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The effect of ICT literacy on the pedagogical competence of physics teachers'

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Abstract: This study aims to determine the effect of ICT literacy on the pedagogic competence of high school physics teachers in North Maluku. This research is correlational quantitative research. The subjects in this study were 80 high school physics teachers with details of 60 female teachers and 20 male teachers. Data collection on ICT literacy and pedagogic competence of Physics teachers was carried out through tests using ICT literacy questions and pedagogical competencies of knowledge aspects. Furthermore, the research data were analyzed using a linear regression test with IBM SPSS 20 software. Based on the results of the study, it is known that the understanding of ICT literacy has a positive effect on the pedagogic competence of physics teachers in the aspect of knowledge. This can be seen from the coefficient value of the variable X of 0.614, which means the magnitude of the influence of X on Y is in a strong category because it has a percentage of 61.4%. The implication of the results of this study is one of the efforts to improve the pedagogic competence of teachers, namely by strengthening their ICT literacy, because the higher the ICT literacy of teachers, the higher their pedagogical competence.

Keywords*:* ICT Literacy, Pedagogical Competence, Quantitative Research

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Introduction

Currently, the world has entered the era of the 5.0 generation industrial revolution which is marked by increased connectivity, interaction and development of digital systems, as well as artificial and virtual intelligence. In this era, technological developments occur very rapidly and become an inseparable part of all aspects of life (Starkey, 2020). One of which is the advancement of Information and Communication Technology (ICT) which has a significant influence on the paradigm shift of learning in schools. In addition, the use of ICT also has a positive influence on scientific understanding (Li et al., 2020); Juggernath & Govender, 2020) and changes in overall attitude dimensions (Kursch, 2021). The role of the teacher in the era of ICT advancement is not easy because the teacher remains the main element in the entire learning process (Montenegro & Fernández, 2019). In this era, teachers are required to master and be able to adapt to new technologies and global challenges, so teachers are required to become professionals in their fields, continuously increase their potential, and update their knowledge according to the times (Garzón-Artacho et al., 2021; Pérez & Torelló, 2012). This is in line with the opinion that improving the quality of teachers is one of the keys to being able to follow the development of the Industrial Revolution 5.0.

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The challenges and opportunities of era 5.0 must be taken by educational units to adapt to various changes. They must be ready to assist students, who are millennials, in terms of pedagogy, digital skills, technological literacy, strengthening character education, and life skills. One of the determining factors for a country's success in facing the 5.0 industrial revolution is the quality of its educator resources (Yulianto, 2021; Rosa, 2020). Therefore, teachers must have high technological literacy (Hasse, 2017).

Technological literacy is the ability to use technology and information applications effectively and efficiently in various contexts such as in the academics and education worlds, learning and teaching, learning assessment, career, and everyday life. Teachers are required to be able to integrate ICT in their subject areas in order to provide educational and meaningful learning (Garzón-Artacho et al., 2021; Canbazoglu et al., 2016). Every teacher should know how to use technology, pedagogy and subject areas effectively in classroom learning so that students become more interested in the learning being carried out (Valtonen et al., 2021; Stanojević et al., 2018; Williams & Otrel-Cass, 2017), and can empower students to work more independently and reflectively (Rogers & Twidle, 2013).

However, the results of the study show that the ability of physics teachers to use and integrate technology into learning is still not maximized (Masrifah et al., 2019; Garba, 2014). The ability to integrate technology into the learning process is one of the pedagogical competency standards that teachers must possess. Pedagogical competence is the ability of teachers to manage learning optimally by applying strategies, models, and student-centered approaches supported by the appropriate use of ICT. Pedagogic competence is very influential on student learning outcomes (Panda, 2012), so this competence is very vital in its position for the continuity of the world of education. In addition to mastery of ICT, knowledge of pedagogical content is also an important part of pedagogical competencies that must be emphasized in teacher education (Mazibe et al., 2020; Coetzee et al., 2020). The teachers' quality and professionalism are the key to improving student learning outcomes and ensuring the quality of world education (Darling-Hammond, 2017; Hightower et al., 2011). Teachers with low technological literacy skills will affect the students' quality and outcomes of physics learning.

Teachers with good literacy skills will be able to maximize physics learning in the classroom (Conceição et al., 2021). Abstract Physics material will be understood better by students by learning using good visualization with technology. In addition, with a good teacher's technological literacy skills, students' critical thinking skills will increase (Hermann et al., 2016), students' cognitive and affective abilities will increase, and students' interests will be motivated. It also provides opportunities for students to explore Physics concepts comprehensively and equips students with basic 21st century skills to live today and in the future that are closely related to technology (Henukh & Astra, 2021; Hermann et al., 2016; Hatlevik & Hatlevik, 2018).

Research related to teacher pedagogic competence and ICT literacy is very important because it will have implications for improving the teacher quality which will ultimately have an impact on the education quality in the current industrial revolution era (Santos & Castro, 2021). In general, the results of previous research studies show that TPACK affects learning plan in the use of technology during learning (Heitink et al., 2016); (Koehler & Mishra, 2008) and professional digital teacher competencies which link technology skills, attitudes, and knowledge (Hämäläinen et al., 2021). The instrument used to assess ICT literacy in the pedagogical competence of teacher candidates is in the form of self-assessment of TPACK related to digital technology in the use of lesson plans (Schmid et al., 2021), as well as self-efficacy for prospective science teachers and prospective physics teachers about web PCK in the use of internet (Hiğde et al., 2014). The majority of previous studies took data in the form of self-assessment of prospective teachers, but the instruments used in this study were developed by adapting the dimensions of ICT literacy (Pernia, 2008). In addition, there are still very few studies that describe the influence of ICT literacy that teachers have on the pedagogic competence of high school physics teachers, especially in North Maluku. This is the novelty of this research, so research is very important. The purpose of this study is to describe the influence of ICT literacy that teachers have on the pedagogic competence of high school physics teachers in North Maluku in learning physics.

Methods

The type of research used is correlational quantitative research. This study involved 80 Physics teachers from 14 high schools in Ternate City with details of 60 female teachers and 20 male teachers. The subjects of this study were taken by probability sampling which provided equal opportunities for every teacher to become a member of the subject. The instrument used is in the form of ICT literacy test questions, totaling 20 multiple choice questions. The instrument is structured by adapting the dimensions of ICT literacy with indicators that include: (1) knowledge about technology, (2) knowledge about the use of ICT technology, and (3) attitudes that arise from critical reflection on technology use (Pernia, 2008). In addition, there are instruments in the form of pedagogic competency test questions in the knowledge aspect as many as 20 multiple choice questions which are arranged referring to the standard indicators of teacher pedagogic competence according to the Minister of National Education Number 16 of 2007. Indicators of questions include: (1) Understanding the characteristics of students, (2) Mastering learning theory and educational learning principles, (3) Developing curriculum, (4) Organizing educational learning, (5) Facilitating the development of students' potential to actualize their potential, (6) Carrying out assessments of learning processes and outcomes, (7) Utilizing the results of the assessment and evaluation for the benefit of learning, and (8) Taking reflective action to improve the quality of learning. Before being applied, the instrument was previously validated and tested for the reliability. Furthermore, ICT literacy data and teacher pedagogic competence data from the research results were analyzed using linear regression test to see the effect of ICT literacy variables on the pedagogic competence of physics teachers by IBM SPSS.20 software.

Results and Discussion

Data Description

Data on ICT literacy and pedagogic competence of physics teachers were obtained through test techniques using instruments in the form of ICT literacy test questions and teacher pedagogic competencies, each of which amounted to 20 multiple choice questions. These instruments were previously reviewed for validity and reliability. The results of the analysis show that both instruments are valid and reliable where the value of Cronbach's alpha in both namely 0.005 and 0.000, which is smaller than the 0.05 significance level. The written test was given to the physics teacher by collecting them at three different locations on the same day. The description of data from ICT literacy and pedagogic competence of physics teachers is presented in Table 1.

Table 1. Descriptive Statistics

	N	Min.	Max.	Sum	Mean	Std. Deviation
ICT	80	5	90	4565	57.06	17.855
Pedagogical	80	25	100	4675	58.44	17.166
Valid N (list wise)	80					

Data on ICT literacy and pedagogic competence of Physics teachers on each indicator are presented in Figure 1 and Figure 2.

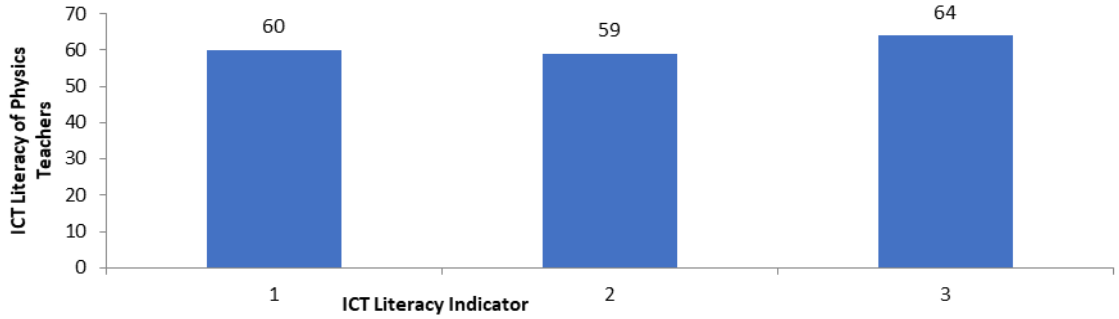

Figure 1. ICT Literacy of Physics Teachers on Each Indicator

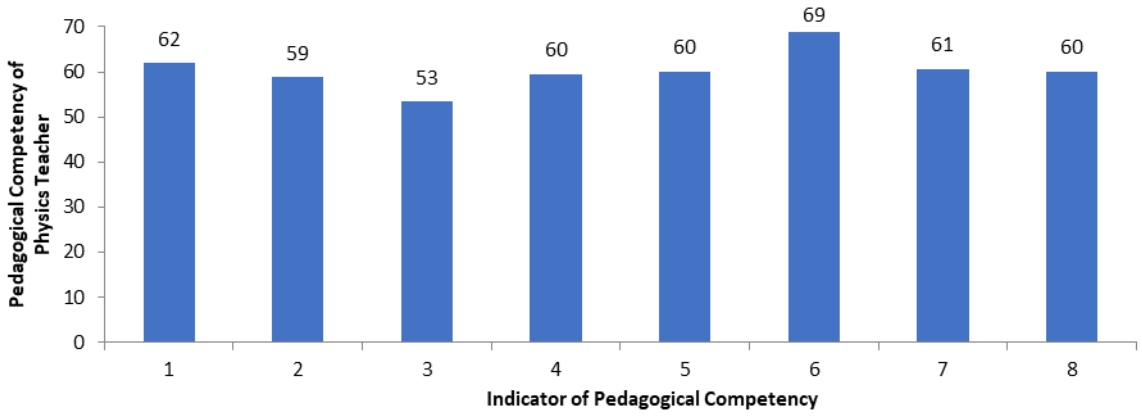

Figure 2. Pedagogical Competency of Physics Teacher on Each Indicator

Furthermore, before being analyzed using hypothesis testing, ICT literacy data and pedagogic competence were previously tested for prerequisites using normality tests and linearity tests. The results of the analysis of the normality test of the two data using the Shapiro Wilk test with a significance value of 0.116 and 0.130 which are greater than 0.05 so that the two data are said to be normally distributed. Meanwhile, from the results of the linearity test, F_{count} is 0.700 which is smaller than F_{table} (0.700 < 1.80), so it can be concluded that there is a linear relationship between ICT literacy and pedagogic competence of Physics teachers.

Based on hypothesis testing using simple linear regression, the data is obtained as shown in Table 2.

Table 2. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	26.076	5.253		4.964	0.000
	ICT Literacy	0.567	0.088	0.590	6.452	0.000

a. Dependent Variable: Pedagogical Competence

In Table 2, it is identified that the value of Constant (a) is 26.076, while the value of ICT literacy (b)/regression coefficient is 0.567, so the regression equation can be written as follows:

Y = a + bX
Y = 26,076 + 0,567 X

Based on the regression equation, the constant (a) value is 26.076, which means that the consistent value of the variable is 26.076. While the regression coefficient for ICT literacy of 0.567 states that for every 1% addition of the ICT literacy value, the value of pedagogic competence is 0.567. The regression coefficient for ICT literacy is positive, so it can be said that the direction of the effect of the ICT literacy variable on the pedagogic competence variable is positive. Improving teacher ICT literacy will have an impact on increasing the teacher's pedagogic competence.

While the results of hypothesis testing using simple linear regression resulted in a calculated F value of 41.622 with a significance level of 0.000 <0.05, so the regression model can be used to predict the pedagogical competence variable or there is an effect of the ICT literacy variable (X) on pedagogic competence (Y).

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.590[a]	0.348	0.340	13.95027

a. Predictors: (Constant), ICT Literacy

Table 3 shows the magnitude of the correlation/relation (R) value of 0.590 where the level of correlation between the independent variable (ICT literacy) and the dependent variable (pedagogic

competence) is in a fairly strong category. This can be seen from the R value of 0.590. From the output, the coefficient of determination (R Square) is 0.348 or 34.8%.

Furthermore, a t-test was conducted to see if there was a significant effect between the ICT literacy variable (X) on the pedagogic competence variable (Y). From the output data in table 2, it is seen that the t_{count} value is 6.452 and is greater than t_{table} 2,000. In addition, a significance value of 0.000 was also obtained, which was smaller than the specified significance value of 0.05. Based on these results, it can be concluded that there is a significant effect between the ICT literacy variable (X) on the pedagogic competence variable (Y).

Discussion

Basically, this study describes the effect of ICT literacy of physics teachers on teachers' pedagogical competence in the era of the industrial revolution 5.0, where technology-based learning is applied to teach the 21st century skills. Based on the ICT literacy data and the pedagogic competence of physics teachers in table 1, it is still found that some teachers have very low ICT literacy on indicators of knowledge related to the use of ICT (Figure 1). This is found in senior teachers who do not master ICT because they have never attended training or courses on the use of ICT. This is in accordance with the results of research which states that junior teachers have better technological literacy than senior teachers (Ertl et al., 2020; Hargittai et al., 2019). Meanwhile, we know that ICT integration is very necessary in physics learning to present abstract physics concepts in a more concrete way, making it easier for students to understand concepts. Understanding the concept of physics is not only to memorize it, because the concepts in physics need to be explained into various kinds of representations. The display of various representations can help students understand the concepts they are learning. This is related to the abilities possessed by each student, some are more prominent in their verbal abilities than their spatial and quantitative abilities, but some are the other way around. If a concept is presented in only one representation, it will only benefit some students (Nussifera et al., 2017), therefore, teachers must be able to use ICT to present physics concepts well.

According to Minister of National Education Regulations Number 16 of 2007 concerning standards of academic qualifications and teacher competence, teachers are required to be able to utilize ICT for the benefit of organizing educational development activities. Teachers whose daily tasks are mostly based on searching, processing, and sharing information, make these skills a core competency requirement of the teaching profession (Saikkonen & Kaarakainen, 2021). In addition, students who are faced today are more inclined and accustomed to using ICT. If teachers are not competent in utilizing existing technology, they will be left behind in this digital era (Briones, 2018). The main focus of teachers today is changing on instructional strategies to improve student achievement and how to teach 21st century skill standards which include technical, information, communication, collaboration, critical thinking, creative, and problem solving skills (van Laar et al., 2020).

On the other hand, low pedagogic competence was found in novice physics teachers who still lacked experience. The experience of teachers in teaching also affects their pedagogic competence. However, pedagogic competence is very important to improve the quality of education (Wiziack & dos Santos, 2021; Syahrial et al., 2019; Fernandez, 2015; Guerriero, 2013). The obstacles faced by novice teachers are related to the mastery of learning theories and the development of physics curriculum (Figure 2). Physics learning curriculum is very important in achieving learning objectives, especially in 21st century learning where physics learning does not only teach physics concepts, but must teach 21st century skills to answer the challenges of the industrial revolution 5.0. The physics learning curriculum must be adaptive to various challenges in the world of 21st century education and the demands of the industrial revolution 5.0. Therefore, the physics curriculum must be structured based on information technology, considering the integration of ICT in physics learning is a 21st century learning component that can improve inventive thinking skill, effective communication, and high productivity (Osman et al., 2013).

The importance of ICT literacy and pedagogic competence for teachers in teaching physics concepts, such as abstract dynamic electrical concepts related to the flow of electrons and the occurrence of electric currents in a circuit, makes teachers have to understand appropriate learning

strategies or models so that learning becomes active, creative, fun, enjoyable, and meaningful, since this electrical material is difficult for students to understand when using conventional learning methods. In addition to learning models, teachers need to use media that can provide a concrete picture of the material because students cannot see electricity directly. Students can only observe the effects caused by electricity. Teachers can use contextual teaching and learning (CTL) methods and PhET simulation media. The teacher first simulates the manufacture of series and parallel circuits using PhEt media. Next, the teacher asks students to open the PhET Interactive Simulations application and look for the Kit-Dc_Virtual Lab construction circuit. Next, students construct a series by selecting the electrical components available in the media. If the circuit is arranged correctly, the light turns on automatically and students can see the direction of the electric current flowing from the positive pole of the battery to the negative one.

In this series, students can remove one of the lamps and see that the electric current does not flow to the other lamp causing the lamp to go out. Next, students are asked to arrange a parallel electrical circuit and then observe the results. Students can remove one of the lamps in the circuit and, as a result, the other lamp remains lit. The use of PhET Simulations helps students understand science concepts visually. PhET media also simulates a fire in the event of a short circuit so that students also understand the dangers of electricity. By using CTL and PhET Simulation students can understand the concept of electricity better because they are more active and enthusiastic in the learning process.

The research findings also show that the coefficient of determination (R Square) is 0.348, which means that ICT literacy affects pedagogic competence by 34.8%. This is reinforced by the results of research which states that teacher ICT literacy affects teachers' pedagogic competence (Khan, 2014). In addition to ICT literacy, teacher pedagogic competence is also influenced by other factors by 65.2%, including the background and level of teacher education, teaching experience, training experience, motivation, facilities and infrastructure, and supervision of the principal. Principals through their policies play an important role in helping teachers integrate ICT into learning through their policies (AlAjmi, 2022).

Improving technological literacy and teacher pedagogic competence can be done through training activities (Garzón-Artacho et al., 2021), either by training and seminars on teaching methods or by training on the use of technology media and e-learning, workshops, and MGMP activities (Mahmud et al., 2010). Support from the government and industry to improve the pedagogic competence of teachers is important because the support and cooperation will acknowledge the school about the needs of the government and industry, so that schools can create an appropriate curriculum to meet the needs of stakeholders in the future (Ramdass & Masithulela, 2016).

The limitations of this study are ICT literacy and pedagogic competence which are measured only on the knowledge aspect because of the pandemic conditions that limit researchers in collecting data. Researchers are still experiencing difficulties in designing instruments to measure ICT literacy skills and teacher pedagogic competence online. The instrument used is only a written question that cannot measure aspects of the teacher's skills in the learning process in the classroom. The recommendations for future research is that the measurement of ICT literacy and pedagogic competence of physics teachers should not only be on the knowledge aspect, but also on the skills aspect in the learning process so that more comprehensive conclusions can be obtained. In addition, the technique used should not only be a test, but also need to be equipped with interviews, so that the more complete data can be obtained and data triangulation can be carried out.

Conclusion

Based on the results of data analysis using the SPSS 20.0 program, the correlation coefficient value (r) is 0.590, which means that there is a fairly strong effect between ICT literacy on teachers' pedagogic competence. Therefore, teachers are required to be able to integrate ICT in their subject areas in order to carry out educated and meaningful learning. Physics teachers who have adequate pedagogic competence will be able to create active and creative learning so that it has an impact on

improving student learning outcomes. Physics learning does not only teach physics concepts, but must be added with 21st century skills to answer the challenges of the industrial revolution 5.0. Thus, increasing teacher competence related to the use of ICT is very necessary to create 21st century professional teachers. Support from the government and industry to improve teacher pedagogic competence is also necessary so that schools can meet the needs of stakeholders.

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