacy as a whole with the conceptual understanding of the excretory system in a high school with a post-pandemic learning situation. This research was held for two months, from March until April 2022, in SMAN 6 Jakarta, involving 94 students of class XI Science as samples. A descriptive correlational study was chosen, while questionnaires and tests were used as instruments. The hypothesis test shows a multiple linear regression model in $\hat{Y}=-12.495+0.345X_1+0.680X_2$ with the model significance of 0.000 and 0.062 as relationship linearity, then concludes that there is a positive relationship which is significant and linear between self-regulated learning and digital literacy simultaneously with excretory system conceptual understanding.

Keywords Biology learning, learning regulation, digitalization, concept mastery, organ system

1. INTRODUCTION

Biology learning in the 21st century requires every student to learn with a series of aspects summarized in the 6Cs, such as critical thinking, collaboration, communication, creativity, citizenship, and connectivity/character education (Fullan, Quinn & McEachen, 2017). Biology, as an element of science, requires students to be able to gain understanding from various ways of thinking, including mastery of concepts (Greene et al., 2019). Concepts need to be mastered in Biology, especially in Anatomy and Physiology, which requires understanding every organ system in the living body, including the excretory organ system. The curriculum in Indonesia states that students must be able to analyze the relationship between structures of the excretory organ with processes and organ dysfunctions as learning outcomes (Ristanto, Rahayu & Mutmainah, 2021).

Remote learning during the COVID-19 pandemic has shown learning loss among students, with some indications of losing learning progress in literacy that is comparable to six months of learning and numeracy which is similar to five months of learning (Engzell, Frey & Verhagen, 2021.; Ministry of Education and Culture, 2021). The excretory system is a difficult biology chapter for students, making students tend to only accept and memorize what is given by the teacher without developing concepts, so that students' knowledge becomes limited and difficult to answer problem-based questions, as evidence shown by research on high school students in several regions (Simorangkir & Napitupulu, 2020; Wardyaningrum & Suyanto, 2019; Rindah, Dwiastuti & Rinanto, 2019). Limited knowledge among students makes 21st-century learning demands for conceptual understanding difficult to be fulfilled.

21st-century learning makes students dependent on formal learning in the classroom and must also learn independently by applying abilities in the state of self-regulation in learning to improve the quality of learning (Zimmerman, 2013; Atmojo, Muhtarom & Lukitoaji, 2020). Self-regulated learning ability is about how students

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can process their learning, including motivation, cognition, and behavior (Antonelli, Jones, Burridge & Hawkins, 2020; Zimmerman & Martinez-Pons, 1986; Pintrich, Smith, Garcia & McKeachie, 1991). Cognition, as a component of self-regulation in learning, is known to be involved in achieving mastery of scientific concepts (Sinatra & Taasoobshirazi, 2017). Self-regulated learning also influences increasing student achievement in Biology scores and has the potential to create concept mastery (Sebesta & Speth, 2017).

Students learning in the modern era must search for almost all information digitally because of the rapid development of technology, and digitalization has become normal (Sa, Santos, Serpa & Ferreira, 2021). Therefore, digitalization makes students need to acquire skills in controlling technology and finding and managing that information with all competencies named by digital literacy (Braten, Britt, Stromso & Rouet, 2011). In addition, digital literacy is often associated with learner autonomy in digital-based learning (Ting, 2015).

Research on Bogor high school students Bogor shows a relationship between digital literacy and learning achievement (Giovanni & Komariah, 2019). Integrating digital literacy in science learning has also proven effective (Tang & Chaw, 2016). Learning through digital sources in the 21st century can occur effectively if students can practice digital literacy combined with self-regulation abilities (Greene, Yu & Dana, 2014). Various studies have shown that there is a positive and linear relationship between self-regulated learning and learning outcomes (Sebesta & Speth, 2017; Hidayat, 2021), digital literacy and learning outcomes (Giovanni & Komariah, 2019; Hafiza, Rahayu & Kahar, 2022), as well as self-regulated learning and digital literacy with overall learning outcomes (Lee, Moon & Cho, 2015).

The relationship with learning outcomes has been widely studied, but not many studies have been found that focus only on concept mastery in biology learning, especially the excretory system. Moreover, relevant research on the relationship between self-regulation in learning, digital literacy, and conceptual understanding in high school students has also not been updated. Although conceptual understanding is important for high school students to develop their thinking ability and for them to be able to master what they learned in this 21st century while the transition from full online learning to offline, face-to-face learning happens, also a more specified study is needed to get a thorough and detailed result about an important particular learning outcome such as concept mastery. Hence it is crucial to focus more on concept mastery rather than learning outcomes as a whole. Therefore, this research urges to determine whether there is a relationship between self-regulated learning and digital literacy with the conceptual understanding of the excretory system in high school students. The specific objectives of this study were to measure the relationship between self-regulated learning and conceptual understanding of the excretory system for XI Science students, to measure the relationship between digital literacy and conceptual understanding of the excretory system for XI Science students, and to measure the relationship between self-regulated learning and digital literacy simultaneously with the conceptual knowledge of the excretory system for XI Science students.

2. METHOD

This is quantitative research, and the method used is descriptive with a correlational study, aimed to measure a group of subjects based on the desired variable and to see whether these variables are related to each other from the observed sample (Punch, 2003). The variables measured in this study include variable X, namely self-regulated learning and digital literacy, then variable Y, which is the student's conceptual understanding of the excretory system. The study has a design shown in Figure 1.

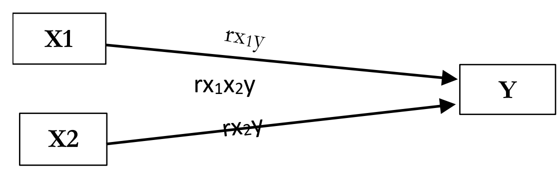

Figure 1 Flow chart regarding the steps followed during the research

The population studied were XI Science students at SMAN 6 Jakarta who was taking their fourth semester when this research was held. After determining the people, samples were picked out using the multi-stage sampling technique, which consisted of selecting three classes with random cluster sampling. Then, from 120 students in the three courses as respondents, 93 students were chosen as final minimum samples with a simple random sampling technique using Slovin Formula.

This study collects data using questionnaires and tests. The questionnaires were used to measure the level of students' self-regulated learning ability, using a 4-point Likert scale with a scale order of "Strongly Disagree", "Disagree", "Agree", to "Strongly Agree". The scaling follows the guidelines developed by Emerson (2017). The statement items in the instrument were developed from the Learning and Study Strategies Inventory (LASSI) indicators, which included anxiety, attitude, concentration, motivation, information processing, selecting main ideas, self-testing, test strategies, academic resources, and time management. The indicator was designed by Weinstein and developed until the 3rd edition (Weinstein, Palmer & Acee, 2016). The outline of this instrument is described briefly in Table 1.

Table 1 The outline of the self-regulated learning instrument

No	Area	Measured indicators	Number of questions
	Motivation	Anxiety	3
		Attitude	3
		Concentration	4
		Motivation	3
2.	Cognition	Information processing	4
		Selecting main ideas	2
		Self-testing	3
		Test strategies	2
3.	Behavior	Academic resources	4
		Time management	3
Total			31 items

The self-regulated learning instrument's validity test was conducted using the Pearson Product Moment formula for all dimensions. The question is valid if r count > r table at $\alpha = 0.05$. Based on the validity test with n=28 and α =0.05, 31 items were valid, and nine were invalid. Calculation of reliability using Cronbach's Alpha formula and obtained a coefficient of 0.882.

The tests measure the level of digital literacy skills and excretory system conceptual understanding of every sampled student. The instrument for measuring digital literacy variables is a multiple-choice test developed with several dimensions and indicators referring to DigComp 2.1, designed by Carretero, Vuorikari, & Punie (2017) and shown in Table 2. Each question contains four choices, with 1 (one) point given to the correct answer and wrong decisions with 0 (zero) points.

Table 2 The outline of the digital literacy instrument

No.	Dimension	Number of questions
1.	Information and data literacy	5
2.	Communication and collaboration	3
3.	Digital content creation	6
4.	Problem solving	6
Total		20

The validity test of digital literacy instruments was conducted using Biserial Point Correlation, where the items are said to be valid if t count > t table = 2.06 at $\alpha = 0.05$ and n-2 = 26. Based on the validity test, there were 20 good statement questions and ten invalid questions. Calculation of reliability using the Kuder-Richardson 20 formula then obtained a value of 0.690, so all of the questions are declared reliable.

The test instrument used in measuring students' conceptual understanding consisted of multiple-choice and short essays that refer to indicators of conceptual understanding that students are expected to achieve in the excretory system chapter that has been studied previously. The indicator used refers to the cognitive dimension integrated with the conceptual size according to Anderson & Krathwohl (2001) formulated by O'Neill & Murphy (2010), as shown in Table 3. Multiple choice questions with correct answers are given a score of 1 (one), while the short essays with correct answers are given a score of 2 (two), and all of the incorrect answers are provided a score of 0 (zero).

Table 3 Conceptual understanding of excretory system instruments' outline

No.	Cognitive level	Number of questions
1.	Remembering (C1)	6
2.	Understanding (C2)	5
3.	Applying (C3)	8
4.	Analyzing (C4)	9
5.	Evaluating (C5)	4
6.	Creating (C6)	2
Total		29

Validity testing of the excretory system conceptual understanding instrument was conducted using Biserial Point Correlation, where the items are said to be valid if t count > t table = 2.06 at α= 0.05 and n-2 = 26. Based on the validity test, there were 24 valid items, six invalid items for multiple-choice questions, and five useful items for short essay questions. The reliability calculation used the Kuder-Richardson 20 formula and obtained a value of 0.856 for all multiple-choice and essay questions, which is said to be reliable.

Data from each variable is calculated by minimum score, maximum score, range of score, mean, standard deviation, and percentage to be represented descriptively. After that, SPSS was used for prerequisite and hypothesis tests. The prerequisite tests include the normality test using the Kolmogorov-Smirnov test and the homogeneity test using the Levene test, both calculated at α =0.05. After the data is normal and homogeneous, the hypothesis can be tested using a simple regression model, multiple regression model, and correlation analysis using the Pearson Product Moment (PPM) formula.

3. RESULT AND DISCUSSION

The data obtained in this study include some assessments for three variables: self-regulated learning, digital literacy, and conceptual understanding of the excretory system. Table 4 shows that the digital literacy variable has the highest average. Table 5 shows the results of every prerequisite test for the three variables. All data are

Table 4 Descriptive analysis of each research variable

Statistical description	Self-regulated learning (X_1)	Digital literacy (X_2)	Conceptual understanding of the excretory system (Y)
Average score	68.32	74.31	61.58
Standard deviation	7.89	12.88	19.74
Maximum score	91.13	100	97.06
Minimum score	52.42	30	8.82
Score range	38.71	70	88.24
Total of samples	94	94	94

Table 5 Test for Normality and Homogeneity for Each Research Variable

X_1		X_2		Y		α
Sig. KS*	**Sig. L****	**Sig. KS***	**Sig. L****	**Sig. KS***	**Sig. L****	
0.200	0.066	0.200	0.588	0.200	0.563	0.05

*Kolmogorov-Smirnov; normality test **Levene Test; homogeneity test

normally distributed and homogeneous because the significance is more than α = 0.05.

3.1 Relationship between self-regulated learning and conceptual understanding of the excretory system

Self-regulated learning is the ability to understand and control the learning environment to achieve the goal of mastering some knowledge or skills (Schraw et al., 2006). The results of the study in Table 6 show that self-regulated learning for students in XI Science SMAN 6 Jakarta is in the High category with a percentage of 80.85%, which indicates that the ability of students to manage their learning is sufficient. However, students still must increase it again (Weinstein, Palmer & Acee, 2016). Self-regulated learning is divided into Cognition, Motivation, and Behavior, with each average score shown in Table 7.

Cognition showed the highest average score among the other dimensions. As part of science, biology requires students to solve problems, think critically, and master concepts progressively, so structured training and cognitive formation process are needed during learning (Nuckles, Roelle, Glogger-Frey, Waldeyer & Renkl, 2020; Greene et

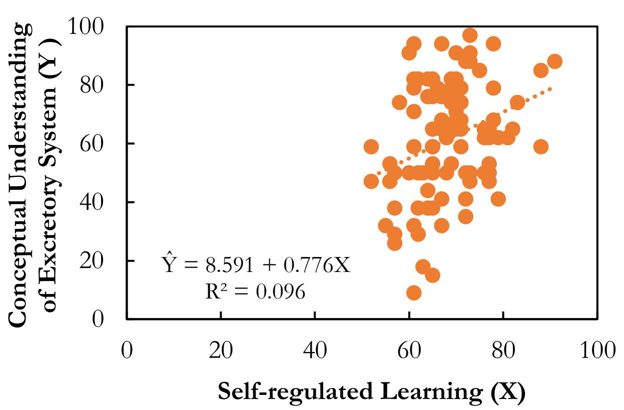

Figure 2 Simple linear regression model between self-regulated learning (X) and conceptual understanding of excretory system (Y).

Table 6 Percentage of Each Assessment Criteria for Self-Regulated Learning Variable

Score Range	Criteria	Frequency	Percentage
$80 \leq X \leq 100$	Very high	6	6.38%
$60 \leq X < 80$	High	76	80.85%
$40 \leq X < 60$	Enough	12	12.77%
$20 \leq X < 40$	Low	0	0.00%
$0 \leq X < 20$	**Very low**	**0**	**0.00%**
Total		94	100.00%

Table 7 Descriptive Analysis of Each Dimension of Self-Regulated Learning Variable

Dimension	Average Score	Standard Deviation	Criteria
Motivation	66.90	8.10	High
Cognition	69.46	9.65	High
Behavior	69.15	11.92	High

al., 2019). Motivation is the dimension with the lowest average score. Many factors cause a lack of student motivation in learning, including internal factors like student disinterest in subjects such as Biology or external factors such as lack of support from teachers and parents (Owens, Troy, Angela & Smith-Walters, 2017; Wahyuni & Suhendar, 2018; Bulic & Blazevic, 2020).

The significance test of the relationship model between self-regulated learning and conceptual understanding of the excretory system shown in Figure 1 at α = 0.05 shows a significance of 0.002 < 0.05, while the linearity test states a significance of 0.598 > 0.05, so it can be seen that there is a positive and linear relationship between self-regulated learning and conceptual understanding of the excretory system. This indicates that if there is an increase in self-regulated learning scores, it will also be followed by an increase in conceptual understanding of the excretory system. The results of the coefficient of determination test showed R Square = 0.096, which means that self-regulated learning contributes to the conceptual understanding of the excretory system by 9.6%

Table 8 Descriptive Analysis of the Percentage of Each Assessment Criteria for Digital Literacy Variable

Score Range	Criteria	Frequency	Percentage
75 ≤ X ≤ 100	High	53	56.38%
50 ≤ X < 75	Good	39	41.49%
25 ≤ X < 50	Basic	2	2.13%
0 ≤ X < 25	Low	0	0.00%
Total		94	100.00%

The result of this research can be considered in line with two previous studies by Sebesta & Speth (2017) and Hidayat (2021), which state that there is a relationship between self-regulated learning and biology learning outcomes. Students who have good self-regulation will be able to find out what is the reason behind their learning (motivational aspect), what is learned and how to learn it (cognitive aspect), to control their learning activities (behavioral aspect) so that the results achieved are more leverage (Weinstein, Palmer & Acee, 2016; Cleary, 2018; Oghenevwede, 2019; Antonelli, Jones, Burridge & Hawkins, 2020). On the other hand, students who only study without self-regulation tend not to be able to achieve mastery of concepts because their learning activities become disorganized and difficult to manage (Wong et al., 2019).

Mastery of the biological concept is often considered a complex requirement, so students must manage which part or chapter is easier to learn first. Organized learning by prioritizing the right amount makes students not only understand something that is known directly but also can provide reasons for every phenomenon that occur due to various influences (Cleary & Platten, 2013; Yoon, Sao & Park, 2017; Efklides, Schwartz & Brown, 2018). The motivational aspect of self-regulated learning is also important in increasing mastery of concepts (Stanton, Neider, Gallegos & Clark, 2015). However, research by Sebesta & Speth (2017) states that not all learning strategies with self-regulation abilities in learning will be successful. Self-regulation in learning also needs to be supported by other parties, such as teachers and parents, to assist students in optimizing their abilities and strategies to achieve the expected level of conceptual understanding of the excretory system (DiBenedetto, 2018; Jansen, Leeuwen, Janssen, Conijn & Kester, 2020; van Alten, Phielix, Janssen & Kester, 2020).

3.2. Relationship between digital literacy and conceptual understanding of the excretory system

Digital literacy is the skill of technology control, finding, then managing digital information obtained in learning (Ting, 2015). Students are dominant in the High category for their digital literacy, with as many as 53 people, with a total percentage of 56.38%, as shown in Table 8. Most students can carry out various digital tasks and complex daily digital problems (Carretero, Vuorikari, & Punie, 2017). XI grade students are in a digitally literate age, supported by mobile phones and laptops, which have become common (Neuman, 2016; Simarmata et al., 2021). Online learning also causes students to adapt and deal directly with technology and the information they get digitally (Limniou, Varga-Atkins, Hands & Elshamaa, 2021). Digital literacy is divided into four dimensions with average scores, as shown in Table 9. The Information and Data Literacy dimension have the highest average, while the Digital Content Creation dimension has the lowest standard.

Table 9 Descriptive Analysis of Each Dimension of Digital Literacy Variables

Dimension	Average Score	Standard Deviation	Criteria
Information and Data Literacy	83.62	18.54	High
Communication and Collaboration	81.91	22.75	High
Digital Content Creation	67.55	16.64	Good
Solution to problem	69,50	21.26	Good

Students with high Information and Data Literacy scores are considered capable of searching, filtering, evaluating, and managing digital information and data (Jin, Reichert, Cagasan, La Torre & Law, 2020). For example, students can determine the right keywords to search for information and determine whether the information received is correct. Students prefer the internet to get more information in a more efficient way to learn, so they can adapt and improve their skills in finding and managing digital information (Nicholas, Huntington, Jamali, Rowlands & Maggie, 2009; Blayone et al., 2018). Meanwhile, the Digital Content Creation dimension shows the lowest average score, which means students' skills in creating, developing content, and understanding content copyright are still lacking compared to other digital literacy skills (Carretero, Vuorikari, & Punie, 2017). The low creativity of students can be caused by unsupportive learning conditions, such as minimal supervision, so students tend to easily copy other people's work or work (Olga, 2018; Hanif, Wijaya & Winarno, 2019; Matraeva, Rybakova, Vinichenko, Oseev & Ljapunova, 2020). Furthermore, the low response of students to copyright-related questions indicates that students do not understand copyright provisions, so further education is needed.

The significance test of the relationship model of digital literacy with the conceptual understanding of the excretion system at the level of = 0.05 shows the significance of 0.000 < 0.05, while the linearity test of the relationship at the level of =0.05 stated a significance of 0.062 > 0.05. So that it was known that there was a positive and linear relationship

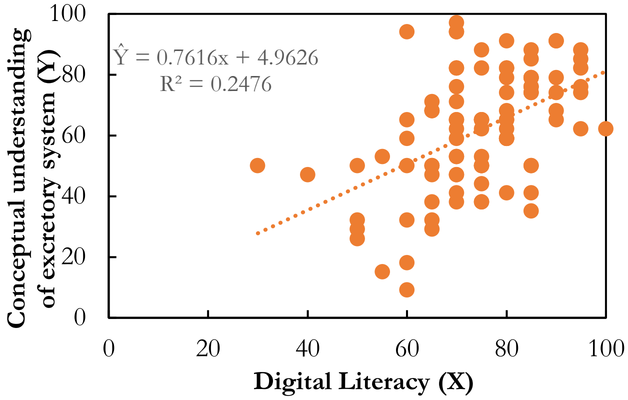

Figure 3 Simple linear regression model between digital literacy (X) and conceptual understanding of the excretory system (Y).

between digital literacy and mastery of the excretion system concept. The significant relationship equation model can be seen in Figure 3. The R Square calculation shows that digital literacy contributes 24.7% to the conceptual understanding of the excretory system.

Previous research by Hafiza, Rahayu & Kahar (2022) and Giovanni & Komariah (2019) has similar results: digital literacy has a significant relationship with learning outcomes, including conceptual understanding. Every educational institution, including high school, is experiencing an increase in digitalization and rapid technological Various studies on the use of digital-based media and e-learning resources have been proven to help students learn Biology, especially in understanding concepts (Puspitasari, Miarsyah & Rusdi, 2020; Ristanto, Rahayu & Mutmainah, 2021). That happened because media and learning resources in the form of digital devices can be variated, interactive, and able to display specifically from basic concepts to simulations of the mechanism, so they are more effectively used in learning when compared to conventional media and resources (Shroff, Ting & Lam, 2019; Suryanda, Sartono & Sa'diyah, 2019; Hillmayr, Ziernwald, Reinhold, Hofer & Reiss, 2020; Susanto, Rachmadtullah & Rachbini, 2020).

Information search engines such as Google and video sites such as Youtube are often some options for students to find as much information as possible while still trying to filter that information with their digital literacy skills, so that information can be used to strengthen their conceptual understanding in learning (Nicholas, Huntington, Jamali, Rowlands & Maggie, 2009; Hermawanto, Kusairi, & Wartono, 2013). In addition, students need interaction with other people, including in learning, then with the development of technology, the interaction will often be done through digital devices such as social media. Social media is considered to be able to improve the overall learning process by triggering students to share their learning and exchange views on the concepts that have been studied, so it ends in a mastery of concepts in the learning process (Meyer, 2010; Al-Rahmi, Othman & Yusuf, 2015; Piantola et al., 2018).

3.3 Relationship between self-regulated learning and digital literacy with the conceptual understanding of the excretory system

Conceptual understanding of the excretory system means that students can think about, use, state, search for and build models of each concept in the excretory system chapter (Konicek-Moran & Keeley, 2015; Nygaard, Cook & Namy, 2009). Therefore, the assessment results of students' conceptual mastery are viewed from two assessment criteria: five categories according to intervals according to Arikunto (2009) in Table 10 and the passing grade determined by the school in Table 11.

Conceptual understanding of the excretory system of Class XI Science SMA Negeri 6 students is in a Good category in Table 11, which means that most students already understand the fundamental concepts of the excretory system (Konicek-Moran & Keeley, 2015). However, different results are shown by data in terms of the passing grade, as shown in Table 10, which states that most students' scores are below the passing grade or declared incomplete. This means that students' conceptual understanding has not been able to achieve the expectation according to the basic competence, namely analyzing the relationship between the structure of the organ tissues in the excretory system with bioprocesses and functional disorders that can occur in the human excretory system (Prayitno, 2009; Hanum, 2017; Perdana & Misnawati, 2021).

Conceptual understanding of the excretory system is divided into six cognitive levels, as shown in Table 12, where the creating level has the highest average score with the most students complete. Meanwhile, the lowest average

Table 10 Score criteria of the excretory system conceptual understanding based on school's passing grade

Score	Criteria	Frequency	Percentage
>75 (over 75)	Complete	27	28.72%
<75 (less than 75)	Not Complete	67	71.28%
Total		94	100.00%

Table 11 Score Criteria of the Excretory System Conceptual Understanding

Score Range	Criteria	Frequency	Percentage
$80 < X \leq 100$	Very good	18	19.15%
$60 < X \leq 80$	Good	34	36.17%
$40 < X \leq 60$	Enough	28	29.79%
$20 < X \leq 40$	Less	11	11.70%
$0 \leq X \leq 20$	Very less	3	3.19%
Total		94	100.00%

Table 12 Descriptive Analysis of Each Dimension in Conceptual Understanding of the Excretion System

Cognitive Level	Average Score	Standard Deviation	Completeness Frequency	Completeness Percentage
Remembering	58.61	20.64	19	20.21%
Understanding	51.60	35.51	25	26.60%
Applying	63.12	32.96	33	35.11%
Analyzing	59.68	23.12	27	28.72%
Evaluating	65.11	29.76	48	51.06%
Creating	78.01	31.89	60	63.83%

Table 13 Descriptive Analysis of Each Sub Material in Conceptual Understanding of the Excretory System

Sub Material	Average Score	Standard Deviation	Completeness Frequency	Completeness Percentage
Excretory system structure	58.51	21.75	19	20.21%
Excretory system principle	70.21	25,50	44	46.81%
Functions of the excretory organs	67.82	28.31	54	57.45%
The mechanism of the excretory process	56.06	25,15	27	28.72%
Excretory system disorder	69.95	26.77	56	59.57%

is Understanding, and the cognitive level with the least completeness is Remembering. The sub-material contained in the excretory system chapter covers several aspects, with the excretory system principle having the highest average score and the excretory system disorders having the highest completeness, as shown in Table 13.

The highest average score in Creating creates the assumption that students already have concepts that become the basis for answering questions, in contrast to the results, which state that students lack mastery of concepts in achieving essential competencies. This can happen when students are more familiar with the language shown in C6 questions. This question asks students to provide solutions to excretory system disorders that can be encountered daily, such as kidney failure and diabetes. This assumption is supported by Table 13, which shows the average score of Excretory System Disorders which is high to the level that is the most completed by students. This assumption is proven by the research of Gunel, Hand & McDermott (2009) and Reinke, Kynn & Parkinson (2019), which show that students are better able to answer everyday life analogies because they feel familiar with the terms or conditions used. Understanding has the lowest score, and Remembering has the least completeness, indicating that students still had a hard to understand every term and process or even could not exactly remember what they learned, supported by the fact that they learned the excretory system chapter in January, while this research distributed instruments at March. Students tend to memorize more than understand almost everything in biology lessons, which makes them forget what they have learned too (Sartono, Komala & Dumayanti, 2016; Kaminske, Kuepper-Tetzel, Nebel, Sumeracki & Ryan, 2020). Low cognitive level questions tend to be oriented by students' memory and understanding of new terms, so that must be the basis for answering questions in C1 (Remembering) and C2 (Understanding) (Jensen & Mark, 2014).

The calculation in the multiple regression model then shows the constant value about a = -12.495 and the regression coefficient $b_1 = 0.345$ and $b_2 = 0.680$ so that the multiple linear regression model is obtained in the form of $Y = -12.495 + 0.345X_1 + 0.680X_2$. The significance test of the model shows a significance of 0.000 < 0.05, while the linearity test of the relationship states a significance of 0.062 < 0.05, so it is known that there is a significant and linear positive relationship simultaneously between self-regulated learning and digital literacy with the conceptual understanding of the excretory system. Hypothesis testing showed similar results to research by Lee, Moon & Cho (2015), which stated that digital literacy and self-regulation could predict learning outcomes, including mastery of concepts. The test stated that self-regulated learning and digital literacy contributed 26.3% to students' conceptual understanding of the excretory system. The results of this contribution indicate the most significant value compared to testing the first and second hypotheses, so it can be assumed that combined self-regulated learning and digital literacy will make a better contribution than each respective contribution.

Self-regulated learning, not accompanied by good digital literacy, makes it more difficult for students to obtain sources of information and visualize their learning material digitally to enrich their knowledge and limit their knowledge to a narrow point of view (Audrin & Audrin, 2022; Yu, 2022). Inappropriate learning strategies can also cause learning outcomes that are not optimal, thus requiring support from other parties to direct students' learning abilities (Dirkx, Camp, Kester & Kirschner, 2019; Lee, Moon & Cho, 2019). Research by Kitsantas & Dabbagh (2011) shows the critical role of technology in self-regulation in learning. Digital literacy also does not necessarily result in total mastery of concepts if it is not carried out with good self-regulation in learning. Ease of access to the digital world frees students to determine each element in their education on a digital basis (Choi, 2012). This freedom makes students do other things outside, while teachers cannot always supervise student learning (Rozgonjuk, Saat & Taht, 2018; Antunano, Resendiz, Cruz-Perez, Paredes-Garcia & Diaz, 2022). Students need to control using digital devices to achieve the main focus or goal during learning by using self-regulated learning ability. That is evident from various studies which reveal that self-regulated learning can improve learning outcomes in the scope of online learning that uses digital access and devices (Cho & Shen, 2013; Muthupoltotage & Gardner, 2018; Anthonysamy, Koo & Hew, 2020). According to Ng & Abdullah (2010). Information-based learning and digital technology require self-regulated learning to achieve maximum academic results.

Self-regulated learning can be improved with appropriate learning strategies and facilities from those around students, such as schools. At the same time, digital literacy is enhanced by wiser use of technology and digital devices. Research by Lee, Moon & Cho (2015) and Rahayu, Dewahrani, Nurkhofiyya & Ristanto (2021) shows the use of self-regulation skills and digital literacy in learning, such as making digital literacy mediate in the form of media or digital-based learning resources by students in strategies to learn independently. Using self-regulation abilities in learning coupled with digital literacy will improve mastery of the concept of the excretory system, which schools or even students can use to improve self-regulation and digital literacy skills simultaneously for more effective learning.

Data collection was carried out when the school still did not allow all students to study offline in class simultaneously, so the data was taken online. However, there were difficulties in coordinating students to be involved as instrument respondents. Some students did not even pay attention to the request to fill out the instrument even though they had been reminded online via group or private chat messages. The solution that can be done in the future is to ensure and remind students regularly if data collection is done online or if they take data directly in a face-to-face condition to facilitate better coordination and optimize the data.

4. CONCLUSION

This study concludes that students of SMA Negeri 6 Jakarta have a level of self-regulation ability in learning in the High category, digital literacy skills in the High category, and the level of mastery of the concept of the excretory system in the Good category but is still dominant under minimum criteria if referring to the passing grade. The study results then show a positive and linear relationship between self-regulated learning and conceptual understanding of the excretory system, and there is a positive and linear relationship between digital literacy and conceptual understanding of the excretory system. Lastly, there is a positive and linear relationship between self-regulated learning and digital literacy, with the conceptual understanding of the excretory system with a large contribution which 26.3%.

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REFERENCES

Al-Rahmi, W., Othman, M. S., & Yusuf, L. M. (2015). The role of social media for collaborative learning to improve academic performance of students and researchers in Malaysian higher education. *The International Review of Research in Open and Distributed Learning*, 16(4). https://doi.org/10.19173/irrodl.v16i4.2326

Anderson, L., & Krathwohl, D. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Addison Wesley Longman, Inc.

Anthonysamy, L., Koo, A. C., & Hew, S. H. (2020). Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning. *Education and Information Technologies,* 25, 2393-2414.

Antonelli, J., Jones, S., Burridge, A., & Hawkins, J. (2020). Understanding the Self-Regulated Learning Characteristics of First-Generation College Students. *Journal of College Student Development* 61(1), 67-83. doi:10.1353/csd.2020.0004.

Antunano, M., Resendiz, J., Cruz-Perez, M., Paredes-Garcia, & Diaz, J. (2022). Teachers' Perception in Selecting Virtual Learning Platforms: A Case of Mexican Higher Education during the COVID-19 Crisis. *Sustainability*, 14(1) , 195-200.https://doi.org/10.3390/su14010195

Arikunto, S. (2009). *Dasar-dasar Evaluasi Pendidikan (edisi revisi). [Fundamentals of Educational Evaluation (revised edition)]*.

Atmojo, S., Muhtarom, T., & Lukitoaji, B. (2020). The Level of Self-Regulated Learning and Self-Awareness in Science Learning in the COVID-19 Pandemic Era. *Indonesian Science Education Journal*, 512-520. https://doi.org/10.15294/jpii.v9i4.25544

Audrin, C., & Audrin, B. (2022). Key factors in digital literacy in learning and education: a systematic literature review using text mining. *Education and Information Technologies*, 1-15. https://doi.org/10.1007/s10639-021-10832-5

Blayone, T. J., Mykhailenko, O., vanOostveen, R., Grebeshkov, O., Hrebeshkova, O., & Vostryakov, O. (2018). Surveying digital competencies of university students and professors in Ukraine for fully online collaborative learning. *Technology, Pedagogy and Education*, 27(3), 279-296. https://doi.org/10.1080/1475939X.2017.1391871

Braten, I., Britt, M., Stromso, H., & Rouet, J. (2011). The role of epistemic beliefs in the comprehension of multiple expository texts. *Educational Psychologist,* 46(1), 48-70. https://doi.org/10.1080/00461520.2011.538647

Bulic, M., & Blazenvic, I. (2020). The Impact of Online Learning on Student Motivation in Science and Biology Classes. *Journal of Elementary Education,* 13(1), 73-87. https://doi.org/10.18690/rei.13.1.73-87.2020

Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples*. Luxembourg: Publications Office of the European Union.

http://publications.jrc.ec.europa.eu/repository/bitstream/JRC-106281/web-digcomp2.1pdf_(online).pdf
Cho, M. H., & Shen, D. (2013). Self-regulation in online learning. *Distance education*, 34(3), 290-301.
Choi, J. (2012). *Effects of mastery of auditory match-to-sample instruction on echoics, emergence of advanced listener literacy, and speaker as own listener cusps by elementary school students with ASD and ADHD*. Columbia University.
Cleary, T. (2018). *The Self-Regulated Learning Guide : Teaching Students to Think in the Language of Strategies*. Oxfordshire: Taylor & Francis.
Cleary, T., & Platten, P. (2013). Examining the Correspondence between Self-Regulated Learning and Academic Achievement: A Case Study. *Education Research International* , 1-19. https://doi.org/10.1155/2013/272560
DiBenedetto, M. (2018). *Connecting Self-regulated Learning and Performance with Instruction Across High School Content Areas*. Switzerland: Springer.
Dirkx, K., Camp, G., Kester, L., & Kirschner, P. (2019). Do secondary school students make use of effective study strategies when they study on their own. *Applied Cognitive Psychology*, 33(5) , 952-957. https://doi.org/10.1002/acp.3584
Efklides, A., Schwartz, B., & Brown, V. (2018). Motivation and affect in self-regulated learning: Does metacognition play a role? *In D. Schunk, & J. Greene, Handbook of self-regulation of learning and performance* (pp. 64-82). New York: Routledge/Taylor & Francis.
Emerson, R. (2017). Likert Scales. *Journal of Visual Impairment and Blindness*, 111(5), 488. https://doi.org/10.1177%2F0145482X1711100511
Engzell, P., Frey, A., & Verhagen, M. (2021). Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences of the United States of America*, 118 (17), 1-7. https://doi.org/10.1073/pnas.2022376118
Fullan, M., Quinn, J., & McEachen, J. (2017). *Deep Learning: Engage the World, Change the World*. New York: SAGE Publishing.
Giovanni, F., & Komariah, N. (2019). The Relationship Between Digital Literacy and Student Achievement at SMA Negeri 6 Bogor City. *Libraria*, 7(1), 147-162.
Greene, J., Plumley, R., C., U., Bernacki, M., Gates, K., Hogan, K., . . . Panter, A. (2019). Modeling temporal self-regulatory processing in a higher education biology course. *Learning and Instruction*, 72, 1-8. https://doi.org/10.1016/j.learninstruc.2019.04.002
Greene, J., Yu, S., & Dana, C. (2014). Measuring critical components of digital literacy and their relationships with learning. *Computers & Education,* 55-69. https://doi.org/10.1016/j.compedu.2014.03.008
Gunel, M., Hand, B., & McDermott, M. A. (2009). Writing for different audiences: Effects on high-school students' conceptual understanding of biology. *Learning and instruction*, 19(4), 354-367. https://doi.org/10.1016/j.learninstruc.2008.07.001
Hafiza, N., Rahayu, H., & Kahar, A. (2022). The Relationship Between Digital Literacy and Learning Outcomes in Biology Learning for Students. *Journal of Science Education Research*, 8(1), 171-176. https://doi.org/10.29303/jppipa.v8i1.1067
Hanif, S., Wijaya, A., & Winarno, N. (2019). Enhancing Students' Creativity through STEM Project-Based Learning. *Journal of Science Learning,* 2(2) , 50-57. https://doi.org/10.17509/jsl.v2i2.13271
Hanum, L. (2017). *Learning Planning*. Aceh: Syiah Kuala University Press.
Hermawanto, Kusairi, S., & Wartono. (2013). Effect of Blended Learning on Mastery of Physical Reasoning Concepts for Class X Students. *Indonesian Journal of Physics Education*, 9(1) , 67-76. https://doi.org/10.15294/jpfi.v9i1.2582
Hidayat, S. (2021). *The Relationship of Self-Regulated Learning with Biology Learning Outcomes for Class XI MIPA Riyadlul Ulum Integrated Senior High School*. Tasikmalaya: Siliwangi University.
Hillmayr, D., Ziernwald, L., Reinhold, F., Hofer, S., & Reiss, K. (2020). The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis. *Computers & Education,* 153 , 1-25. https://doi.org/10.1016/j.compedu.2020.103897
Jansen, R., Leeuwen, A., Janssen, J., Conijn, R., & Kester, L. (2020). Supporting learners' self-regulated learning in Massive Open Online Courses. *Computers & Education,* 146 , 1-17. https://doi.org/10.1016/j.compedu.2019.103771
Jensen, J., & Mark, M. (2014). Teaching to the Test or Testing to Teach: Exams Requiring Higher Order Thinking Skills Encourage Greater Conceptual Understanding. *Educational Psychology Review*, 26(2), 307-329. https://doi.org/10.1007/s10648-013-9248-9
Jin, K., Reichert, F., Cagasan, L., La Torre, J., & Law, N. (2020). Measuring digital literacy across three age cohorts: Exploring the dimensionality and performance differences. *Computers & Education* , 1-55. https://doi.org/10.1016/j.compedu.2020.103968
Kaminske, A. N., Kuepper-Tetzel, C. E., Nebel, C. L., Sumeracki, M. A., & Ryan, S. P. (2020). Transfer: a review for biology and the life sciences. *CBE—Life Sciences Education*, 19(3), es9. https://doi.org/10.1187/cbe.19-11-0227
Kitsantas, A., & Dabbagh, N. (2011). The role of Web 2.0 technologies in self-regulated learning. *New Directions for Teaching and Learning*, 126, 99-106. https://doi.org/10.1002/tl.448
Konicek-Moran, R., & Keeley, P. (2015). *Teaching for conceptual understanding in science*. Arlington: NSTA Press, National Science Teachers Association.
Lee, J., Moon, J., & Cho, B. (2015). The Mediating Role of Self-Regulation Between Digital Literacy and Learning Outcomes in the Digital Textbook for Middle School English. *Educational Technology International*, 16(1), 58-83.
Limniou, M., Varga-Atkins, T., Hands, C., & Elshamaa, M. (2021). Learning, student digital capabilities and academic performance over the COVID-19 pandemic. *Education Sciences*, 11(7) , 31-36. https://doi.org/10.3390/educsci11070361
Matraeva, A., Rybakova, M., Vinichenko, M., Oseev, A., & Ljapunova, N. (2020). Development of Creativity of Students in Higher Educational Institutions: Assessment of Students and Experts. *Universal Journal of Educational Research,* 8(1) , 8-16. https://doi.org/10.13189/ujer.2020.080102
Meyer, K. (2010). A comparison of Web 2.0 tools in a doctoral course. *Internet and Higher Education*,13(4) , 226-232. https://doi.org/10.1016/j.iheduc.2010.02.002
Ministry of Education and Culture. (2021, December 23). *Prototype Curriculum as an Option to Support Learning Recovery*. Ministry of Education, Culture, Research and Technology: https://www.kemdikbud.go.id/main/blog/2021/12/kurikulum-prototipe-as-opsi-support-pemulihan-pembelajaran
Muthupoltotage, U. P, & Gardner, L. (2018). Analysing the relationships between digital literacy and self-regulated learning of undergraduates—a preliminary investigation. *In Advances in information systems development: methods, tools and management* (pp. 1-16). Springer International Publishing.
Neuman, W. R. (2016). *The digital difference: Media technology and the theory of communication effects*. Harvard University Press.
Ng, M., & Abdullah, L. (2010). *Self-Regulated Learning: Theory and Application*. Penang: USM Publisher.
Nicholas, D., Huntington, P., Jamali, H., Rowlands, I., & Maggie, F. (2009). Student digital information-seeking behavior in context. *Journal of Documentation,* 65(1) , 106-132. https://doi.org/10.1108/00220410910926149
Nuckles, M., Roelle, J., Glogger-Frey, I., Waldeyer, J., & Renkl, A. (2020). The Self-Regulation-View in Writing-to-Learn : Using Journal Writing to Optimize Cognitive Load. *Educational Psychology Review,* 32 , 1089-1126. https://doi.org/10.1007/s10648-020-09541-1
Nygaard, L. C., Cook, A. E., & Namy, L. L. (2009). Sound to meaning correspondences facilitate word learning. *Cognition*, 112(1), 181-186.
Olga, M. (2018). Features of Creativity and Innovation Development in Students at Secondary and High School. *International Journal of Cognitive Research in Science, Engineering and Education*, 6(2) , 11-20. https://doi.org/10.5937/ijcrsee1802011M

O'Neill, G., & Murphy, F. (2010). *Assessment : Guide to Taxonomies of Learning*. Dublin: UCD Teaching and Learning.

Owens, C., Troy, S., Angela, B., & Smith-Walters, C. (2017). Student Motivation from and Resistance to Active Learning Rooted in Essential Science Practices. *Research in Science Education* , 1-25. https://doi.org/10.1007/s11165-017-9688-1

Perdana, I., & Misnawati. (2021). *Learning Evaluation*. Bogor: GUEPEDIA.

Piantola, M., Moreno, A., Matielo, H., Taschner, N., Cavalcante, R., Khan, S., & Ferreira, R. (2018). Adopt a Bacterium - an active and collaborative learning experience in microbiology based on social media. *Brazilian Journal of Microbiology*, 49(4) , 1-10. https://doi.org/10.1016/j.bjm.2018.04.005

Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1991). *A manual for the use of the motivated strategies for learning questionnaire* (MSLQ). http://files.eric.ed.gov/fulltext/ED338122.pdf

Prayitno. (2009). *Basic Theory and Practice of Education*. Jakarta: Grasindo.

Punch, K. (2003). *Survey Research : The Basics*. London: SAGE Publications.

Puspitasari, R., Miarsyah, M., & Rusdi, R. (2020). Flash Based Interactive Multimedia Development to Increasing Learning Outcomes of Participants in High School in Materials Excretory System. *International Journal for Educational and Vocational Studies*, 2(4) , 1-15. https://doi.org/10.29103/ijevs.v2i4.2530

Rahayu, S., Dewahrani, Y. R., Nurkhofiyya, A., & Ristanto, R. H. (2021, April). *Scaffolding self-regulated learning through Android-based mobile media on hormone system*. In AIP Conference Proceedings (Vol. 2331, No. 1, p. 050004). AIP Publishing LLC.

Reinke, N., Kynn, M., & Parkinson, A. (2019). Conceptual understanding of osmosis and diffusion by Australian first-year biology students. *International Journal of Innovation in Science and Mathematics Education*, 27(9), 17-33. https://doi.org/10.30722/IJISME.27.09.002

Rindah, M. A. K., Dwiastuti, S., & Rinanto, Y. (2019). Excretory system learning in senior high school: comparative analysis of students' problem solving skills. *Biosfer: Jurnal Pendidikan Biologi*, 12(2), 249-257. https://doi.org/10.21009/biosferjpb.v12n2.249-257

Ristanto, R., Rahayu, S., & Mutmainah, S. (2021). Conceptual Understanding of Excretory System: Implementing cooperative Integrated Reading and Composition Based on Scientific Approach. *Participatory Educational Research (PER),* 8(2), 28-47. http://dx.doi.org/10.17275/per.21.2.8.1

Rozgonjuk, D., Saat, K., & Taht, K. (2018). Problematic smartphone use, deep and surface approaches to learning, and social media use in lectures. *Journal of Environmental Public Health*, 15 , 92-100. https://doi.org/10.3390/ijerph15010092

Sa, M., Santos, A., Serpa, S., & Ferreira, C. (2021). Digital Literacy in Digital Society 5.0 : Some Challenges. *Academic Journal of Interdisciplinary Studies*. 10(1), 1-9. https://doi.org/10.36941/ajis-2021-0033

Sartono, N., Komala, R., & Dumayanti, H. (2016). Pengaruh Penerapan Model Reciprocal teaching Terintegrasi Mind Mapping terhadap Pemahaman Konsep Siswa pada Materi Filum Arthropoda. Biosfer : *Jurnal Pendidikan Biologi*, 9(1), 20-27. https://doi.org/10.21009/biosferjpb.9-1.4

Sebesta, A., & Speth, E. (2017). How Should I Study for the Exam? Self-Regulated Learning Strategies and Achievement in Introductory Biology. *CBE-Life Science Education*, 16(2), 1-12. https://doi.org/10.1187/cbe.16-09-0269

Shroff, R. H., Ting, F. S. T., & Lam, W. H. (2019). Development and validation of an instrument to measure students' perceptions of technology-enabled active learning. *Australasian Journal of Educational Technology*, 35(4).

Simarmata, J., Sihotang, J., Karim, A., Purba, R., Hazriani, Koibur, M., & Jamaludin. (2021). *Digital Literacy*. Medan: Our Writing Foundation.

Simorangkir, A., & Napitupulu, M. (2020). Analysis of Student Learning Difficulties in Human Excretory System Material. *Journal of Pelita Pendidikan,* 8(1). https://doi.org/10.24114/jpp.v8i1.11247

Sinatra, G. M., & Taasoobshirazi, G. (2017). The self-regulation of learning and conceptual change in science: Research, theory, and educational applications. *In Handbook of self-regulation of learning and performance (pp. 153-165).* New York: Routledge Taylor and Francis.

Stanton, J., Neider, X., Gallegos, I., & Clark, N. (2015). Dierences in metacognitive regulation in introductory biology students: when prompts are not enough. *CBE Life Science Education,* 14

Suryanda, A., Sartono, N., & Sa'diyah, H. (2019). Developing smartphone-based laboratory manual as a learning media. *Journal of Physics: Conference Series (p. 1402).* Bristol: IOP Publishing. https://doi.org/10.1088/1742-6596/1402/7/077077

Susanto, R., Rachmadtullah, R., & Rachbini, W. (2020). Technological and pedagogical models: Analysis of factors and measurement of learning outcomes in education. *Journal of Ethnic and Cultural Studies*, 7(2), 1-14.

Tang, C., & Chaw, L. (2016). Digital Literacy: A Prerequisite for Effective Learning in a Blended Learning Environment?. *Electronic Journal of e-Learning*, 14(1), 54-65.

Ting, Y. (2015). Tapping into students' digital literacy and designing negotiated learning to promote learner autonomy. The Internet and *Higher Education*, 26, 25-32. https://doi.org/10.1016/j.iheduc.2015.04.004

van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2020). Self-regulated learning sup port in flipped learning videos enhances learning outcomes. *Computers & Education*, 158, 104000.https://doi.org/10.1016/j.compedu.2020.104000

Wahyuni, A., & Suhendar. (2018). Achievement and response of students at favorite junior high schools in Sukabumi on trends in international mathematics and science study (timss) questions. *Biosphere: Journal of Biological Education*, 11(2) , 126-133. https://doi.org/10.21009/biosferjpb.v11n2.126-133

Wardyaningrum, A., & Suyanto, S. (2019). Improving Students' Conceptual Understanding of Biology through Quipper School. *Journal of Physics: Conference Series* 1233, 1-8. https://doi.org/10.1088/1742-6596/1233/1/012001

Weinstein, C., Palmer, D., & Acee, T. (2016). *Learning and Study Strategies Inventory (LASSI) User's Manual, Third Edition*. Texas: H&H Publishing Company, Inc.

Wong, J., Baars, M., Davis, D., Der Zee, T., Houben, G., & Paas, F. (2019). Supporting Self Regulated Learning in Online Learning Environments and MOOCs: A Systematic Review. *International Journal of Human-Computer Interaction,* 35(4) , 356-373. https://doi.org/10.1080/10447318.2018.1543084

Yoon, S., Sao, G., & Park, M. (2017). Teaching and Learning Aboit Complex Systems in K-12 Science Education: A Review of Empirical Studies 1995-2015. *Review of Educational Research* , 1-41. https://doi.org/10.3102%2F0034654317746090

Yu, Z. (2022). Sustaining Student Roles, Digital Literacy, Learning Achievements, and Motivation in Online Learning Environments during the COVID-19 Pandemic. *Sustainability*, 14(8) , 43-48. https://doi.org/10.3390/su14084388

Zimmerman, B. J. (2013). Theories of self-regulated learning and academic achievement: An overview and analysis. *Self-regulated learning and academic achievement,* 1-36. https://doi.org/10.1080/00461520.1998.9653292

Zimmerman, B., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, 23(4), 614-628. https://doi.org/10.3102%2F00028312023004614