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Students' ICT literacy and conceptual knowledge correlation: from a genetic course and a gender perspective

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ABSTRACT

The correlation between students' information communication technology (ICT) literacy and conceptual knowledge from a gender perspective is essential to understanding the causal effects of student learning. Therefore, this study aimed to describe the relationship between students' ICT literacy and conceptual knowledge in a genetics course, especially from a gender perspective. This study employed a descriptive research method that used randomized sampling. The instruments used were conceptual knowledge and ICT literacy test sheets. The data were analyzed by using analysis of variance (ANOVA) and Pearson correlational statistics. The results showed male students have higher ICT literacy than females. Otherwise, male students have a lower conceptual knowledge than females. Furthermore, male students' ICT literacy and conceptual knowledge showed a strong relationship, while female students showed a weak relationship. The findings support the idea that integrating ICT into genetics curricula might help students develop their ICT literacy and conceptual knowledge more effectively, especially female students.

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1. INTRODUCTION

The development of technology and information in this century has significant implications for the rapid development of genetics research. It generates new knowledge essential to health and well-being [1]. Bioinformatics studies and the integration of genetic data provide valuable information that significantly increases the efficiency of disease prevention and treatment efforts [2]. New experimental and analytical technologies have revolutionized the diagnosis of hereditary diseases [3]. Genetic engineering studies in agriculture have produced transgenic plants resistant to pathogens [4] and increased crop production [5]. However, this development has also generated controversy, particularly concerning genetically modified products. Scientists and the general public have different perceptions regarding genetically modified organisms' usefulness and safety [6]. Genetics is becoming increasingly crucial for all aspects of life [7], including the health and agricultural sectors [8].

The development of information related to genetics continues to increase. However, some research results indicate a need for more understanding of genetics [1]. Genetics is one of the biology courses students consider complicated [9]. Learning difficulties in genetics courses cause students' conceptual knowledge to be lower. A total of 45% students' conceptual knowledge is classified as very poor, and 11% are classified as

poor [10]. Efforts to improve student understanding and conceptual knowledge in genetics courses have been carried out in various ways, including inquiry-based learning [11] and project-based [12].

Inquiry-based and project-based learning are proven to increase students' understanding of genetics. The various efforts that have been made have yet to involve much information and communication technology (ICT) in learning. ICT can potentially increase student access and interaction with information resources [13]. The development of ICT makes it easy for students to get as much information about the development of genetics as possible. However, not all genetic information available on information sources (the Internet) can be verified. Therefore, students must have exceptional skills in correctly accessing and using information, known as ICT literacy.

ICT literacy is a student's ability to understand and utilize information and communication technology effectively and efficiently [14] in solving life problems based on information and knowledge obtained from the digital environment [15]. ICT literacy should be understood as a meta-competence that is not only related to technical knowledge but also to the individual's ability to use digital technologies to access, manage, integrate, evaluate, and create [16] and communicate information [14]. ICT literacy is critical to development because it is one of the essential goals of education in the 21st century [17], [18] and facilitates students to succeed academically [19]. These skills allow students to interact seamlessly with the learning network [20]. ICT literacy is also essential for students to compete globally in a knowledge society. Thus, ICT literacy has an essential role in education today.

Student ICT literacy can change over time and is influenced by various factors, one of which is gender [19]. Gender is an important variable to study to identify digital equality on campus and understand the right approach to conducting lectures. The study of gender differences related to the use of technology has long been a concern in education [21], as in the context of ICT use and experience [21]. The study was also concerned about computer self-efficacy [22] and their performance in carrying out ICT tasks [23]. Gender differences significantly affect students' ICT literacy [19]. However, it is still unclear how gender differences affect students' ICT literacy and student conceptual knowledge. In addition, studies have yet to be found on the relationship between ICT literacy and student conceptual knowledge. This information is essential for designing learning with gender equality. Therefore, this study aimed to determine the relationship between students' ICT literacy and conceptual knowledge in genetics courses, especially from a gender perspective.

2. RESEARCH METHOD

The quantitative descriptive approach was applied to this study. The research population consisted of students enrolled in genetics courses from the Department of Biology Education, Faculty of Teacher Training and Education, University of Sultan Ageng Tirtayasa, Indonesia. A random sampling strategy was used to select the research sample. The sample size was determined using the Slovin formula, with a 95% confidence level and a margin of error of 0.05. It acquired 85 samples from a population of 95 people [24]. ICT literacy test questions measured students' ICT literacy. Otherwise, the cognitive test questions measured student conceptual knowledge in the Genetics course. The knowledge dimension was used to construct the ICT literacy exam questions, which contained seven aspects: the capacity to identify information requirements and the ability to access, manage, integrate, assess, produce, and transmit information [25]. ICT literacy was measured using multiple-choice tests and open-ended questions/ essays with a distribution of questions, as shown in Table 1.

Cognitive test questions measured students' conceptual knowledge in genetics courses. The questions refer to learning achievement indicators and cover levels C1 to C6. The questions include knowledge of facts, concepts, principles, and procedures. The type of question used was an essay question. A Genetics lecturer from the Biology Education Department State University of Malang has validated the cognitive test questions. The questions have also been tested on a limited basis on students who have passed the Genetics course. The test questions proved valid and had a reliability value of 0.465, categorized as sufficient.

The measurement of ICT literacy results was then analyzed based on students' answers to the given test questions. The correct answer was given 1 point for multiple-choice questions, while the wrong answer was given 0 points. Answers to essay test questions are assessed based on scores that refer to the answer key. As for project questions, they are assessed using an assessment rubric based on predetermined indicators. The value of ICT literacy was obtained by comparing the scores obtained by students with the maximum score multiplied by 100. Student conceptual knowledge is assessed based on the answers to the test questions. The final score of ICT literacy and student conceptual knowledge was then interpreted based on the range of values into five criteria, namely excellent (score>80), good (70<score<80), sufficient (60<score<70), low (50<score<60), and very low (score<50).

Furthermore, the data obtained were analyzed for normality and homogeneity. The effects of gender differences on ICT literacy and student conceptual knowledge were analyzed using the analysis of variance (ANOVA) test. The relationship between ICT literacy and student conceptual knowledge was analyzed using the Pearson product moment correlation test [26]. Simple regression analysis was performed between ICT literacy and conceptual knowledge to determine the appropriate predictor of the effect of gender differences.

Table 1. Distribution of questions on each aspect of student's ICT literacy

No.	Skill aspect	Key indicators/ competencies	Question type
1	Skills determine information needs and ICT functions in life.	1.1 Able to state the problem formulation that underlies the information needs.	Alternative options
		1.2 Able to determine the actual and potential functions of ICT in life.	Alternative options
2	The ability to access information.	2.1 Able to determine how to collect or retrieve information from a digital environment (Internet)	Alternative options
		2.2 Able to sequence steps/strategies to obtain the required information.	Alternative options
		2.3 To determine the use/function of each feature of ICT/information sources.	Alternative options
		2.4 Able to choose the right source of information to obtain information.	Alternative options
3	Information management skills.	3.1 Able to convert information into appropriate visualization schemes.	Alternative options
		3.2 Determine the most efficient data/information structure for a particular purpose.	Alternative options
4	The capability to incorporate information.	4.1 Able to interpret information from digital sources.	Essay
		4.2 Able to summarize information from various sources to compare and make decisions.	Essay
		4.3 Able to conclude from information obtained from digital sources	Essay
		4.4 Able to compare information from various sources.	Essay
5	The ability to evaluate information.	5.1 Able to assess the quality of the information.	Essay
		5.2 To determine the relevance of the information obtained with a particular topic.	Essay
		5.3 Able to assess the accuracy of the information.	Essay
6	The capability to generate information.	6.1 Able to produce information products in the form of papers and PPTs by integrating information in the form of text, data, and images from the ICT environment	Project
		6.2 Able to produce information products in the form of videos by integrating information in the form of text, data, and images from the ICT environment	Project
7	The ability to communicate information.	7.1 Able to determine ICT features/devices that can be used to communicate information	Alternative options
		7.2 Able to communicate information in writing using blogs or posters	Essay
		7.3 Able to communicate information verbally by using video media	Project

3. RESULTS AND DISCUSSION

3.1. Student's ICT literacy

The student's ICT literacy showed an average score of 60.2, with the highest score of 76.2 and the lowest of 23.8. The average value of ICT literacy for male students is higher than for female students as presented in Table 2. The results of the ANOVA test showed a significant difference between the ICT literacy of male and female students, with a significance of 0.002. The research results show the same results of another study that there is an effect of gender differences on students' ICT literacy [27]. Male students are more interested in how technology works, whereas female students are more concerned with using technology. Male students are also more confident than female students when using information technology for studying [28]. Technology is a male-dominated practice, so they are more likely to use it and want to spend more time using it [29]. Female students prefer the Internet to boys, but male students use the Internet and computers more often [30]. The results of this study differ from reports by other researchers that the ICT literacy of female students is higher than that of male students [31]. Gender inequalities in ICT literacy were low at age 15, while substantial differences in favor of boys emerged at age 18. Gender inequalities in ICT confidence, on the other hand, benefited boys at 15 but did not improve subsequently [32].

Table 2. Mean scores and standard deviations of student's ICT literacy

Gender	Mean	Std. Deviation	N
Male	69.450	11.9292	12
Female	58.703	10.3790	73
Total	60.220	11.1867	85

Students' ICT literacy is in the good to unsatisfactory category. Most male students were in a need's improvement category, namely 50% of 85 students, while most female students were in a suitable category, namely 32% of 85 students as shown in Figure 1. The excellent category shows that students can answer about 71-79% of the ICT literacy test questions correctly, while the needs improvement category shows that students can only answer questions correctly, around 61-69%. The lack of mastery of ICT literacy of female students was caused by the learning process that was less than optimal in utilizing information and communication technology. In addition, lecturers need to initiate students to use the Internet to complete college assignments, so students' ICT literacy is less empowered. Therefore, ICT literacy should be an essential component of every educational program. Students' ICT literacy promoted by the availability and ease of access to digital devices within the University should be ensured through a high-speed and free Wi-Fi connection [33]. As the first step toward eliminating the barriers to fostering digital citizenship competence among Indonesian citizens, the government must implement policies to reduce the lack of digital access [34].

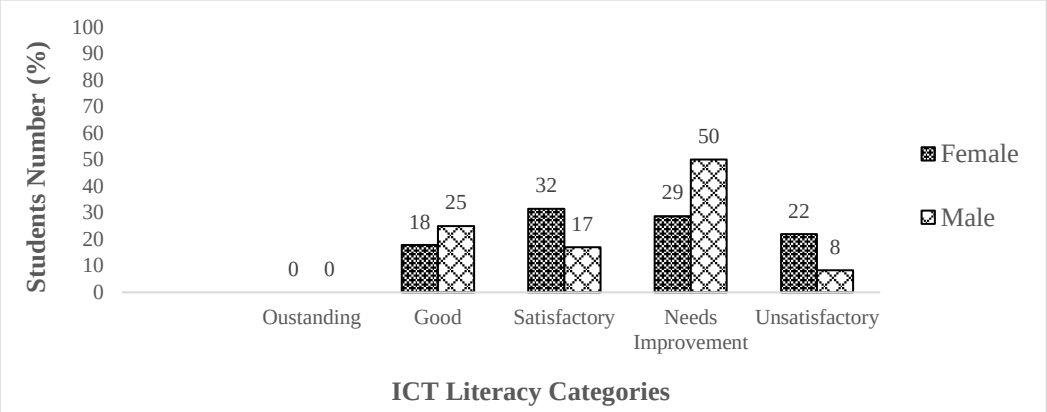

Figure 1. Distribution of student's ICT literacy in each category

ICT literacy includes five essential aspects: the ability to access, manage, integrate, evaluate, create, and communicate information by engaging the digital world [25]. In general, the ICT literacy of male students in all aspects showed higher scores than female students, except for communicating information as presented in Figure 2. Male students could better access, manage, integrate, and evaluate information, while female students could better communicate information. In this study, the communication aspect scored the highest for both male and female students, with 92 and 88. Communication skill refers to a person's understanding of communicating and exchanging information with others [35]. An example of this capability is using software to disseminate information or modify an information product to suit a specific audience or purpose [31].

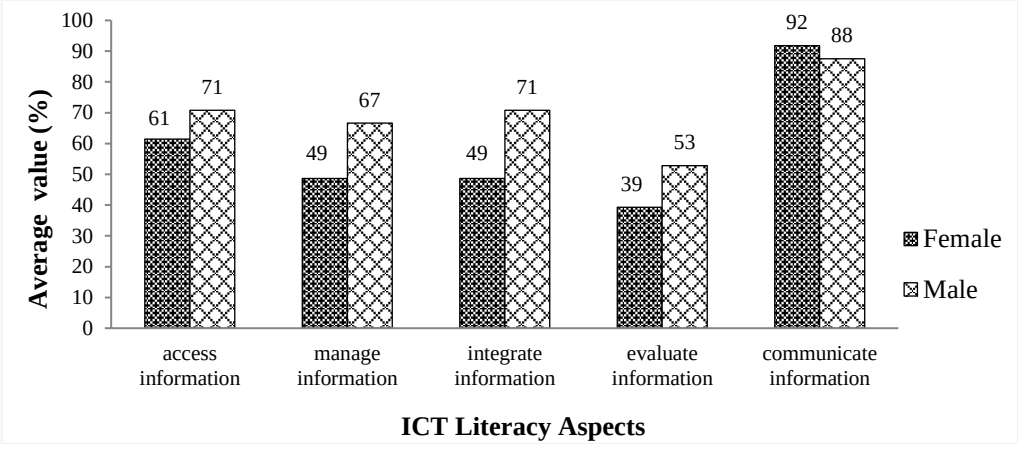

Figure 2. The average value of students in each aspect of ICT literacy

Evaluating information showed the lowest scores for male and female students, with 39 and 53, respectively. The evaluating aspect was the ability of students to make judgments about the quality, relevance, use, or efficiency of information. The low value of ICT literacy indicates that students need help to determine the suitability of the information obtained with the required information. Students need to be more able to provide an assessment of the truth of information. Students are less empowered to use the Internet to get information in lectures and assignments.

The results of the ICT questionnaire analysis show that only 36.4% of students are accustomed to using Google Scholar to access scientific articles. Furthermore, interview results show that lecturers do not initiate students to use the Internet, especially the Google Scholar site, through structured assignments. As a result, ICT literacy in this aspect is less empowered. Evaluating information is also the weakest aspect of Korean students' ICT literacy [31]. Accessing and assessing information is an investigative procedure that allows a person to locate, obtain, and assess information's relevance, integrity, and usefulness. Choosing information from a website is an example of a skill demonstrating a student's capabilities in this area [35].

3.2. Student's conceptual knowledge in genetics course

Students' conceptual knowledge in the Genetics course showed an average score of 71.2, with the highest score of 92.6 and the lowest score of 10.7. The average value of female students' conceptual knowledge (71.7) is higher than that of male students (68.2). The ANOVA test results showed that both scores were not significantly different with the asymp. sig value of 0.005. Regarding gender, this study does not show a significant relationship between gender and students' conceptual knowledge. Kintu *et al.* reported no significant difference between male and female student conceptual knowledge [26]. However, there have been no conclusive studies that show differences in the variables of gender and age [36].

The conceptual knowledge of female students is in the outstanding to needs improvement range, with the highest percentage being in the excellent category, namely 38% of 85 students, and no female students in the unsatisfactory category. While the conceptual knowledge of male students could have been more satisfactory, none were in a need's improvement category. The most significant percentage of male students' conceptual knowledge is in the outstanding and satisfactory category, with 33% of 85 students as shown in Figure 3. Students with good conceptual knowledge can answer most of the cognitive test questions correctly, around 61-69%, while students in the excellent category can answer cognitive test questions correctly, around 51-59%.

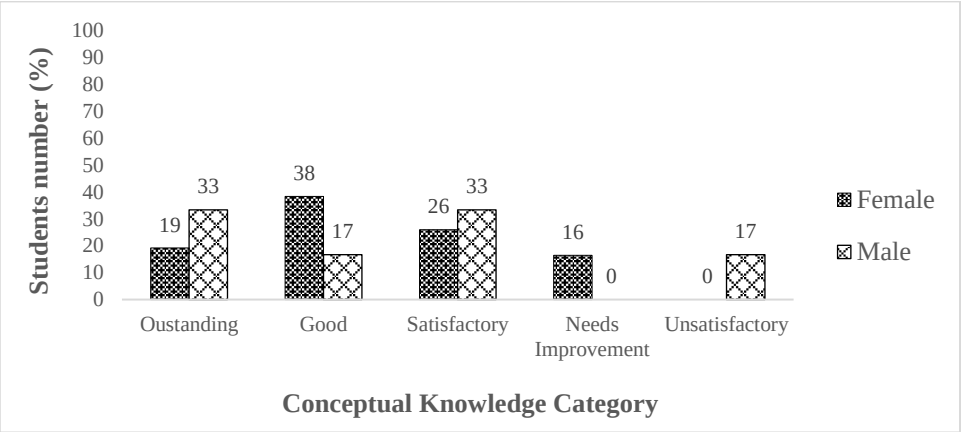

Figure 3. Distribution of student's conceptual knowledge in genetics subjects

Students' conceptual knowledge in the unsatisfactory categories indicates that students need help understanding the concept of genetics. Student's difficulties in Genetics are related to the complex character of genetics courses involving foreign terms and many mathematical calculations [37]. Unlike other branches of biology, genetics involves more mathematical formulas to calculate a cross's possible phenotypic and genotype ratios [38]. The concept of genetics is difficult because there are too many concepts to learn, and the object needs to be more abstract [39]. Student's difficulties in understanding the concept of genetics caused students to fail to store the information in their long-term memory or be unable to explore the information that has been stored. Therefore, students' conceptual knowledge is in the need's improvement category.

3.3. Relationship of student's ICT literacy and conceptual knowledge in genetics course

Male students' ICT literacy and conceptual knowledge showed a strong relationship with an R-value of 0.660 and a significance of 0.020. In contrast, female students showed a weak relationship with an R-value of 0.366 and a significance of 0.001 as shown in Table 3. The use of technology is significantly correlated with student conceptual knowledge. The ICT literacy possessed by male students contributes to their conceptual knowledge. ICT literacy positively affects student skills essential for successful learning [40]. Students with good ICT literacy have high conceptual knowledge [41]. Good ICT literacy supports student conceptual knowledge [42]. Students with good ICT literacy will be able to take advantage of digital resources in their independent learning to increase their learning abilities and conceptual knowledge.

ICT literacy affects how technology is used in learning [43]. ICT literacy allows students to find information on the Internet in completing assignments and projects from lecturers [44]. The Internet also motivates and provides students with an effective learning environment. The educational environment is surrounded by digital technology provides information as a content resource that is more accessible than traditional paper-based resources for learning [45]. Students' academic performance has improved due to the usage of ICT [35].

Table 3. Relationship between student's ICT literacy and conceptual knowledge

		Male students		Female students	
		Conceptual knowledge	ICT Literacy	Learning	Conceptual knowledge
Conceptual knowledge	Pearson correlation	1	0.660*	1	0.366**
	Sig. (2-tailed)		0.020		0.001
	N	12	12	73	73
ICT literacy	Pearson correlation	0.660*	1	0.366**	1
	Sig. (2-tailed)	0.020		0.001	
	N	12	12	73	73

*Correlation is significant at the 0.05 level (2-tailed)

Genetics lecture materials, especially molecular genetic material, are closely related to information technology. In discussing this material, students with high ICT literacy can be empowered by given assignments to search for literature through the Google Scholar search engine so that their ability to access information can be improved. The Internet can give students the information they need to learn [46]. Students can also understand DNA sequencing by accessing the NCBI website. ICT literacy allows students to benefit from technological resources and information ethically, safely, and environmentally responsibly [47]. Mastering digital information, or the capacity to access, interpret, assess, and use information efficiently and ethically to satisfy personal and academic requirements, is critical to students' learning processes [48]. In addition, students must also be facilitated to use various bioinformatics software related to genetic data analysis. So far, students have never used all software because practicum related to the use of software has never been done. As a result, students cannot answer all questions related to using software related to genetics.

4. CONCLUSION

This study shows that gender affects ICT literacy but does not affect student conceptual knowledge. Male students have higher ICT literacy than female students, but the conceptual knowledge of female students is higher than male students. The correlational test results show a close relationship between ICT literacy and the conceptual knowledge of male students, while female students show a weak relationship. In summary, gender stereotyping for ICT-related activities is a complex process, and many factors influence gender patterns in using ICT. The findings of this study have implications for the necessity of equalizing student ICT literacy through curricular integration and evaluating the impact of obtaining these abilities on overall academic attainment. Experiences that combine cognitive and technical learning can lead to ICT literacy. ICT literacy skills must be included in courses targeting cognitive, information technology-related, and technical abilities. Therefore, lecturers should be encouraged to integrate technology into lectures. According to the study's findings, public institutions should arrange various training, workshops, and seminars to improve students' enthusiasm for learning and practicing digital literacy while removing numerous barriers to learning and practicing digital literacy.

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