



Measuring Science Teachers' Digital Teaching Competence in Rural Area, Keerom Regency of Papua

Nurbaya Nurbaya¹, Hanida Listiani¹, Suriyah Satar¹, Cartika Candra Ledoh²

¹Department of Biology Education, Faculty of Teacher Training and Education, Universitas Cenderawasih, Papua, Indonesia.

²Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Cenderawasih, Papua, Indonesia.

Received: September 18, 2024

Revised: November 29, 2024

Accepted: January 25, 2025

Published: January 31, 2025

Corresponding Author:

Nurbaya

nurbaya@fkip.uncen.ac.id

DOI: [10.29303/jppipa.v11i1.9859](https://doi.org/10.29303/jppipa.v11i1.9859)

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Abstract: The demand of ICT-based learning required teachers to adapt 21st century teaching skills. These skills are encompassed in Digital Teaching Competence (DTC) developed from DogCompEdu Framework. The aim of this paper is to measure the DTC of science teachers in Keerom Regency of Papua. This research is developed through a 22-items and completed by 23 science teachers, with quantitative study with a descriptive approach. There are six dimensions measured in this study (professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learner's digital competence. The main results of the study show the level of DTC stood at medium to high category. Teachers who are still relatively young have a higher average questionnaire score than the older teacher age group. For the female teachers, the scores are slightly higher than male teachers. Teaching experience did not determine the level of DTC, but instead the competence measured relevant to years of experience using ICT-based learning class.

Keywords: Digital teaching competence; Education; ICT; Papua

Introduction

Since the 21st century, the rapid advance of Information and Communication (ICT) has resulted some major changes in different sectors, such as communication, education, employment, economy, etc. (Bond et al., 2018; Cabero-Almenara et al., 2023; Infante-Moro et al., 2019). In the field of education, teachers are demanded to master technological skills to teach in an ICT-based environment in order to establish a flexible and interactive teaching-learning process in class as well as to develop digital competence of their students (Infante-Moro et al., 2019, 2022; Nurbaya, 2023; Vásquez Peñafiel et al., 2023). Not only the present-day teachers, but also the twenty-first-century higher education students need competences that allow them to keep up with new regulation of education system (Çebi & Reisoglu, 2020; Maderick et al., 2016). The growing recognition of ICT skill and digitalization verify the need of upgrading new learning theories, including

methodologies, material, resources to reestablish the conventional classroom to digital-based classroom that relevant to future professional performance as teachers (International Society for Technology Education., 2016; International Society for Technology Education, 2017; Nurbaya, 2024; OECD, 2015b, 2015a, 2018; Punie & Redecker, 2017). The society urge to well-trained teaching professionals with digital competence to integrate ICT into daily educational process (Cózar Gutiérrez et al., 2015; Guillén-Gámez et al., 2022; Tondeur et al., 2017).

Digital Teaching Competence (DTC) encompasses the skills of teaching, the ability to master ICT that contribute to solve pedagogical and professional problems in the context of being 21st century teachers (Esteve-Mon et al., 2020; Ilomäki & Lakkala, 2018; Nurbaya et al., 2024; Redecker, 2017; Tanta et al., 2023). DTC can also be interpreted as the specific knowledge of teaching, the abilities to collect information and to communicate using digital tools that help to resolve

How to Cite:

, N., Listiani, H., Satar, S., & Ledoh, C. C. (2025). Measuring Science Teachers' Digital Teaching Competence in Rural Area, Keerom Regency of Papua. *Jurnal Penelitian Pendidikan IPA*, 11(1), 282–290. <https://doi.org/10.29303/jppipa.v11i1.9859>

pedagogical and professional problems as teachers (Ghomi & Redecker, 2019). Digital Teaching Competence for teachers (DigCompEdu) was published by Punie et al. (2017) which include 6 areas of teachers' competencies in order to create an effective, comprehensive and innovative ICT-based learning strategies (Cabero-Almenara, Romero-Tena, et al., 2020; Cabero-Almenara & Palacios-Rodríguez, 2020; Redecker, 2017). The 6 differentiated areas of DTC that proposed by Punie et al. (2017) consisted of professional engagement, digital resources, teaching and learning (digital pedagogy), assessment (evaluation and feedback), empowering learners, and facilitating learner's digital competence. The number of research of DTC is increased based on the amount meta-analysis (Basilotta-Gómez-Pablos et al., 2022; Bilbao Aiausti et al., 2021). This paper used the six areas mentioned to measure DTC of science teachers in Papua.

In the world of education, the increasing dependence of technology by teachers is required the skills to integrate ICT in digital environment, which ensure the teaching-learning practices are easy to access, interactive, and help students to achieve their great potentials (Cabero-Almenara et al., 2023; Infante-Moro et al., 2022; Vásquez Peñafiel et al., 2023). This research conducted on science teachers in Papua, precisely in Keerom District. Science teachers have to master DTC to increase the quality of teaching-learning process. Located in urban area, near the border line with Papua New Guinea, the number of research related to digital competence of teachers is limited, in spite of the urgent of DTC acquisition. That is the main subjective of this research, that to measure the DTC of science teachers in Keerom District of Papua. For more specific, this research's objective is to analyze the degree of DTC of science teachers related to gender, age, and teaching experience.

Method

The study is defined as non-experimental and ex post facto, which is not manipulated the variable. This is a quantitative study with a descriptive approach. The central purpose of this study was to analyze the level of Digital Teaching Competence of teachers. The population of this research is all of science teachers in Keerom Regency, Papua. Convenience sampling was used to obtain data (Cabero-Almenara et al., 2023), with the instrument was sent to all science teachers via link (WhatsApp) during the month of April and June 2024. The number of respondents who completed the questionnaire were 23 science teachers, with 5 (21.73%) were male and 18 (78.26%) were female. In terms of age, there were 5 teachers (21.73%) between 25-30 years, 8

teachers (34.78%) between 30-39 years, 8 teachers (34.78%) between 40-49 years, and 2 teachers (8.69%) between 50-59 years.

The instrument used to analyze teachers' digital competence based on Digital Teaching Competence Framework by Cabero-Almenara et al. (2020). There are six areas of DTC's framework with 22 items (see Table 1): 1) professional engagement (items 01-04), 2) digital resources (items 05-07), 3) teaching and learning (items 08-11), 4) assessment (items 12-14), 5) empowering learners (items 15-17), and 6) facilitating learner's digital competence (items 18-22). The level of DTC category was identified using a five-point Likert scale from point 1 (very low) to point 5 (very high). Research Design can be seen in Figure 1.

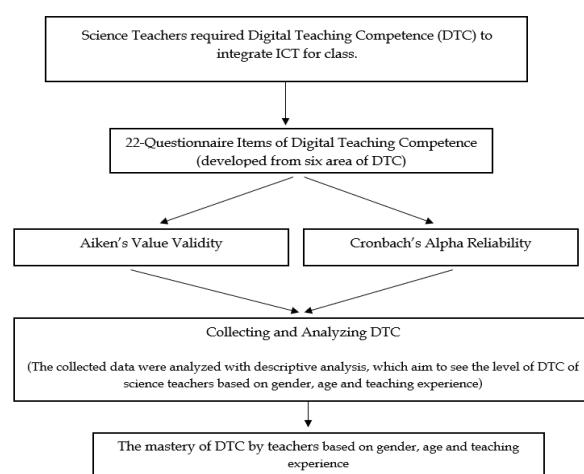


Figure 1. Research design

As for validity and reliability, the Aikens Value used to measure the validation of instrument and The Cronbach's Alpha statistic to identify can be used to gather research data (Bond et al., 2018). With the help of four-lecturers, the validation of instrument using the Aikens Value. According to Table 2, the 22-items measured are valid, which mean the instrument can be used as tools to collect data. With the help of IBM SPSS ver.22.0, the Cronbach's Alpha statistic conducted to calculate the reliability of questionnaires. There 20 prospective science teachers took part in this trial, which resulted all the items of instrument are high in reliability. The calculation of the Aikens Value and The Cronbach's Alpha statistic can be seen in Table 2.

The collected data were analyzed with descriptive analysis, which aim to see the level of DTC of science teachers (Cabero-Almenara et al., 2021; Guillen-Gamez et al., 2022; Guillén-Gámez et al., 2021). In the descriptive analysis, we will look at the level of digital competency mastery of science teachers in Keerom Regency, and analyze it based on gender, age and

teaching experience. Items and dimensions analysis will also be seen in the mastery of DTC by teachers.

Table 1. DTC Areas

Area	Items	Description
Professional Engagement	01, 02, 03, 04	Mastering digital technology used in teaching-learning process and the ability to communicate professionally with colleagues, students and all people connected to school community, which allow them to improve the quality of educational system.
Digital Resources	05, 06, 07	The ability of teacher to identify, adapt, design, share information based on student's need. This area also covers the ability to pay attention to author rights and licenses.
Teaching and Learning	08, 09, 10, 11	The implementation of teaching design using ICT tools in the class.
Assessment	12, 13, 14	The ability of teachers on using digital technologies to evaluate students with better analyze and methods.
Empowering Learners	15, 16, 17	Increasing students' collaboration work in learning activities based on individual interests and learning needs.
Facilitating Learner's Digital Competence	18, 19, 20, 21, 22	The competence to encourage and guide students on mastering the use of ICT in teaching-learning process.

Table 2. Result of The *Aiken's Value* and *Cronbatch's Alpha* Statistic

Area	Items	Aiken's Value	Cronbatch's Alpha for All Items	Description
Professional Engagement	01, 02, 03, 04	0.667-0.833	0.912	Valid and Reliable
Digital Resources	05, 06, 07	0.667-0.750		Valid and Reliable
Teaching and Learning	08, 09, 10, 11	0.667-0.833		Valid and Reliable
Assessment	12, 13, 14	0.583-0.750		Valid and Reliable
Empowering Learners	15, 16, 17	0.677-0.750		Valid and Reliable
Facilitating Learner's Digital Competence	18, 19, 20, 21, 22	0.667-0.750		Valid and Reliable

Result and Discussion

As the set of knowledge, competence, ability to access Information and Communication Technology (ICT), Digital Teaching Competence is linked to teaching profession, which can help the educators to deal with professional pedagogic problems (Cabero-Almenara, Gutiérrez-Castillo, et al., 2020; Carretero et al., 2017; Ghomi & Redecker, 2019). Descriptive and inferential analysis was carried out to discuss the DTC

questionnaire scores that were answered by the respondents. There are four parts of descriptive analysis that will be analyzed, namely analysis of Digital Teachers Competence by science teachers as a whole (Table 3), analysis of DTCs of science teachers based on age (Table 4), gender (Table 5) and teaching experience (Table 6). The score represents self-assessment of DTC mastery based on the 5 dimensions mentioned (professional engagement, digital resources, teaching and learning, assessment, empowering learners', and facilitating learners' digital competence).

Table 3. Descriptive Statistics (Means) of DTC

No	Items	Lowest	Highest	Mean
01	Using various types of digital tools to communicate (Gmail, WhatsApp, Telegram, ...).	2	5	3.74
02	Using digital tools for collaboration purposes (Zoom, Google Meet, Canva, Google Workspace, ...).	1	5	3.61
03	Upgrading my teaching ability.	1	4	3.35
04	Actively join online training course for teachers (Webinar, online courses...).	2	4	3.43
Professional Engagement				3.53
05	Using various online sites to search and select information needed.	3	4	3.65
06	Identifying my needs on digital information resource and modifying that already used before.	3	5	3.70
07	Protecting the safety of the document (exams, personal data, ...).	2	5	3.48
Digital Resources				3.60
08	Knowing the best timing to integrate ICT in classroom.	1	4	3.52
09	Keeping in track the student's interaction and collaboration in online environment.	1	4	3.17
10	Implementing digital use when students' working on group collaboration.	2	4	3.39

No	Items	Lowest	Highest	Mean
11	Integrate digital tools for student to track their work (self-assessment test, digital forums, blogs, ...).	1	5	3.26
Teaching and Learning				3.33
12	Implementing assessment on digital environment to track student's achievement.	1	5	3.13
13	Identifying students who need more assistances through their available data.	1	5	3.22
14	Providing effective feedback using digital tools.	1	4	3.04
Assessment				3.13
15	Considering the potential issues, the compatibility and the digital competence of students.	2	4	3.57
16	Implementing differentiative learning for students based on their potential needs.	1	4	3.26
17	Creating active and dynamic environment for student in classroom using digital technology.	2	4	3.39
Empowering Learners'				3.40
18	Teaching students the skill to analyze and to search information on internet	1	5	3.35
19	Demanding collaboration and communication while working on tasks	1	4	3.09
20	Giving task for student to create digital content such as audio-visual content, canva-presentation, LMS tasks, ...)	2	4	3.04
21	Teaching students the important of safety and ethics in online environment.	2	5	3.52
22	Encouraging students to optimize digital technology to overcome challenges in learning process.	2	5	3.70
Facilitating Learners' Digital Competence				3.33
Questionnaire for the study of Digital Teaching Competence (DTC) (Cabero-Almenara et al., 2023)				

Table 4. Teachers' Digital Competence According to Age

Area	Age			
	Between 25-29	Between 30-39	Between 40-49	Between 50-59
Professional Engagement	3.50±4.33	3.14±3.28	3.37±3.75	3.00±3.50
Digital Resources	3.83±4.17	3.14±3.71	3.25±3.62	3.00±3.50
Teaching and Learning	3.67±3.83	2.71±3.42	3.12±3.25	3.00±3.50
Assessment	3.67±3.83	2.57±2.71	2.87±3.00	3.00±3.50
Empowering Learners	3.67±3.83	2.85±3.42	3.25±3.62	2.00±3.50
Facilitating Learner's Digital Competence	3.17±4.17	2.71±3.42	3.12±3.62	3.00±3.50
Questionnaire for the study of Digital Teaching Competence (DTC)				

Table 5. Teachers' Digital Competence According to Gender

Area	Gender	
	Male	Female
Professional Engagement	3.00±3.40	3.40±3.83
Digital Resources	3.20±3.80	3.55±3.61
Teaching and Learning	2.80±3.40	3.22±3.55
Assessment	2.80±3.00	3.05±3.33
Empowering Learners	3.40±3.60	3.16±3.55
Facilitating Learner's Digital Competence	3.20±3.60	3.00±3.77
Questionnaire for the study of Digital Teaching Competence (DTC)		

Table 6. Teachers' Digital Competence According to Teaching Experience

Area	Teaching Experience		
	Between 1-9 Years	Between 10-19 Years	More Than 20 Years
Professional Engagement	3.50±4.25	3.08±3.41	3.00±3.67
Digital Resources	3.75±4.00	3.16±3.58	3.33±3.67
Teaching and Learning	3.25±4.00	3.00±3.16	3.00±3.66
Assessment	3.25±3.62	2.66±2.83	3.33±3.66
Empowering Learners	3.50±3.75	3.16±3.50	3.33±3.66
Facilitating Learner's Digital Competence	3.00±3.62	3.00±3.25	3.33±3.66
Questionnaire for the study of Digital Teaching Competence (DTC)			

Table 3 obtained shows the averages calculated of six areas of DTC. Professional Engagement are recognized with average of mean 3.53 (category 'high'),

the second highest mean of all six areas. This area included four indicators. Precisely, Item (01) scores the highest out of all 22-items in questionnaires, stood at 3.74

of average mean. This item indicated the ability of using various types of digital platforms to communicate (such as Gmail, WhatsApp, Telegram,...). As for items (02) and (03), the ability to use digital tools for working in group as well as improving the ability to teach have teachers at lowest score. Which means there are teachers who need training in using digital tools such as Zoom Meeting, Google Meet, Canva, and Google Workspace. Knowing these digital tools will not improve the DTC of teachers, they should also integrate this ICT tools in teaching-learning process.

The second dimension, Digital Resources, is at an average of 3.60 (category 'high'). This dimension is the dimension with the highest average among all DTC dimensions. The Digital Resources dimension measured the ability to use different websites to find information online (average mean 3.65) for item (05); the ability to find specific information and to modify the information used (average 3.70 – the second highest score out of 22 items) for item (06); and indicated the ability of teachers to protect such secret documents (exams, personal data, ...), with an average 3.48 for item (07).

The third area measured in this research is Teaching and Learning. The third area had an average 3.33 (indicated with 'medium' level). There are four items of Teaching and learning area. Item (08) specify the ability of teachers to integrate ICT in classroom based on needs, with a value of 3.52. The next item measured (09) is the ability of teachers to follow the student's interaction and collaboration while working in online environment, which have an average score 3.17. Item (10) covered the ability of teachers implementing digital tools while students working in group, with a value 3.39. And the last item (11) indicated the ability of teachers to track the student's work (self-assessment test, digital forums, blogs,...), with an average score 3.26.

Assessment was the fourth area measured in this research, which owned 3 items, with a value of all 3 items 3.13- the lowest score in paper (medium category). Item (12) covers the ability of teachers to implement digital assessment to follow up the students' achievement, which stood at a value 3.13. As for the ability of teachers to identify the students who need to improve their digital competence through data available, belonging to item (13) with an average of 3.22. The last item (14) in this area covers the ability of teachers to give learning feedback with technology, with a value of score 3.04- the lowest score out of 22-items measured.

The next area of DTC is Empowering Learners, which elaborate the competences in 3 indicators. The average score of the fifth area of DTC scored at the vicinity of 3.40 (medium level). Empowering Learners

covers the ability of teachers to identify potential issues as well as the state of students' digital competence (item 15), with a value of 3.57. Item (16) indicate the teacher's ability to implement differentiated learning for students, with an average score 3.26. As for the ability of teachers to create a ICT-based learning which active and dynamic for students (item 17), stood at average score 3.39.

The last area of DTC, facilitating learners' digital competence, indicate at medium level (with a value of items 18-22, 3.33). Item 18 covers the ability of teaching students the skill to find information on internet, with an average score 3.35. The skill of teachers to make the class that could work on groups (item 19), with a value 3.09- quite low at level of mastery DTC. Item (20) covers the ability of teachers to give students task creating digital content, with an average score 3.04. Item (21) covers the ability of teaching students the safety and ethics of using technology, with a value of 3.52. And the last item (22) measured the ability of teachers to encourage students using digital technology during their learning period, with an average score 3.70.

Digital Teaching Competence scores' average mean then analyzed with according to age. There four groups of ages based on Table 4 below, between 25-29 years, 30-39 years, 40-49 years, and 50-59 years. Based on the graph below, teachers who are aged 25-29 years have a higher average DTC than other age groups. In each dimension of DTC, the 25-29 years age group looks superior, with a mean score of 3.17-4.33 (medium to high category). Surprisingly, the group of teachers aged 30-39 years had a lower average mastery of DTC competencies compared to the older age group. Even for the dimensions of teaching and learning, assessment, empowering learners, and facilitating learner's digital competence, this group is indicated to be at a low level (with a value of 2.57). The group of teachers in the 40-49 years age range is at a DTC mastery level from medium to high (with an average score of all dimensions from 2.87 to 3.75). The oldest age group (between 50-59 years) is in the medium to high category. Overall, the table data shows that teachers who are still relatively young have a higher average questionnaire score than the older teacher age group. This indicates that young teachers are interacting more frequently with digital technology, making it easier for them to master ICT-based learning. In educational work, age is a significant factor for mastering the DTC (Cabero-Almenara, Barroso-Osuna, et al., 2021; Cabero-Almenara & Palacios-Rodríguez, 2020; Garzón-Artacho et al., 2020).

According to gender, DTC mastery by science teachers (Table 5), female science teachers have higher scores in all dimension (from 3.05 to 3.83 – medium to high level) than male teachers (from 2.80 to 3.80 – medium to high level), except for Empowering Learners.

The Fifth area indicated male teachers have better ability to identify the potential issues and digital competence of students. Male teachers also have better ability in implementation of differentiative learning based on analytic needs of students' potential. Male teachers also have better ability in inventing active and dynamic in digital environment learning. In this context, some research published stated that there is no consensus or agreement about gender and the level of mastery of digital competence (Cabero-Almenara & Palacios-Rodríguez, 2020; Guillén-Gámez & Mayorga-Fernández, 2020; Jackson et al., 2008). Based on study by Cai et al. (2017), 50 studies of meta-analysis according to gender and the use ICT, male have higher score than female. On the other hand, study by Siddiq et al. (2016), found that there was different score between 2 genders measured, but female scored higher.

Table 6 explains the mastery of DTC based on teaching experience. There are 3 groups, namely teaching experience between 1-9 years, 10-19 years, and more than 20 years. Based on the data that has been collected, the table analysis shows that science teachers who taught for a period of 1-9 years have a higher DTC score than the other two groups, with an average score from 3.00 to 4.25 (high category). For the group with more than 10 years of teaching experience, mastery was seen from 2.66 to 3.67 (indicated in low, medium and high categories). This may be influenced by the age of teachers who have less than 10 years of teaching experience, including young people and 'digital natives'. This is in line with the results in table 4 above, with teachers aged 25-29 years having higher mastery of DTC than the age group above. In other world, the older the teachers with high teaching experience tended to have lower ICT-skills profile than those of younger teachers, even with low teaching experience (Fernández-Cruz & Fernández-Díaz, 2016).

This work focused on measuring DTC of science teachers, located in rural areas, more specific in Keerom Regency of Papua. Ascertaining the self-perception of science teachers about their mastery of six dimension of DTC (namely, professional engagement, digital resources, teaching and learning, assessment, empowering learners, facilitating learner's digital competence). In this paper, there are variables that also be considered in mastery of DTC, such as gender, age, and years of teaching. Regarding on data table provided, the level of science teachers' DTC is stood at the level of medium-high. From the data that has been analyzed, science teachers' mastery of DTC still needs improvement, especially in the dimensions of teaching and learning and assessment. These two dimensions are the dimensions with the lowest mastery, approaching the low category. For DTC mastery based on age, of

course teachers aged between 25-29 years have better DTC mastery than the other three age groups. This in line with research by Russell et al. (2007) that teacher with younger age group have a higher category of digital competence. This because the teachers implemented ICT based learning such as used digital resources, used digital tools to communicate more often for educational goals (Guillen-Gamez & Mayorga-Fernández, 2022). This is because teachers under 30 years of age have a greater frequency of interaction with digital technology than those over 30 years. As for the second age group (between 30-39 years) have excelled by the age group between 40-49 and the age group between 50-59. Surprisingly, the last age group have higher score than the second group. It can be said that age was not related to teachers' DTC, this variable seems have no affect to teachers' ability to obtain high level digital competence (Cabero-Almenara et al., 2023).

In terms of DTC mastery based on gender, male science teachers have slightly lower mastery than female science teachers, with an average level from medium to high level. The results of this finding contradict the results of research which shows that male teachers have better mastery of digital competence (Dominguez Castillo et al., 2018). and mastery of ICT than women (Nedungadi et al., 2018). Research by Guillen Gamez et al. (2022) stated that the reason male teachers have higher level of digital mastery because ICTs were part of daily tools in teaching and learning. In stark contrast, Cabero-Almenara et al. (2023) have the same finding with this research, which indicated female teachers have high level of DTC. Female teachers surpassed male teachers in the following competence dimension: digital resources, teaching and learning, assessment, and facilitating learner's digital competence. In the area of professional engagement, it is the female teachers who score highest. As for the fifth dimension, male teachers are slightly higher than female teachers. With regard of the data provided, the last variable in this study confirmed that the level of DTC of science teachers did not determine by years of teaching experience, but instead relevant to years of experience using ICT in the class room for educational purposes (Cabero-Almenara, Barroso-Osuna, et al., 2021; Cabero-Almenara et al., 2023; Cabero-Almenara, Guillén-Gámez, et al., 2021; Ghomi & Redecker, 2019). Teachers with teaching experience between 1-9 years have higher DTC level than those who have become teacher more than 20 years. The result found that teachers' years of experience in using ICT during teaching-learning process will impact the increase teachers' ability in DTC.

Conclusion

DTC has a relevant role in educational world and as one of quality indicators of professional teachers. There are six areas of DTC's framework with 22 items (namely, professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learner's digital competence. In this research, the level of DTC of science teachers in Keerom Regency of Papua lead us to conclude that the scores indicated from medium to high category. Digital resources area along with professional engagement are two dimensions with the highest score. These two dimensions are the dimensions with the lowest mastery, approaching the low category. Science teachers' mastery of DTC still needs improvement, especially in the dimensions of teaching and learning and assessment. As expected, the younger age group of teachers have higher level of DTC. But surprisingly, teachers with age more than 50 years have better scored than those around 40s. It can be said that age was not related to teachers' DTC, this variable seems have no affect to teachers' ability to obtain high level digital competence. Female teachers also score higher than the males. As for teaching experience, the results found that teachers' years of experience in using ICT during teaching-learning process will impact the increase teachers' ability in DTC. The result of these research can be used by the government or other rearchers for planning the next digital training Science Teacher in Keerom Regency of Papua.

Acknowledgments

The author would like to thank all science teachers in Keerom Regency that helped in this research.

Author Contributions

N; methodology, validation, formal analysis, investigation, formal analysis, writing—original draft preparation, writing, H.L, S.S., C.C; review and editing, supervision, project administration. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest

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