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Digital Competence of Science Teachers at Jayapura City of Papua

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Abstract: The digital competence of science teachers is of vital significant to improving the quality teaching-learning process. The aim of this study is to know the level of digital competence of science teachers in Jayapura City. The methodology used was non-experimental and descriptive quantitative, with survey design. In such a context, 41 science teachers took part in this research, who were teaching in state junior high schools and private junior high schools. As for data collection tools, the study used 31-items of digital competence questionnaire, developed from 5 main areas of DigComp Framework (information and data literacy, communication and collaboration, digital content creation, safety, and problem solving). Based on data analyses, the digital competence of science teachers stood from high to very high level. Although the third and the fourth showed some indicator with the low ability in teachers' competence.

Keywords: Digital competence; ICT; Papua; Science teachers

Introduction

The world of education is faced with the increasing relevance of information and communication technology (ICT) which is integrated in the teaching and learning process (Çebi & Reisoğlu, 2020; Tondeur et al., 2017). Teachers are expected to be able to improve the quality of learning implementation dynamically by utilizing ICT (Guillén-Gámez et al., 2022). By increasing digital literacy by teachers, it will also facilitate students' mastery of technology (Ferrari, 2013; Siddiq et al., 2016; Siddiq & Scherer, 2016). Innovative use of ICT makes learning more accessible and provides greater opportunities for students to carry out collaborative activities (Heemskerk et al., 2011). The teacher's ability to integrate ICT in the teaching and learning process is the definition of digital competence (Fernández-Morante et al., 2023; Salcines-Talledo et al., 2020). In Indonesia, Digital Competency is better known as Digital Literacy, which is one of the 6 basic literacies that must be mastered in order to improve the world of education (namely: reading-writing literacy, numeracy literacy, scientific literacy, digital literacy, financial literacy, and cultural literacy) (Zaenab et al., 2020).

Digital competence in this research comes from the Framework for the Development and Understanding of Digital Competence in Europe (DigComp 1.0) by Ferrari, (2013), which was then developed in the Digital Competence Framework for Citizens in 2017 (DigComp 2.1) by Carretero et al. (2017). In Indonesia, digital competency is better known as Digital Literacy (one of the 6 Basic Literacies), while in Europe this skill is more familiar as Digital Competence (DigComp) (Ferrari, 2012, 2013). Digital competencies include information and data literacy, information assessment and management, communication and collaboration, digital content creation, digital media, knowledge of digital world security, problem solving, critical thinking and creativity (Carretero et al., 2017; Carretero et al., 2017; Ferrari, 2013; Ilomäki et al., 2016). To be more specific, this research will focus on 5 indicators of digital competence, namely information and data literacy, communication and collaboration, digital content creation, safety, and problem solving.

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The urgency of mastering significant digital competencies in this digital era is not balanced with comprehensive research. Research related to the digital competence of teachers in schools or prospective teachers in universities is still relatively small in number (Alarcón et al., 2020; Gutiérrez-Martín et al., 2022; Lázaro-Cantabrana et al., 2019). Several research results related to mastery of digital competency indicators by teachers range from low to high categories and are influenced by age, gender, teaching experience, place of teaching placement, and training undertaken before serving (Casillas Martín et al., 2020; Çebi & Reisoğlu, 2020; Hinojo-Lucena et al., 2019; Keskin & Yazar, 2015).

Digital competency is considered an indicator of educational quality in 21st century learning (Maderick et al., 2016; Napal Fraile et al., 2018). Natural Sciences (IPA) is a complex subject and requires not only environment as learning resources (Nurbaya et al., 2022), but also need an assistance of digital media visualization in its delivery (Kareem, 2018; Nurbaya et al., 2024; Parmin & Savitri, 2022; Tanta et al., 2023). This adds to the urgency of mastering digital competencies by Science (Science) Teachers in the learning process (Agbo, 2015). The integration of ICT in the teaching and learning process has implications for mastering digital competencies that are essential for teachers to master. Mastering digital competencies is important as an effort to provide more meaningful learning to students, especially for science subjects which require digital media in explaining the material. Research has been carried out by researchers regarding the competencies of Cenderawasih University Biology Education students who will later become Biology/Science teachers in junior high schools. The digital competency level of prospective teachers is at medium to very high level (Nurbaya, 2023). This research will focus on junior high school science teachers in Jayapura City, considering that the quantity of research related to digital competency is still limited. This then became the background for researchers in formulating the research problem 'Analysis of Digital Competence (Digital Competence) of Middle School Science Teachers in Jayapura City'.

Method

This research will be conducted on science teachers in state junior high schools and private junior high schools in Jayapura City. The research was carried out from April to June 2024. The research method used in this research was non-experimental and descriptive quantitative, using survey design (Lumsden, 2007; Rusydiyah et al., 2020; Supardi et al., 2021). The population in this study was all science teachers at state junior high schools and private junior high schools in the city of Jayapura totaling 50 people. The sampling technique was non-probability sampling with convenience sampling, with the results of the respondents being 41 science teachers spread across 26 state junior high schools and private junior high schools in Jayapura City.

Quantitative data in this research was obtained using a questionnaire with a Likert scale, ranging from the 'Strongly Disagree' category to the 'Strongly Agree' category, which contains 31-item statements related to five digital competency areas. The digital competency questionnaire that will be used in this research comes from an article written by Cebi et al. (2020), based on the DigComp 2.1 Framework by Carretero et al. (2017).

The results of the instrument validity test using the Aiken's Values technique, and the reliability test using the Cronbach's Alpha with the help of SPSS Ver.22.0 (Bond et al., 2018; Rusydiyah et al., 2020) can be seen in Table 2. Research questionnaires that have been tested for validity and its reliability will be shared with respondents. Results of the measurements of average score of science teacher digital competence were analyzed based on Table 3 (Riduan & Akdon, 2006; Rusydiyah et al., 2020).

Table 1. Digital Competence Areas

Area	Items	General Description
Information and Data Literacy	01-06	Searching, selecting, processing, evaluating, storing and organizing information.
Communication and Collaboration	07-11	Interacting and sharing information found, participate in online society, and collaborating using digital media.
Digital Content Creation	12-15	Developing and modifying digital content, applying the copyright and licences, and understand the program and software devices.
Safety	16-26	Protecting devices and personal data, avoiding health-risks using technology.
Problem Solving	27-31	Identifying technical problem, innovating and creatively using technology, upgrading digital-self competence.

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
Information and Data Literacy	01-06	0.500-0.833		Valid and Reliable
Communication and Collaboration	07-11	0.500-0.833		Valid and Reliable
Digital Content Creation	12-15	0.677-0.833	0.690	Valid and Reliable
Safety	16-26	0.583-0.833		Valid and Reliable
Problem Solving	27-31	0.583-0.750		Valid and Reliable

Table 3. Interpretation of Questionnaire Data

Interval	Criteria
4.3 < M < 5.0	Very high
3.5 < M < 4.2	High
2.7 < M < 3.4	Medium
1.9 < M < 2.6	Low
1.0 < M < 1.8	Very low

Result and Discussion

Descriptive analysis of the digital competence of science teachers in Jayapura in five areas, namely information and data literacy, communication and collaboration, digital content creation, safety and problem solving can be seen in Table 4.

Table 4. The Descriptive Analysis' Results of the Digital Competence of Science Teachers at Jayapura

Items	Lowest	Highest	Mean
01 I can explore the internet using various search engines (for example: Google, Bing, Yahoo, Baidu, etc.) to search for data, information and digital content related to science material	1	5	4.59
02 I can find the right keywords when using a search engine regarding the science material I need online.	3	5	4.49
03 I criticize and evaluate the accuracy of data, information and digital content related to science material that I access online.	2	5	4.10
04 I can access data, information and digital content related to science material online in the form of journals, scientific articles, e-books and various other literature.	3	5	4.37
05 I can investigate whether or not the source of data, information and digital content related to science material that I access online is reliable.	3	5	4.10
06 I pay attention to detailed sources and citations of data, information and digital content related to science material that I access online before sharing it with others.	2	5	4.17
Information and Data Literacy			4.30
07 I can easily organize and store data, information and digital content related to science materials that I access online.	3	5	4.34
08 I can use various digital platforms to communicate (example: Instagram, Facebook, Instagram, E-mail, WhatsApp, Telegram, WeChat, etc.).	2	5	4.63
09 I can share data, information and digital content related to science material that I access online via different digital devices (example: WhatsApp, Telegram, Instagram, Gdrive, Gmail).	2	5	4.51
10 I use digital technology to collaborate online (example: Zoom Meeting, Google Meet, Google Workspace, Slack, Canva, etc.).	2	5	4.46
11 I comply with the rules (ethics) when interacting online.	2	5	4.61
Communication and Collaboration			4.51
12 I can develop science content/learning materials with the help of digital technology (example: Canva, Flip Book, Kahoot, Google Classroom, etc.).	3	5	4.29
13 I can develop digital content related to science learning materials (in the form of videos, images, animations, etc.) via various platforms (example: WhatsApp, Telegram, Instagram, Gdrive, Gmail).	3	5	4.34
14 I can create digital content related to science learning materials by changing/editing slightly or changing the entire content.	1	5	4.02
15 I pay attention to copyright and licensing when developing digital content related to science learning materials.	2	5	4.29
Digital Content Creation			4.23
16 I know what to look out for when creating a digital identity (profile) online to avoid cybercrime (example: phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.).	2	5	4.29
17 I am aware that I will leave digital traces when navigating/searching online.	1	5	4.37
18 I am aware of online risks and threats (e.g. phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.).	2	5	4.32
19 I know how to protect my digital devices and content to avoid phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.	1	5	3.90
20 I can take precautions regarding safety and privacy online.	1	5	3.93
21 I can protect personal data and privacy online.	1	5	4.10
22 Regarding sharing personal data, I take precautions to protect other people's personal data (e.g. not tagging them in photos without permission, etc.).	3	5	4.44

Items	Lowest	Highest	Mean
23 I am aware of the impact of using digital technology on health both physically and psychologically.	2	5	4.61
24 I understand the data policies (how to use personal data) of various social media services.	1	5	4.27
25 I am aware of the environmental impact of using digital technology.	1	5	4.44
26 I know how to deal with online threats (examples: phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.).	2	5	4.02
Safety			4.24
27 I can identify the causes of technical problems that I encounter when using digital media and devices.	3	5	4.12
28 I can solve technical problems that I encounter when using digital media and devices.	1	5	4.12
29 I use various digital technologies to create innovative solutions.	1	5	4.32
30 I can identify opportunities for developing digital competence as a teacher.	3	5	4.34
31 I develop my digital competence by following the latest developments and trends.	3	5	4.46
Problem Solving			4.27

Questionnaire for Digital Competencies based on Carretero et al. (2017)

Information and Data Literacy

The first area of Digital Competence that is measured is information and data literacy which consists of 6 items. This paper uses indicators developed by Carretero et al. (2017). Information and data literacy refers to skills of browsing, searching, filtering, evaluating and managing data, information and digital content. This area along with communication and collaboration are the basic elementary areas of DigCom Framework (Hinojo-Lucena et al., 2019; López-Belmon et al., 2019; Keskin & Yazar, 2015). The results of the descriptive analysis show that this area has a mean of 4.30 and is in the very high category. Of the 6 items analyzed, the highest mean is item 01 (average 4.59) which is the ability to explore the internet using various search engines (for example: Google, Bing, Yahoo, Baidu, etc.) to search for data, information and digital content related to science materials. Despite having the highest average in this area, there was one respondent who chose a scale of '1' with the assumption that the teacher did not have the ability to explore search engines to find information related to science material. An interesting thing can also be seen in items 03 and 06, regarding the ability to criticize, evaluate, and pay attention to source and citation of information, there are 2 teachers who have a scale of '2' which indicates the ability in both items is at a low level. The ability to find the right keywords, to access data, and to investigate whether or not the information is related to science material (which includes items 02, 04, and 05), teachers seem to master at very high level.

Based on the data results in Table 4, science teachers' digital competence is seen a very high category. Similar studies by Casillas Martín et al.,(2020), Çebi et al. (2019), Gutiérrez-Porlán et al. (2016), Nurbaya (2024), Nurbaya (2023), Pieterse (2018), and Rusydiyah (2020) found that the informational and digital literacy of teachers and prospective teachers stood at very high category. Science teachers at Jayapura City have confidence in mastering the ability of exploring the internet, finding the right keywords, criticizing, investigating and paying attention the citation of data, information, and digital content. Jayapura City is one of the easternmost regions in Indonesia. Although far for the Capital City of Indonesia, Jayapura indicated as developed city compare to other cities in the eastern regions and the socio-demographic influenced the development of digital competence, which resulted the digital competence of science teacher in informational and data literacy at very high category (Cortina-Pérez et al., 2014; Aguaded-Gómez et al., 2015; Gui & Argentin, 2011). Integrating digital tools and ICT required competence such as Information and data literacy skills that will help teachers to perform effective, inclusive and innovative science materials in class (Durán Cuartero et al., 2019; Fernández-Morante et al., 2023; Punie & Redecker, 2017).

Communication and Collaboration

Communication and collaboration as the second competence show calculated mean of 4.51, by far the highest average level of all areas measured in this paper. This area consisted of 5 items (Carretero et al., 2017), which refers to ability in interacting through digital media, storing and sharing data and information using digital technologies, collaborating in online environment, and understanding of netiquette. For communication and collaboration skills, science teachers in the city of Jayapura are at the very high level. The ability to store data, information and digital content about science material on item 07 stood at average 4.34, with the lowest score at '3' Likert scale. As for items 08-11, the science teachers show very high ability, with average from 4.46 to 4.63, which is the highest average of all items analyzed. Teachers have very good understanding on using various digital platforms to communicate (example: Instagram, Facebook, Instagram, E-mail, WhatsApp, Telegram, WeChat, etc.). in terms of sharing data, information and digital content related to science material that I access online via

different digital devices (example: WhatsApp, Telegram, Instagram, Gdrive, Gmail), average teachers stood at very high level at the vicinity of 4.51. and the ability to use digital technology to collaborate online (example: Zoom Meeting, Google Meet, Google Workspace, Slack, Canva, etc.) as well as understand the ethics rules while interacting online also have a very high level. The frequently used of social application/software such as WhatsApp, Telegram, Instagram, Facebook gave high impact on communication skills (Guillén-Gámez et al., 2022; Lucas et al., 2021; Yunus et al., 2019).

There are numerous ICT tools that provide communication and collaboration skills to access these technologies, such as MOOCs tele-training platforms, intelligent tutorial systems, games, social networks, and virtual simulators (Callaghan et al., 2017; Cornellà Canals & Estebanell, 2018; Dumpit & Fernandez, 2017; González Pérez, 2018; Guzmán Duque & del Moral Pérez, 2018; Nurbaya, 2024b; Pedroza et al., 2018; Soler-Adillon et al., 2018; Suaka et al., 2023; Torres-Díaz et al., 2014; Vlachopoulos & Makri, 2017), therefore the second area is included as essential area of digital competence. Based on Table 4, science teachers scored at very high level, which indicate that the respondents master this competence and can apply the skills as a professional teacher. In the present study by Çebi et al. (2020), conducted to pre-service teachers in Turkey, the study showed the knowledge and skills have high category in the area of communication and collaboration. The reason of the high category achievement may be caused by the daily use of digital technologies in their daily lives. In line with the result, Papers by Infante-Moro (2019) and Guillen Gamez et al. (2022) stated that communication and collaboration skill found in high category.

Digital Content Creation

Digital Content Creation, developed by Carretero et al. (2017), consists of 4 items that encompasses skills in developing digital content, integrating and re-elaborating digital content, and paying attention to copyright and licenses. For the third area, the average for this competency was 4.23 (high category) slightly lower than the first two areas mentioned. This competency consists of 4 items. The lowest score of this area is '1' that shown on item 14, The item analyzed indicate that one respondent has a very low ability of creating digital content related to science learning materials by changing/editing slightly or changing the entire content (with average 4.02). Next item to mark is number 15, related to understand the copyright and license when developing digital content related to science learning materials. The lowest score of this item is '2', which indicate there is respondent that have low ability in terms of paying attention in copyright and license. As for the ability to develop science content/learning materials with the help of digital technology (example: Canva, Flip Book, Kahoot, Google Classroom, etc.) and the ability to develop digital content related to science learning materials (in the form of videos, images, animations, etc.) via various platforms (example: WhatsApp, Telegram, Instagram, Gdrive, Gmail), science teachers' competence stood at very good level. The implementation of the 'Merdeka Belajar' Curriculum requires teachers to use various digital tools in creating teaching materials (example: Canva, Flip Book, Kahoot, Google Classroom, etc.). Canva and Flip Book are the platforms most used by science teachers in Jayapura. This platform is considered the most effective in developing teaching materials. More specifically, the Canva platform provides free access to teachers who access it with a special email 'belajar.id'. This is of course widely used by teachers in integrating ICT in learning.

Based on Table 4, the average scores of science teachers indicate high category, although there are teachers who indicate themselves in low level of creating digital content. Study by Çebi et al. (2020) found the low mastering of skill due to lack on practicing and focused on theoretical knowledge only. Creating digital content also scored the lowest out of all areas measured in the study conducted by Hinojo-Lucena et al. (2019). The study stated that teaching experience and socio-demographic factor influenced the level achieved by teachers. Concerning prior studies, it can be seen that digital competence development affected by age, gender, branch, professional, teaching experience, and training (Çebi & Reisoğlu, 2020; Moreira-Fontán et al., 2019; Hinojo-Lucena et al., 2019; Moreira et al., 2019; Area-Moreira et al., 2016; Arrosagaray et al., 2019; Hatlevik et al., 2018). Regarding of age and teaching experience, Benali et al. (2018) stated that the more years of teaching experience the more likely for the teachers to have higher digital competence level. While other study by Lucas et al. (2021) indicate no such correlation between the level of digital competence and age/teaching experience.

Safety

Next area to elaborate is safety, which refers to ability of protecting devices, protecting personal data and privacy, protecting health and well-being, and protecting the environment (Carretero et al., 2017). Safety is the fourth area in the DigComp Framework that is measured, consisting of 11 items with a mean of 4.24 (at the high level). There are 6 items that have '1' Likert as the lowest score, which is items number 17, 19-21, 24 and 25. All of these items encompass the awareness of leaving digital traces when navigating/searching online; the ability to protect my digital devices and content to avoid phishing scams, hacking of personal

data, cyber stalking, cyber bullying, etc.; the ability to take precautions regarding safety and privacy online; the ability to protect personal data and privacy online; understand the data policies (how to use personal data) of various social media services; and the awareness of the environmental impact of using digital technology. Also noteworthy is the fact that items 19 and 20 have the lowest average of all 31 items (with a value 3.90 and 3.93 respectfully). Science teachers score average 4.44 (very high level) on item 22, which is related to take precautions to protect other people's personal data (e.g. not tagging other people in photos without permission, etc.). Regarding the awareness of online risks and threats (e.g. phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.) as well as the awareness of the impact of using digital technology on health both physically and psychologically, both items score at average 4.32 and 4.61 respectfully, indicate the very high level of competence. The last item on this area is talking about how to deal with online threats (examples: phishing scams, hacking of personal data, cyber stalking, cyber bullying, etc.). As for this item, the teachers have average score 4.02, indicated at high level.

As previously mentioned, the lowest average scores are found in safety items. The two-items refer to ability in protecting digital devices from phishing scams, hacking of personal data, cyber stalking, cyber bullying as well as the low ability to take precaution regarding on safety and privacy online. These results in line with study conducted by Gutiérrez Porlán et al. (2016), in theoretically the prospective teachers know privacy issue and the important of protecting personal data, but they lack of knowledge avoiding cyber stalking/bullying. In stark contrast, Çebi et al. (2020) and Napal Fraile et al. (2018) found a positive result of safety area. The respondents of research seem to understand avoiding cyber bullying by not to leave negative comments, understand the dangerous of spreading personal data on social media, as well as understand protection of health and environment as part of teachers' duty.

Problem Solving

The final area measured in the digital competence of science teachers in Jayapura is Problem Solving, that encompass skill on solving technical problems, identifying needs and technological responses, creativity in using digital tools, and identifying digital competence gaps (Carretero et al., 2017). This area has 5 items, with a mean of 4.27 (indicated at high level of competence). Item 28 and 29, which relate to ability to solve technical problems while using digital media and devices and use various digital technologies to create innovative solutions, has average 4.12 (indicated high level) and 4.32 (indicated very high level) respectfully, with the lowest score of both items '1'. The science teachers have 'good' level category on identifying the causes of technical problems when using digital media and devices, with average 4.12, with the lowest score '3'. The last two items, item 30 about the ability identify opportunities for developing digital competence as a teacher and item 31 about developing digital competence by following the latest developments and trends, have very high level with average from 4.34 to 4.46. it was determined that science teacher problem solving competence, based on Table 4, have high level category.

In line with this study, Gutiérrez Porlán et al. (2016) found that students teachers at Muricia University have high level in problem solving area. Student teachers seem understand the use of their devices and technology tools to solve their daily routine activities. The same result found in the study conducted by Cabezas-González et al. (2022). This paper shows high level of the fifth area of DigComp, indicate that respondents can maximize better use of digital tools in academic purpose. On the other hand, some studies indicated problem solving competence from low to medium criteria (Çebi & Reisoğlu, 2019; Esteve-Mon et al., 2020; Margaryan et al., 2011; Napal Fraile et al., 2018; Ng, 2012; Nurbaya, 2024a; Thompson, 2015), the participants of these research know theoretically the function of digital tools, but they don't know how to use them as innovation to solve their academic problem. There are some factors that influence the development of digital competence, such us frequently use of digital application in order to complete tasks, characteristic of the family unit, owning digital tools, gender, age, access to internet, as well as reading habits (Almerich et al., 2018; Cabezas-González et al., 2022; Chaudron et al., 2018; García-Martín & Cantón-Mayo, 2019; Marsh et al., 2017; Montenegro et al., 2020).

Conclusion

This study illustrates the level of digital competence of science teachers at Jayapura City, more specifically focusing on five areas on DigComp (namely: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving). In general, the results of descriptive analysis of data in the five areas show that science teachers have abilities from high to very high level, although some teachers indicated with low level in mastering the areas of DigComp. Teacher learning activities cannot be separated from integrating digital technologies in order to develop the quality and to become a good example for students in using ICT. It is important to take note of the limitation for this research that the descriptive character of variable, in future

studies it would be practical to include deep analyzes of factors that influence the development of digital competence. Lastly, following the future works, the extension of sample not only form Jayapura City but also other regions, as well as not limited to Teachers but prospective teachers at university.

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

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Conflicts of Interest
The authors declare no conflict of interest.

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