

Pilot Study of Digital Competency Mapping of Indonesian Preservice Teachers: Rasch Model Analysis

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Abstract

Typically, biology students pursue natural sciences. As the world becomes increasingly interconnected and reliant on digital technologies and platforms, it is essential to evaluate their technological preparedness. This study aims to validate a mapping instrument of the digital competence of pre-service Biology teachers in a leading private university in Indonesia. The analysis used the Rasch model to measure the validity and reliability of questionnaire instrument utilizing the Logit Value of Item (LVI). The Digital competency (Digcom) questionnaire contains 36 statements in the Indonesian language (Bahasa). This questionnaire aims to record respondents' answers to digital skills for preservice teachers. The statement is adapted from the digital competence area for EU citizens combined with the Digital Literacy guidelines of the Indonesian Ministry of Communication and Information. The result of the retranslation has been validated to remove the ambiguity of each item of the statement by English language experts. The pilot research was conducted on preservice teachers from different backgrounds (gender, department, and year of study) in a private University (n=261). The findings indicated that all the items were deemed acceptable as they met the criteria for the PTMEA-CORR range, MNSQ outfit, and ZSTD outfit. This study is among the few that have explored the digital competency framework of preservice teacher students in Indonesia, specifically in relation to the difficulty level of each competency area.

Keywords: competency mapping, digital competency, educational technology, innovative approach, preservice teachers, rasch analysis, science education

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1. Introduction

The era of the Industrial revolution 4.0 is disrupting various sectors to respond and adapt to the various changes and demands (Rhenald, 2017). Coupled with the plague of the COVID-19 pandemic, which has further accelerated digitization in various aspects of life (Iivari et al., 2020; Awaludin et al.,

2023), including in the field of Education. The education curriculum is expected to adapt flexibly in line with the disruption of digital technology needs. This rapid change is ultimately the background for forming the independent learning program. It encourages every university to organize Education more

autonomously and flexibly according to the needs of students (Fuadi et al., 2021).

The world of Education should implement the need to understand the digital system in this era, including higher Education (Varga & Egervári, 2014), in a comprehensive-adaptive curriculum (Dutt et al., 2020). The curriculum must contain literacy aspects needed in the digital era 4.0, namely data literacy, technological literacy, and human literacy (UNESCO, 2018). The implementation of curriculum development is intended to guide the achievement of the profile of higher education graduates with future-oriented competencies and ensure suitability for present and future challenges (Falloon, 2020).

Digital competence is the latest concept that describes digital technology skills (Cabero-Almenara et al., 2020), such as skills in utilizing information technology, information and digital literacy, and 21st-century skills (Ghomi & Redecker, 2019). According to the European Union Commission, this digital competence is essential and is recognized as one of the eight main competencies for life and activities (Kuzminska et al., 2018). Digital competence is more comprehensive than just digital skills. Digital competence includes cognitive abilities related to knowledge and Education (content knowledge) as well as technical aspects related to the ability to manage hardware and software (Voogt et al., 2013). In the light of post Covid-19 pandemic, the need for digital competence in the world of Education has become increasingly urgent. The world of Education significantly impacts the need for competent teaching staff in digital skills and the community's need for teachers who understand the character of the digital native generation (alpha generation) in the 21st century (Fadlurrohm et al., 2019). Therefore, simultaneous steps are needed to explore,

observe, map, and take concrete steps in preparing digitally competent preservice teachers. This study is a preliminary step (pilot study) to observing and mapping the digital competencies of student-teacher candidates in Indonesia before developing a framework and curriculum to implement digital competency learning.

Educational technology is developing very rapidly. The competence and quality of teachers in the 21st century and the technology used during the Covid-19 pandemic affect human behavior and affect how to teach, adapt, and get student engagement (Awaludin et al., 2023). Educating more qualified or digitally competent teachers is very necessary.

The requirements for digitally proficient instructors have grown along with the growing digitalization of society, requiring new approaches or methods in terms of technology integration in Education, especially during this pandemic. Teacher education is considered the place to start this integration of nature and what teachers need. However, recent studies show an apparent gap between the digital needs of qualified teachers and their qualifications (Amhag et al., 2019). The research shows that teachers need access to many things, such as equipment access, a job, and a good attitude toward technology, to achieve technology integration and have digital proficiency (Kay, 2006).

Today, information and communication technology come together and impact our daily lives. Competence in information and communication technologies or digital skills is an important prerequisite for teachers to engage in active social engagement (Gudmundsdottir & Hatlevik, 2018). The development of technology and more excellent ICT resources, especially during the Covid-19 pandemic, has also influenced and will continue to change the traditional ways of

learning and working. The government has implemented many policy measures over the previous decade according to the times to address the problems resulting from one transition to the next. For example, steps have been put in place to make ICT materials and resources accessible, to help instructors integrate ICT into their schools, and to promote that these digital competencies are essential as part of a later national school curriculum (Tondeur et al., 2017). Table 1 elaborate the general description of DigCom areas.

Research related to educating teachers to be digitally competent has been conducted by Elen J. Instefjord et al. (2017). The research's primary goal is to integrate digital professional knowledge into early or basic teacher education programs (Instefjord & Munthe, 2017). A survey was conducted, and data from three national surveys were analyzed: teacher teachers, mentor teachers, and preservice teachers in Norway. This study reveals a weak positive relationship between positive management, development support for management, and teacher educator digital competence but a stronger positive correlation between self-reported effectiveness and teacher educator digital competence. The results of the teacher education function in qualifications in the digital classroom are examined.

The study has limitations, especially in the variation of responses from higher education institutions (HEIs). The research carried out an analysis related to multiple responses from the incoming responses, including investigating the influence of workplace supporting variables on the learning technology

used. Strengths This research addresses the multidimensional concept of professional digital competence, which can be used as a reference in the future (E. J. Instefjord and E. Munthe, 2017). In addition, the table presented reflects the expected relationship between the variables, which indicates construct validity. This study also highlights the need to examine how workplace support for HEIs can affect the integration of digital competencies among teacher educators. There is a need to look more closely and detail how and where digital competencies for preservice teachers are developed and can also be explored (E. J. Instefjord and E. Munthe, 2017). The validation scheme and development flow of the instrument is shown in the Figure 1.

It is of tremendous importance to develop accurate instruments for digital testing skills. That is why Steffen's research has reassessed the measurement quality of the evaluation tool D21-Digital-Index. The D21-DigitalIndex is a two-year, prominent German research project. The DigComp is the theoretical basis for the instrument used in the D21 surveys (Wild & Schulze Heuling, 2021). Data from 1142 participants in the research analyzed from vocational and higher education establishments were utilized to estimate item parameters and the quality of the Item Response theory. Since selecting a suitable Item-Response- Theory (IRT-model) is critical for instrument assessment, two models were calculated and compared. The IRT model is a reference for measuring digital capabilities in the D21 survey (Wild & Schulze Heuling, 2021).

Table 1. The Competency Areas of Digital Competency (Røkenes & Krumsvik, 2014)

Areas	General description
Data and Information Literacy	Locate and catalog any pertinent information and digital assets. Filtering, analysis, evaluation, interpretation, organization, and storage are all possible with digital information, data, and material.
Communication and Collaboration	Use digital tools to collaborate and share files, information, and data. Participate in online communities using a variety of public and private digital services; demonstrate an understanding of digital-related social norms; create and manage distinct online personas.
Digital content creation	Collaborate digitally with others and exchange relevant data, files, and other resources. Use both societal and private digital resources for communication and participation; learn and apply digitally related social norms; create and manage many online personas
Safety	Understand the potential for harm when using digital technology, take precautions to protect yourself from harm (both psychologically and physically), and be conscious of the effects your actions may have on the natural world.
Problem-solving	Employ digital tools to identify and rectify issues. This innovative approach involves leveraging digital technologies to produce goods and data. It is crucial to assess and elevate the demand for digital proficiency.

This research uses several IRT modeling methodologies to review the D21 Digital Index evaluation tool (S. Wild and L. Schulze Heuling, 2021). The analysis produces robust results with a sample size of more than 1,000 participants and shows fine measurement quality: Local independence was virtually always supported (Q1). The 2 PL-Birnbaum models have also shown that it fits better with the data than the 1 PL-Rasch model (Q2 and Q4). The level of discrimination and difficulty (Q3) often gave good results (S. Wild & L. Schulze Heuling, 2021). The data-gathering approach involves in-depth interviews with 30 in-service high school science teachers. This study showed the ins-

tructors' perception of their position and involvement in the digital revolution in three major categories: 1) non-observers, 2) careful participants, 3) conscientious participants. The research presents an extensive examination by examining the findings from structural and content analysis of the worldview of secondary school science instructors on the digital revolution. In this survey, 19 participants' opinions on the digital world are cautious people, eight are awareness-raising people, and only three have an external observation category. These findings imply that digital teachers analyze and rebuild their ideas about the world (Tsybulsky & Levin, 2019).

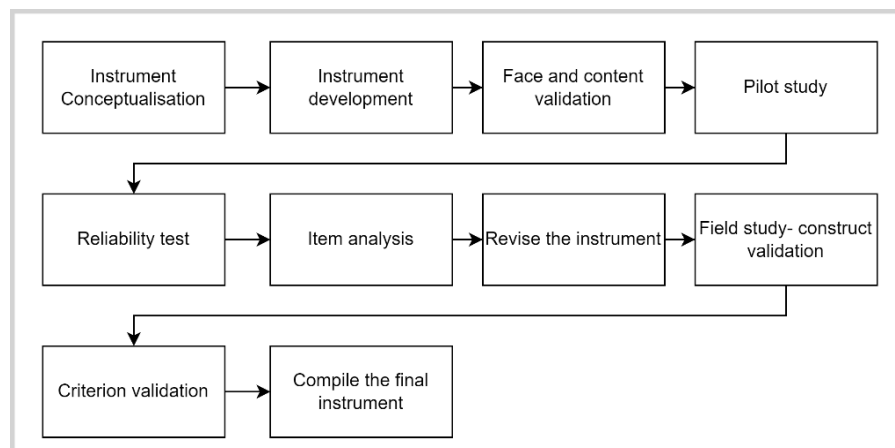


Figure 1. Instrument Development and Validation Scheme (Chan et al., 2021)

Overall, the findings of this study propose an instrument for validation, aimed at measuring the digital competency of preservice teachers in Indonesia. Factors such as information literacy, collaboration skills, security awareness, creative content creation, and the ability to evaluate digital skills are pertinent to examining these competencies. Conse-

quently, the goal of this study is to develop a valid instrument that can be used to map the digital skills of the study's subjects. Additionally, the psychometric properties of the developed items will be assessed using the Rasch model to enhance the instrument's reliability. Figure 2 illustrates the theoretical framework of this study.

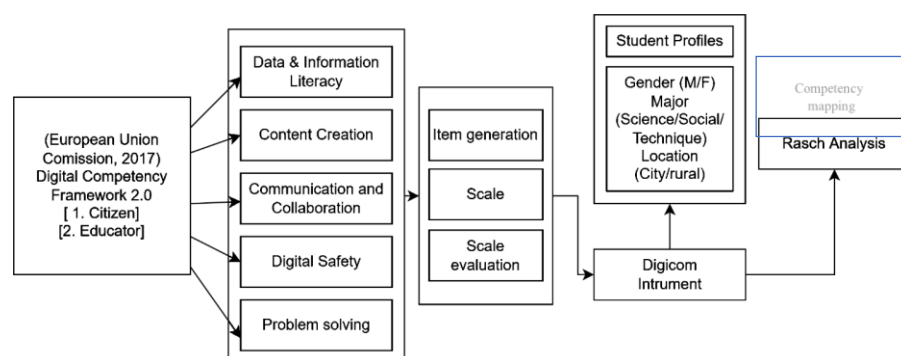


Figure 2. The theoretical Framework for Rasch Model Analysis for DigComp

Based on the literature review that has been carried out, the following are the research objectives of this study, namely a). Measuring the psychometric properties of digital competency measurement instruments for pre-service Biology teachers; b). Mapping the digital competency difficulties area according to pre-service Biology teachers' perception using the Rasch analysis model.

2. Method

a. Research Design

This study employs a quantitative approach, as it facilitates the collection and analysis of data in a numerical framework to explain the phenomena under investigation (Annisa et al., 2024). The data was gathered through a self-administered online survey due to its cost-effectiveness, elimination of paper usage, and lack of need for manual coding. Using digital forms for data collection is also straightforward and enables

the collection of detailed and well-organized data (Creswell & Creswell, 2018). Participants were required to answer all items before submitting their responses, ensuring that there was no missing data. The data analysis was conducted in two phases: a pilot study to identify outliers and clean invalid data, followed by a final analysis to examine the interaction between items and respondent measurements (Bambang Sumintono & Wahyu Widhiarso, 2014). The study aims to assess pre-service teachers' perceptions of digital competencies using a survey-based quantitative approach.

b. Data Collection Procedure

In this study, probability sampling was employed. Sampling was targeted at individuals with direct experience related to the phenomenon being studied (Creswell & Creswell, 2018). Respondents were invited to participate until the required sample size was reached. The sample size met Linacre's recommendation of a minimum of 110 respondents for polytomous data with a 99 percent confidence interval and a calibration value of 0.5 logits, necessary for Rasch measurement model analysis (Linacre, 2012). The final sample consisted of 264 undergraduate pre-service Biology teachers from various fields within the teacher training faculty of a private university in Surakarta, Indonesia. Data was collected during the 2021-2022 academic year using a digital form questionnaire, a convenience sampling method. Prior to completing the questionnaire, students were informed about the study and consented to participate, ensuring ethical standards were maintained. Participation was voluntary and anonymous.

For this study, data was collected using a web-based questionnaire designed around the Digital Competency Framework-based Questionnaire (DFBQ) (Hidayat et al., 2023). The

DFBQ was primarily developed using the DigComp framework for citizens and the Indonesian Minister of Information and Communications' digital literacy framework. The questionnaire consisted of 36 items divided into five categories, each addressing different aspects of pre-service teachers' digital competence: Area I (5 items), Area II (7 items), Area III (6 items), Area IV (9 items), and Area V (9 items).

After exporting the data to an Excel spreadsheet, it was validated and cleaned using WINSTEPS version 5.2.3, a Rasch measurement model program. Among the 264 participants, three respondents gave extreme responses (either all maximum or minimum ratings), which were identified and removed as outliers. After this cleaning process, the final dataset included responses from 261 participants.

3. Result and Discussion

This study's measuring model utilized Rasch model analysis. The approach is appropriate for measuring latent characteristics for evaluating human opinions, perceptions, and attitudes (Rusland et al., 2020). The Rasch analysis provides several psychometric components: descriptive analysis, Chi-square (χ^2), person and item reliability, and Cronbach Alpha.

The descriptive analysis of the Rasch model exposes participants' judgments of knowledge and practice. Chi-square (X^2) determines the level of significance among DFBQ questionnaire statements. The unidimensionality rating scale was utilized to evaluate the capability and measurability of the instrument under development. The person reliability index (PRI) reveals the consistency of an individual's responses, whereas the item reliability index (IRI) indicates whether or not the instrument adequately defines the latent variable.

Finally, All of the analysis are described in Table 2.

Table 2. Summary Statistic of N= 261 Respondents (Post-Data-Cleaning)

	Total score	Count	Measure	Model error	Infit MNSQ	ZSTD	Output MNSQ	ZSTD
Mean	136.0	36.0	1.61	.26	1.01	-.31	1.01	-.32
Standard Deviation	17.7	.0	1.18	.07	.50	2.4	.49	2.3
Max.	179.0	36.0	6.60	1.01	3.81	7.68	3.74	7.56
Min.	53.0	36.0	-3.22	.23	.21	-5.66	.21	-5.43
Real RMSE	.30	True SD	1.14	Separation	3.84	Reliability	.94	
Model RMSE	.27	True SD	1.15	Separation	4.29	Reliability	.95	
Standard Error of person Mean = .07								
Cronbach Alpha person raw test reliability = .95								

Cronbach's Alpha, used as a reliability measure (reflecting the association between individuals and items), is 0.95, signifying that the instrument's quality is 'excellent,' with respondents providing consistent responses. The person reliability index (PRI), as shown in Table 4, is also 0.95, which indicates that the consistency of the respondents' answers is 'very good,' and that the scale effectively distinguishes between individuals. The same interpretative logic applies to the Item Reliability measurement of 0.99, which is also categorized as 'very good.' This suggests a high likelihood that respondents consistently answered the questions. A high estimate of item reliability indicates that the

items are effective in defining the underlying construct (Bond & Fox, 2007).

The DFBQ can be considered a reliable instrument across various respondent groups. Table 3 further shows a high Cronbach's Alpha coefficient of 0.95, illustrating the interaction between the 261 respondents and the 36 items. According to instrument quality standards, a reliability score of 0.98 is classified as 'Excellent' (Bambang Sumintono & Wahyu Widhiarso, 2014), indicating a strong interaction between respondents and items. An instrument with high internal consistency is regarded as highly dependable.

Table 3. Reliability of Person and Item (*p < 0.01)

N	Person 261	Item 36
Mean	1.61	0.00
SD	1.38	1.18
SE	0.03	0.07
Separation	4.29	7.84
Reliability	0.94	0.98
Cronbach's Alpha	0.95	
Raw variance	42.6%	
Chi-Square (X ²)	84138.1	

Table 3 shows the Person Separation Index (PSI), which indicates how effectively

the DFBQ distinguishes between 'person abilities' in the latent trait. A higher separa-

tion index suggests a greater likelihood that respondents will answer the questions accurately. Conversely, the Item Separation Index (ISI) represents how well the items cover a range of simple to difficult concepts (William J. Boone, 2016). The broader the range, the better the fit. In this study, the Person Separation Index is 4.29, and the Item Separation Index is 7.84, as shown in Table 3, demonstrating that the DFBQ has a robust distribution among respondents and items. These metrics establish the DFBQ as a suitable and reliable instrument for assessing undergraduate pre-service students' knowledge perceptions related to the digital competency framework. The Person Separation Index (PSI) is used to assess the instrument's ability to distinguish between different levels of ability or competence among respondents (in this case, pre-service teachers). A higher PSI indicates that the instrument is effective in separating individuals into distinct groups based on their digital competency levels. Essentially, a high PSI suggests that the instrument can reliably identify who has higher or lower levels of the measured trait (e.g., specific digital competency).

Meanwhile, the Item Separation Index (ISI) measures the ability of the instrument to distinguish between the difficulty levels of the items themselves. It assesses how well the items are spread along the difficulty continuum, helping to identify whether the instrument includes items that range from easy to difficult, as appropriate for the trait being measured.

For this pilot study on digital competency mapping, a strong PSI would indicate that the instrument effectively categorizes pre-service teachers into different competency levels, which is crucial for understanding where they stand in relation to digital skills. Similarly, a robust ISI would show that the instrument's items are appropriately distribu-

ted across difficulty levels, making it possible to assess both lower and higher levels of digital competency. Together, these indices provide critical insight into the instrument's readiness for broader application and its potential utility in shaping the teacher education curriculum.

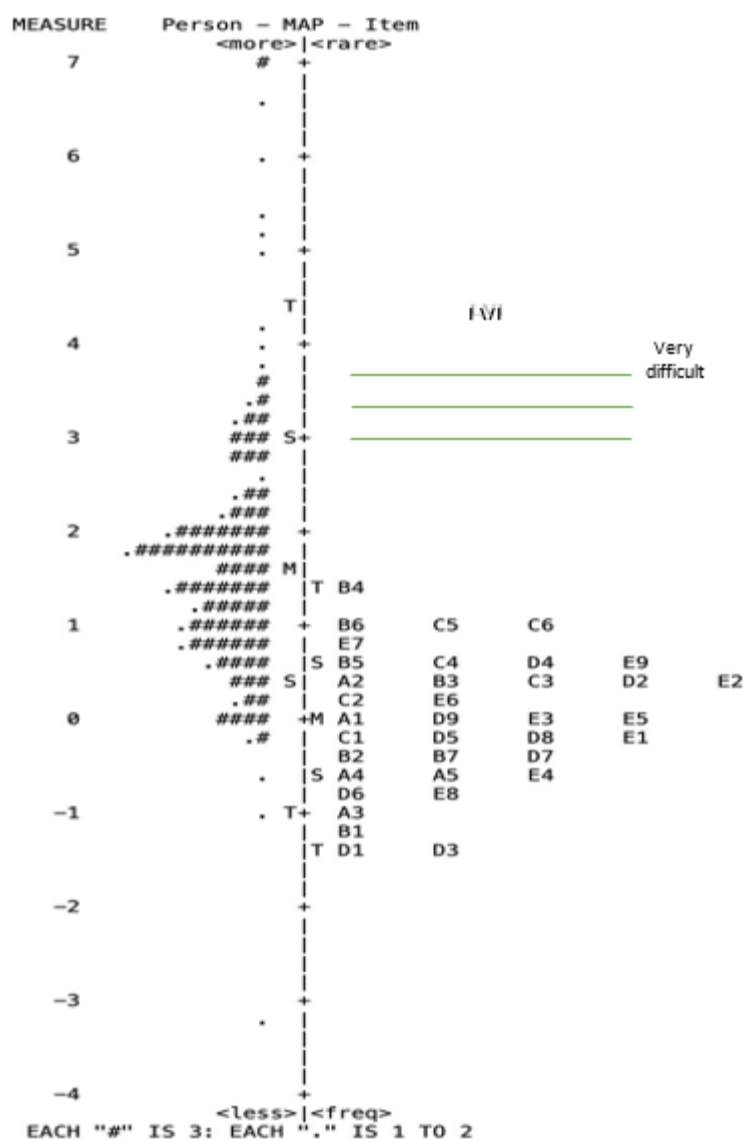


Figure 4. Wright's Map of Variables for LVI (*Logit Value of Items*)

In the case of the digital competency, the Logit Value of an Item (LVI) refers to the location of an item on the latent trait continuum. The logit value is a measure of the difficulty of an item, and it is derived from the relationship between the probability of a respondent answering an item correctly (or agreeing to it in the case of Likert scales) and the person's ability level.

According to the map (Figure 4), items are arranged vertically according to their logit values (item difficulty), with more difficult items positioned higher (closer to positive values) and easier items lower (closer to negative values).

For example, items C5 and C6 have higher LVI (logit values), meaning they are more difficult for the majority of respondents. Conversely, items D1 and D3, located at the lower end of the scale, are easier.

This mapping helps ensure that the test can effectively differentiate between individuals with varying levels of the measured ability or trait (digital competency, in this case). The Rasch model ensures that both the person abilities and item difficulties are measured on the same logit scale. The items are divided into four difficulty levels by segmenting the dis-

tribution of item logit scores according to their mean and standard deviation values.

As detailed in Table 4, Nine items (25%) fall into the "very difficult" category, meaning respondents found them challenging to agree with ($LVI > 0.56$ logits). In the second category, labeled "difficult" ($+0.56 \geq LVI \geq 0.00$), there are 12 items (30%). Additionally, 11 items (30%) are categorized as "easy" ($0.00 \geq LVI \geq 0.56$), while 5 items (22%) are classified as "very easy" for respondents to agree with ($LVI < 0.64$ logits). Table 4 provides a detailed description of the item difficulty classification according to the LVI analysis, offering further insights into the item difficulty levels of the DCFBQ by area and category:

a. The First Competence: Data and Information Literacy

Three of the five items in this competency category (A4, A5, and A3) are classified as "easy" and "very easy." These items relate to organizing digital resources (A4), comparing various sources of information to avoid hoaxes or fake news (A3), and understanding the rules for using digital resource copyrights (A5), which respondents found easy to comprehend. Conversely, items A1 (using search engine filters to identify relevant digital content) and A2 (filtering digital resources by date recency, source validity, multimedia type, file format, or modifiability) are considered by students to be challenging, though not extremely difficult.

Students readily recognize the accuracy of online information and are accustomed to verifying the credibility of multiple information sources through comparison. These findings align with the report by [Mynaříková & Novotný \(2021\)](#), which suggests that Millennials, aged 24 to 39, are more susceptible to encountering and spreading fake news compared to Generation Z. Pre-service teachers are also familiar with orga-

nizing digital resources for future personal use by storing them on a hard drive, flash drive, or cloud storage (e.g., Google Drive or Dropbox).

However, these future teachers struggle with using search engine filters to locate relevant digital content based on factors such as date recency, source validity, multimedia type, file format, and modifiability. This gap in search engine proficiency is linked to students' limited understanding of copyright laws for digital resources used in class or for personal purposes (including images, text, audio, and video). In Indonesia, the understanding of copyright is still underdeveloped. This is supported by [Sudjana \(2022\)](#), who highlighted the high rate of piracy in art and intellectual property in the country. Lastly, if the results of this competency mapping are used to develop a Digital Competency learning program for future Biology teachers, attention should be given to improving the basic technical skills needed to effectively use search engines.

b. The Second Competency: Communication and Collaboration

Items B3 (developing a vision or strategy to enhance educational practice through digital technology, either individually or in collaboration with colleagues) and B5 (actively leveraging digital communities to exchange ideas, collaborate on assignments, or create digital learning resources) are considered challenging for students. It is understandable that networking with colleagues outside the university is difficult for them. However, the advancement of digital technology during the global pandemic has facilitated easier communication and collaboration with distant colleagues, even across countries.

Additionally, items B4 (commenting or providing feedback based on their knowledge on appropriate social media) and B6 (understanding the concept of netiquette, its application, and its impact on their life, repu-

tation, and career) are particularly challenging for students, indicating unfamiliarity with these concepts.

Conversely, the items considered "easy" or "very easy" by students include B2, B7, and B1. These items pertain to competencies such as selecting appropriate digital technology (media type, characteristics, and advantages/limitations) for sharing and exchanging digital content (B2), understanding the risks and threats to their identity in the digital environment and responding appropriately (B7), and using digital technology to explore, interact, or discuss new learning resources (B1).

Students find it difficult to express thoughts and opinions through relevant social media, such as commenting on news stories, writing blogs, sharing social media posts, or actively participating in specialized community networks. It is not surprising that pre-service teachers have a limited understanding of "netiquette" or the ethics of interacting in the digital environment, including its impact on their life, reputation, and profession. While students may be familiar with some aspects of netiquette, [Soler-Costa et al. \(2021\)](#) argue that it is essential for social engagement in the digital age. Providing students with the necessary personal, social, and professional vocabulary is crucial for navigating online interactions effectively.

c. The Third Competency: Content Creation

These third competency items were the most challenging for students, with 5 out of 6 items categorized as difficult or very difficult. Ranked from least to most difficult, the items include C2, C3, C6, C4, and C5. Items C2 and C3 involve students' ability to use applications for developing relevant multimedia (e.g., editing photos, videos, text, or audio) and delivering it at an appropriate cognitive level. Meanwhile, items C4 and C5 were identified by students as very difficult,

likely because they do not fully understand the implications of different types of intellectual property (e.g., copyright, copyleft, or trademarks) and how to ask permission from intellectual property owners.

Once again, expertise related to copyright is a significant concern ([Ebner & Braun, 2020](#)). To ensure that these competencies are mastered, education and training in teacher preparation programs must address and reshape this perception. As an example of the implementation of digital competencies of items C4 and C5, a course on intellectual property for pre-service biology teachers can be developed. This course would cover an introduction to key IP types (such as copyright, copyleft, trademarks, and Creative Commons) and their legal frameworks. It would emphasize the ethical use of digital resources, including proper attribution and case studies on copyright misuse in education. Practical activities would include exploring open-license platforms and role-playing exercises to practice requesting permissions for using digital content. Students would create and peer-review digital lesson plans that comply with IP laws, and assessments would consist of written reflections, digital projects, and discussions on integrating IP awareness into their future teaching practices.

On the other hand, some complexities related to digital content development competencies, particularly programming skills (item C6), are somewhat understandable. Prospective instructors in vocational departments, such as informatics and engineering education, typically acquire only basic programming skills (e.g., Macro, Excel, Java, Python, or PHP) to solve problems in a digital environment. These fundamental programming skills differ from the pedagogical curriculum for students in departments such as education, social studies, natural sciences, and language studies, for instance.

d. The Fourth Competency: Safety

Students generally felt confident about safety aspects (see Table 4). Two items in the Safety dimension were particularly easy for them to agree with. These items are: D1, "I understand how to enable, utilize, and update security features on my device," and D3, "I am quite careful and have good judgment about when to share (or not share) personal

information and sensitive data." Additionally, four other items were also easy for students to agree on: maintaining personal safety from excessive gadget use or addiction (D6, D7), ensuring standard gadget security such as updating passwords and encryption (D5), and protecting against cyberbullying (D8).

Table 4. Item Classification According to the Difficulty Level (LVI)

Difficulty Level	Area/ Dimension					N
	Data and Information Literacy	Communication and collaboration	Content Creation	Safety	Problem-solving	
Very difficult		B5, B6, B4	C4, C5, C6	D4	E7, E9	9
Difficult	A1, A2	B3	C2, C3	D2, D9	E5, E3, E6, E2	11
Easy	A4, A5	B2, B7	C1	D5, D7, D8	E1, E4	10
Very easy	A3	B1		D1, D3, D6	E8	6

As shown in Table 4, respondents generally found the safety dimension manageable, with 6 out of 16 items (D5, D7, D8, D1, D3, D6) being classified as easy or very easy to agree on. In contrast, the problem-solving dimension proved more challenging, with 6 out of 20 items (E2, E3, E5, E6, E9, E7) falling into the "difficult" and "very difficult" categories.

Regarding the safety dimension, respondents struggled with cybersecurity items that were not covered in their Teacher Training institution. Items such as identifying phishing and malware attacks (D4, "I know various methods to identify phishing and malware (malicious programs)") were particularly challenging. Additionally, they found it difficult to agree on the principles of cyber-attacks (D2, "I understand some of the risks of cyber-attacks on the devices I use, e.g., know the working principles of ransomware attacks, malware, adware, phishing, or privacy violations") and understanding how to limit gadget use (D9, "I understand

and practice healthy use of devices when working in a digital environment").

Pre-service Biology teachers feel unprepared to handle cyberbullying and are unsure how to address it if it occurs to them or their future students. Given that Generation Z is likely to encounter cyberbullying in the digital age, understanding and responding to it is crucial. This finding supports [Falloon's \(2020\)](#) research, which highlights cyberbullying as a significant risk in digital social interactions, potentially impacting mental and physical health.

[Andriani Kusumaningrum & Bayu Dwi Raharya \(2022\)](#) conducted a study titled "Cybersecurity Vulnerability Behavior Scale Model to Measure the Level of Vulnerability." They found that with a rating scale of 3.30 out of 5, students are still vulnerable to errors. They recommended that students be more vigilant and proactive in safeguarding their security and digital environment, especially as online communication, study, and work remain prevalent post-pandemic.

Additionally, students need to be aware of the risks posed by cyberattacks on their devices, such as ransomware, malware, adware, phishing, or privacy violations. This awareness is essential for students using internet-connected devices for learning. Furthermore, understanding these threats will benefit future teachers. However, students currently lack knowledge about physical health guidelines for working in a digital environment, including duration limitations, posture comfort, screen positioning, and ergonomic considerations.

e. The Fifth Competency: Problem-Solving

The problem-solving competency items were challenging for students to agree on, with 5 of the 9 items categorized as difficult (E2, E3, E5, E6) or very difficult (E7, E9). Only 3 items fell into the easy category (E1, E4, E8). Items E1 and E8, classified as “easy,” were related because they indicated that students could independently find solutions to problems from digital sources (E4) or know whom to contact for tutorials or expert advice (E8). In contrast, E2, E3, and E5 addressed challenges such as persistence in solving software or hardware issues (E2), using hotkeys (E3), and understanding when technology can or cannot meet specific needs (E5). The skill to detect plagiarism using digital technology (E7) was notably difficult for students, as most disagreed with this item.

Overall, data suggest that undergraduate pre-service Biology teachers face significant difficulties with problem-solving competencies in a digital context. Students find troubleshooting in software or hardware particularly challenging, as it requires persistence and patience. Additionally, understanding application settings and using hotkeys for efficient digital work (e.g., undo, search, screenshot, bold text, navigation, or zoom) are less familiar to them. This aligns with

Charlesworth, Tessa E.S. & Banaji's (2019) study, which found that men are more likely than women to major in STEM fields such as Engineering and Computer Science, with a gender gap of 20% for men compared to 4% for women.

In the education sector, the ratio of men to women is 3% to 8%. There is a need for pre-service teachers to enhance their digital pedagogical skills, possibly through online lessons or learning from more experienced colleagues. Despite the current gap, there is a recognized need to improve their ability to offer guidance or tutorials on learning innovations via social media.

4. Conclusion

To address the research objectives of this study—namely, evaluating the psychometric properties of digital competency measurement instruments for pre-service teachers—the data from each Digicom item aligned with the Rasch model's assumptions. All 36 items were retained, showing strong performance in terms of suitability, polarity, and local independence. Rasch analysis confirms that Digicom is an effective tool for assessing students' digital competency skills in everyday life, particularly within higher education and for future digital citizens.

The second objective was to map areas of digital competency difficulty based on pre-service teachers' perceptions using the Rasch analysis model. The study identifies critical gaps in the digital competencies of preservice biology teachers, particularly in content creation, problem-solving, and intellectual property comprehension. To address these deficiencies, curriculum design should prioritize practical workshops on multimedia content development, training in intellectual property rights, and advanced techniques for digital information retrieval. Furthermore, the inclusion of cybersecurity

education and the enhancement of digital communication and collaboration skills are essential, given the increasing need for educators to manage data privacy and engage professionally in online spaces. Continuous formative assessments, such as digital portfolios, peer evaluations, and reflective exercises, will enable students to monitor their progress and adapt to emerging digital technologies and pedagogical methods.

A scaffolded and differentiated instructional approach is recommended to progressively build students' digital competencies, providing additional support for those struggling in specific areas. The integration of practical, real-world activities—such as troubleshooting simulations and collaborative digital projects—can enhance their capacity for problem-solving and effective digital communication. Incorporating reflective practices and professional development planning will further cultivate a commitment to ongoing digital skill enhancement, ensuring that preservice teachers are equipped to utilize digital tools effectively within contemporary educational environments.

This study makes a significant contribution to the development of digital competency test instruments specifically tailored for preservice teachers, particularly in a region as diverse as Indonesia. Indonesia, with its vast demographic diversity and high internet penetration (185.3 million users), presents unique challenges and opportunities for digital education. The creation of this digital competency instrument is expected to support the development of a curriculum focused on enhancing the digital skills of preservice teachers. As future educators, these individuals will be responsible for teaching Generation Alpha—a cohort characterized by

their unique relationship with technology and digital environments.

The instrument will provide a foundation for measuring and improving key competencies in areas such as digital literacy, content creation, cybersecurity, and online collaboration, which are essential in modern classrooms. Given Indonesia's socio-cultural and technological context, this tool can help ensure that teachers are adequately prepared to navigate the complexities of educating a generation Alpha that has been immersed in digital technologies from birth. Furthermore, the development of such competency assessments could inform broader educational policies and practices across the country, aligning teacher training programs with the needs of both students and the rapidly evolving digital landscape. Future research should consider expanding the range and number of sample respondents and also the variance of departments from other clusters (vocational, language, social sciences, and engineering).

Additionally, it is recommended to study the Logit Value of Person (LVP) to provide a more thorough discussion on digital competency mapping, leveraging the Rasch analysis model's capability to explore relationships between items and respondents' answers in research contexts.

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