

Validation of the DigComp tool and evaluation of the level of digital literacy skills among Zimbabwean in-service secondary school teachers

Israel Mbekezeli Dabengwa¹, Tinashe Byron Gashirai², Sibonile Moyo³, Smart Ncube³, Daga Makaza⁴, Paul Makoni¹, Notice Pasipamire⁵, Goodwill Kudakwashe Chademana⁶, Mafoti Mufudzi⁶, Dzikamayi Mandaza⁶, Stonard Mapfumo⁶

¹Research and Internationalisation Office, National University of Science and Technology, Bulawayo Zimbabwe

²Department of Applied Mathematics, Faculty of Applied Science, National University of Science and Technology, Bulawayo Zimbabwe

³Department of Informatics and Analytics, Faculty of Applied Sciences, National University of Science and Technology, Bulawayo Zimbabwe

³Department of Informatics and Analytics, Faculty of Applied Sciences, National University of Science and Technology, Bulawayo Zimbabwe

⁴Department of Sports Science and Physical Education, Faculty of Applied Sciences, National University of Science and Technology, Bulawayo Zimbabwe

¹Research and Internationalisation Office, National University of Science and Technology, Bulawayo Zimbabwe

⁵Department of Library and Information Science, Faculty of Communication and Information Science, National University of Science and Technology, Bulawayo Zimbabwe

⁶Ministry of Primary and Secondary Education, Queen Loziqueyi Dlodlo House, Harare

⁶Ministry of Primary and Secondary Education, Queen Loziqueyi Dlodlo House, Harare

⁶Ministry of Primary and Secondary Education, Queen Loziqueyi Dlodlo House, Harare

⁶Ministry of Primary and Secondary Education, Queen Loziqueyi Dlodlo House, Harare



Abstract

It has become essential for teachers to possess digital literacy to effectively deliver lessons. In this context, a study was conducted utilising the European Commission's DigComp tool to assess the digital competence skills of secondary school teachers. This study marks the first application of the DigComp tool in Africa. A survey was conducted using questionnaires and interview instruments to collect data from 2,263 conveniently selected secondary school teachers across 150 purposively chosen schools in 10 provinces of Zimbabwe. The selection included peri-urban, rural, boys-only, girls-only, and mixed-sex institutions. Descriptive statistics, reliability analysis, and structural validation of the questionnaire were conducted using SPSS 27, with data analysis performed for statistical inferences. The results indicated that Zimbabwean secondary school teachers generally exhibited intermediate digital literacy. The digital skills were ranked in order of increasing difficulty as follows: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Problem Solving, and Safety. Additionally, the findings suggest that competencies in Communication and Collaboration vary by gender. It is recommended that the Ministry of Primary and Secondary Education provide in-service teachers with professional development opportunities to help them reskill and upskill, ensuring their relevance in an ever-evolving world.

Keywords: Digital literacy; DIGCOMP framework In-service teachers; Secondary teachers; Zimbabwe



Introduction

Information and Communication Technologies (ICTs) have been rapidly advancing in all sectors of the economy. This has brought about a new era in education, necessitating the integration of digital tools and resources in teaching and learning programs. To maximise the benefits of technology in education, teachers are challenged to acquire digital literacy skills (Khvilon and Patru 2002). Digital literacy at times known as digital competences is defined as “the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs, and entrepreneurship. It includes competencies that are variously referred to as computer literacy, such as Information Communication Technology (ICT), information, and media literacy (Global Alliance to Monitor Learning 2018)”. Digital literacy combines different literacies which are required for the effective and persistent usage of information.

Although various literacies exist, the research team assumed that other literacies are intertwined with ICT interactions of the education system and the world outside of it. This is appropriate because literacy practices and meanings are developed in culturally organised contexts. For instance, it is possible to learn some of the literacies from practice, enjoyment, or as part of a course delivered in a formal setting. In the previous century, general literacy (the ability to read and write) has had a huge impact on global citizens’ ability to participate in all spheres of life. As such, digital literacy is needed to use various digital technologies, such as smartphones, desktops, laptops, and smart devices that use the Internet in what is known as the 4th Industrial Revolution. In the context of the sustainable development goals (SDGs), digital literacy skills are critical in secondary school settings to achieve SDG 4.4.2 that seeks to increase the number of young people with digital skills [United Nations Educational and Scientific Organisation (UNESCO), 2018]. Other meanings of digital literacy include the ability to identify fake news and stop the spread of such news to protect persons whom it harms, the protection of data, and the dissemination of information using digital tools (Tinmaz et al. 2022).

Digital skills assessments fall under three facets: self-assessment, knowledge-based assessment, and performance-based assessment (International Telecommunications Union [ITU] 2020). Self-assessments often assess participants’ digital skills using rates that are based on their level of knowledge, ability, confidence, or usage of a technology using a Likert scale or “yes” or “no” responses. In this case, the participants provided their assessments using the

above responses. The self-assessment tool has the advantages of being easy to administer, less costly, and can be paired with other types of assessments (ITU, 2020). However, self-assessments have flaws such as the lack of honesty among participants, as participants may not have the ability to understand questions, or the participant's background may skew the results. Another disadvantage of self-assessment is that it lacks nonverbal cues, such as expressions of confusion on a participant's face and, more importantly, the amount of time taken to complete a task using the technology on which the participant is being assessed.

Knowledge-based assessments rely on factual questions about the operation of a technology, and are usually presented in the form of multiple-choice questions (ITU, 2020). Knowledge-based assessments have more advantages than self-assessment. However, knowledge-based assessments are limited because they focus on the application of a specific technology (on a desktop or laptop) instead of using digital skills to solve a problem (ITU, 2020).

Performance-based assessment relies on real-life application of digital skills using technological application tools on which the participant is evaluated. In some situations, researchers have used models to test participants' skills in a simulated environment. Virtual and immersive reality tools can be used to ascertain the capabilities of a participant in performance-based assessments (ITU, 2020). Performance-based assessment is regarded as the most accurate form of assessment because it can obtain real-life usage of technology. One key difference between self-assessments and simulations is the inability of the assessor to read the learner's real-life interaction with technology. However, performance-based assessments are criticised for being quite expensive to conduct, as they require equipment and technology to accurately assess the participant and cannot be applied to large groups such as national assessments.

Moreover, the ITU Handbook (ITU, 2020) recommends that different assessments be combined to increase the generalisability of the results instead of relying on only one type of assessment. This means that self-assessments can be combined with knowledge-based assessments, knowledge-based assessments with performance-based assessments, self-assessments with performance-based assessments, or a combination of all three. There are examples of assessment tools that combine self-assessment with knowledge-based assessment. An example of such an assessment is the Europass Digital Skills Assessment Tool (Europass 2022).

The ITU (2020) provides four digital skills frameworks that are used for assessments: the Digital Competence Framework for Citizens (DigComp), Digital Literacy Global Framework (DLGF) (UNESCO 2018), Digital Skills to Tangible Outcomes (DiSTO) (van Deursen, Alexander, Helsper, & Eynon 2014), and the New Essential Digital Skills Framework (NEDSF) (United Kingdom Department of Education 2019). Assessment frameworks are necessary because they can help countries compare data with each other and then set relevant benchmarks. Among these four frameworks, DigComp has been applied as the most widely used framework because it is comparable across regions and age groups (ITU, 2020).

The DigComp framework was developed by the European Commission's Digital Competence Framework. DigComp defines digital literacy in five areas: (1) Information and Data Literacy, (2) Communication and Collaboration, (3) Digital Content Creation, (4) safety, and (5) problem-solving (Vuorikai et al., 2022). DigComp also suggests 250 statements as examples that can be adapted to suit the type of assessment, as well as the audience level at which the assessment is conducted (Vuorikai et al., 2022). The 250 statements come from 21 statements to demarcate the level of digital literacy into proficiency levels that include foundation, intermediate level advanced level, and highly specialised while cutting across knowledge, skills, and attitudes on the five dimensions (Mattar et al., 2022; Vuorikai et al., 2022). This paper discusses the results of a study that used a slightly modified version of the DigComp tool. Instead of the eight levels used in the DigComp tool, the modified tool used five levels, as discussed in the methodology section.

The starting point in making decisions regarding digital literacy among populations is to assess their current state to shed light on current needs and gaps. This is essential, as decisions regarding teachers' level of digital literacy can impact learners' level of digital literacy. Once the current state of digital skills and the ability to use technology in and outside the classroom are known, each gap must be matched to an indicative strategy that sustains the skills or fills the gaps related to the goal. This is an "early detection" device for teachers' future contribution to national development. For instance, if teachers currently lack critical skill sets in using technology, it is doubtful how they can impart these skills to learners to contribute effectively to lifelong learning, national development, and personal development. For learners, this skill gap is likely to follow after completing their schooling.

This paper highlights a gap in the existing literature from a Zimbabwean perspective, as no prior studies have utilized the DigComp tool to evaluate the digital literacy of high school teachers in the country. The Zimbabwean context differs from those identified in previous studies, as it is marked by limited ICT resources both within and outside the classroom. The objective of this research is to address this gap by offering policymakers a comprehensive understanding of the current state of digital literacy among high school teachers in Zimbabwe, enabling them to make well-informed decisions when formulating policies and developing curricula.

As highlighted above, the Union's Digital Competence Framework (DigComp) has emerged as a leading framework for defining and measuring digital literacy. The DigComp framework has been applied in various contexts, whereby its suitability and effectiveness in assessing the digital literacy of teachers has been tested, but this has not been explored in developing countries such as Zimbabwe (Gümüş & Kukul, 2023). The extent to which teachers possess digital literacy skills varies, with wide differences having been reported even in developed countries. This study focuses on Zimbabwe, a developing country in which ICT integration into education is expected in its nascent stage. Therefore, this study aimed to validate the DigComp tool for assessing the digital literacy skills of Zimbabwean in-service secondary school teachers. It further seeks to evaluate the current level of digital literacy among this cohort with the aim of providing insights into the digital competence landscape within the Zimbabwean education sector.

Objectives

The overall objective of this study is to assess the level of digital literacy skills among secondary teachers in Zimbabwe, in line with DigComp 2.2 guidelines. The specific objectives of this study were as follows:

- i. To gauge teachers' digital literacy competence across the five DigComp dimensions.
- ii. To benchmark teachers' digital literacy performance against the five DigComp dimensions
- iii. To discover teachers' attitudes towards digital literacy in five DigComp areas
- iv. To uncover the difference between teachers regarding their level of digital competencies for the five dimensions.

Literature Review

Digital literacy has evolved to include the technical, cognitive, and social-emotional capabilities of individuals to use computing devices and associated technologies (Arslantas & Gul, 2022). Based on the above definition, a methodological review of selected databases known to publish literature on this topic was conducted to inform the methods section of the paper and interpret the findings according to the DigComp framework. This is due to the confusion between the application of DigComp and DigCompEdu, where the latter examines teachers' general digital citizenship, while the former applies to teachers' digital competencies in classroom and professional activities. Additionally, the absence of model studies from the African context meant that there were no clear guidelines on how to adapt the DigComp tool to the Zimbabwean context.

A methodological review was conducted to evaluate the methods and tools employed by researchers in assessing digital literacy among teachers. This evaluation aimed to identify the strengths, weaknesses, and suitability of various methods. The study's research design and data collection methods were improved by addressing gaps found in previous research. To guide the literature search, the following question was posed: "What studies have used the DigComp framework in assessing the digital literacy of secondary school teachers?" Previous reviews of the DigComp tool were deemed insufficient as they did not include secondary school teachers. For instance, Godaert et al. (2022) focused on primary school teachers, while Siddiq et al. (2016) studied lower secondary school learners. Peng and Yu (2021) concentrated on the digital literacy of high school students.

A Google Scholar search was used to find literature. Our main interest was to identify studies that discuss the digital literacy of secondary schools, as seen from the DigComp framework, preferably in an African context. No date limitation parameters were placed on the search. We focused on studies that applied the European Framework for Digital Competence, known as DigComp. Studies had to be conducted on in-training and in-service secondary education teachers. We were interested in studies that used quantitative surveys of the target population and were written in the English language. We excluded studies using part of the DigComp framework and other frameworks, such as Teacher Training for Compulsory Secondary Education, and Digital Competence Framework for Educators (DCF)/DigCompEdu. Similarly,

studies evaluating the digital literacy of practitioners other than secondary schoolteachers were excluded.

Sample search on Google Scholar

The sample search was applied in other databases with some modifications based on the syntax capabilities.

Searcher: Israel Mbekezeli Dabengwa

Date of Search: 07 August 2024

Search phrase	Results
“digcomp” NEAR “Information and Data Literacy” NEAR “Communication and Collaboration” NEAR "Digital Content Creation” NEAR “Safety” NEAR “Problem-solving” AND “teach*” OR “educat*” AND "secondary school" OR "high school"	156

In total, 156 records were found on Google Scholar. Only 3 duplicates were removed, leaving 153 records for screening in their titles and abstracts. The team had 3 reviewers who selected and screened the studies [ID, SN, and SM]. The disputes between the two reviewers were resolved by ID. Finally, 148 records were discarded and we identified five studies that satisfied the set criteria (see Table 1).

The demographics of the identified studies show that Lim et al. (2021) explored the upsurge of digital competence and social media usage among teachers but did not specify the demographics of pre-service secondary school teachers. On the other hand, Zhang et al. (2023) evaluated 910 pre-service teachers from 12 Chinese universities. García et al. (2023) assessed 266 pre-service secondary school teachers from Spain, whereas Nančovska Šerbec et al. (2016) examined 138 secondary school teachers from Slovenia. Macedonia, Tsankov, and Damyanov (2019) surveyed 338 Bulgarian preservice secondary school teachers. From the identified literature, there are more studies conducted on pre-service teachers than on in-service teachers which are the focus of our study. Therefore, our study is unique in that it seeks to establish the practical experience of teachers as opposed to the theoretical experience of pre-service teachers.

The identified literature shows that there is no consistency in the DigComp tools administered to teachers. In other instances, the number of items per dimension differed between studies.

The number of items ranges from 21-91, while other authors did not specify the number of items used. For example, Tsankov and Damyanov (2019) used 21 items, Zhang et al. (2023) relied on 21 items, and García-Vandewalle García et al. (2023) used 91 items. The DigComp questionnaire in our study had 62 items spread across Knowledge, Skills and Attitude levels. Although the number of items differs, all of the studies (including the present study) conform to the DigComp framework, and the number of statements used is suggestive according to the need rather than prescriptive and whole (Vuorikai, Kluzer, and Punie 2022).

In classifying teachers' digital literacy, all studies seem to use a Likert scale. Nančovska Šerbec (2016) and Tsankov, and Damyanov 2019 use the 3-point Likert scale. García et al. (2023) use the 4-point Likert scale as opposed to Lim, Halim, and Ramayah (2021) who used the 8-point Likert scale. It should be noted that the 8-point Likert scale is rarely used, although it is used on the DigComp online platform. Although not included in the analyses, a 5-point scale was found in the studies by Alnasib (2023) and Jiménez-Hernández et al. (2020). There are instances when the DigComp tool has been adapted to fit in measures from other instruments, such as. There are also differences in the grading, even on the same scale. For example, some 5 Likert scales use (1 = Rarely, 2 = Sometimes, 3 = Half the Time, 4 = Almost Always, and 5 = Always), e.g., (Pérez-Navío, Ocaña-Moral, and Martínez-Serrano 2021). Whereas, Jiménez-Hernández et al. (2020) stated that 1 was the minimum and 5 was the maximum and Alnasib (2023) used Agree (4), Partially Agree (3), Disagree (2), and Strongly Disagree (1).

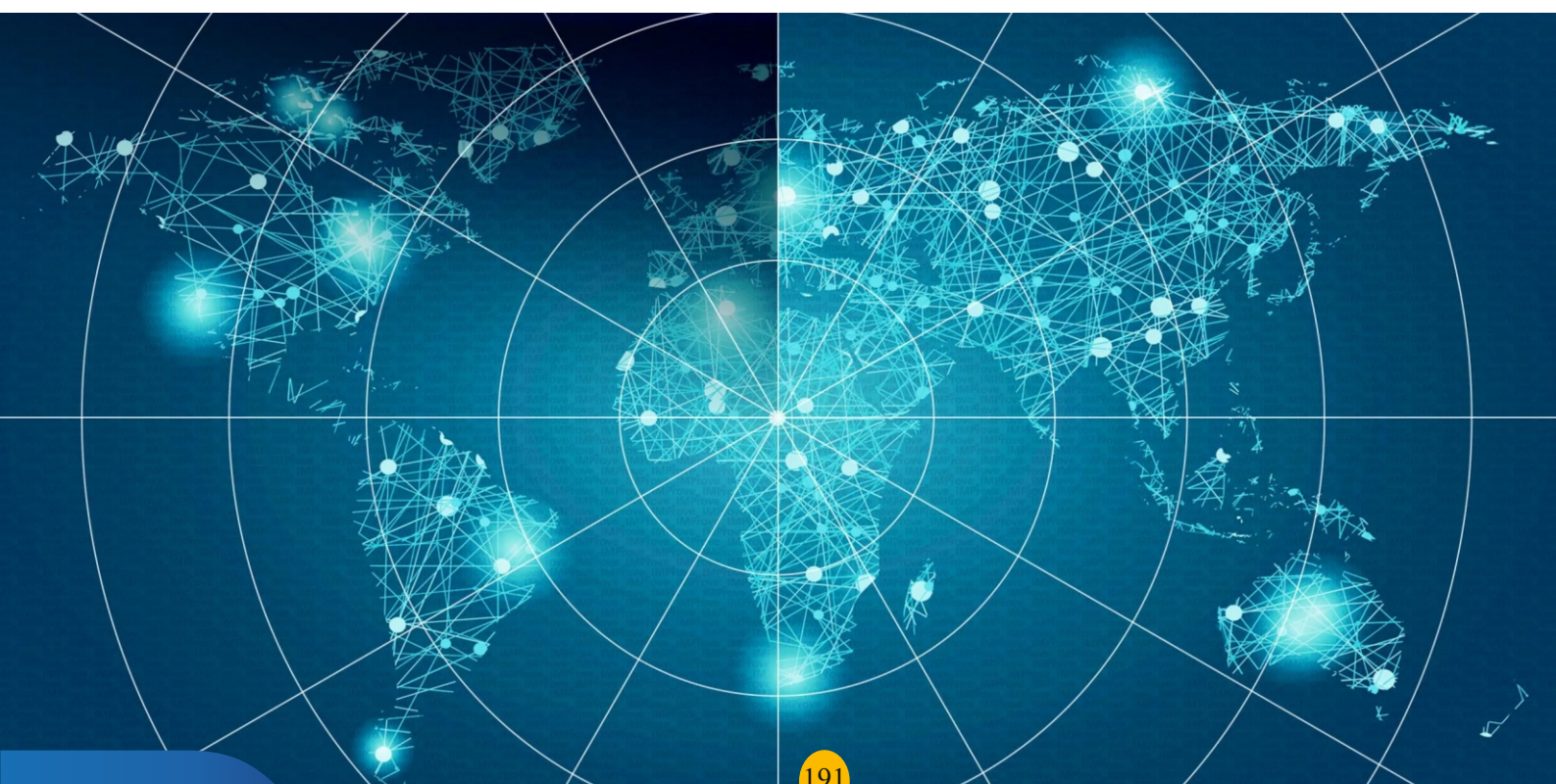


Table 1: An Index to Compare the Results of Digcomp Tools Applied on Secondary School Teachers

Authors	Country	Likert Scale	Reliability of Scale (Alpha upper boundary: lower boundary)	Level of Digital literacy	Ranking of DigComp Dimensions
García et al., (2023)	Spain	4-Point Likert Scale	Information and Data Literacy ($\alpha = 0.870$); Communication and Collaboration ($\alpha = 0.900$); Digital content creation ($\alpha = 0.854$); Security ($\alpha = 0.723$); Problem-solving ($\alpha = 0.830$).	Slightly Above Intermediate	1. Information and Data Literacy, 2. Safety; 3. Digital content creation; 4. Problem-solving; 5. Communication and collaboration
Lim et al., (2021)	Malaysia	8-point Likert scale	1. Information and Data Literacy ($\alpha = 0.939$); Communication and Collaboration ($\alpha = 0.964$); Digital Content Creation ($\alpha = 0.920$); Safety ($\alpha = 0.915$); Problem Solving ($\alpha = 0.956$)	Advanced	1. Information and Data Literacy; 2. Communication and Collaboration; 3. Digital Content Creation; 4. Safety; 5. Problem Solving
Nančovska Šerbec et al., (2016)	Macedonia and Slovenia	3-Point Likert scale	Not stated	Slovenia (Slightly Below Intermediate) Macedonia	1. Information and Data Literacy; 2. Digital Content Creation; 3. Communication and Collaboration; 4.
				(Slightly Above Intermediate)	Problem-Solving and 5. Safety. Both countries scored low on Problem Solving and Safety.
Tsankov & Damyanov (2019)	Bulgaria	3-point Likert scale	Not stated	Basic	1. Information & Data Literacy (Independent/Intermediate); 2. Communication and Collaboration (Basic); 3. Digital Content Creation (Basic); 4. Problem-Solving (Basic); 5. Safety (Basic)
Zhang et al. (2023)	China	7-point scale	1. Information and Information Literacy ($\alpha = .93$); 2. Communication and Collaboration ($\alpha = .91$); Security ($\alpha = .92$); Problem Resolution ($\alpha = .96$); Digital Content Creation ($\alpha = .93$)	Not stated	Not stated

Although the selected studies were not of Africa origin, we have borrowed some concepts from these studies but kept our study unique in that we focused on secondary school teachers in Zimbabwe. For example, the use of a Likert scale to determine the levels of digital literacy and reliability of the instruments. The review also showed the research team how to rank the DigComp dimensions as well as the statistical tests that can be interrogated to understand the findings. These findings helped to shape the methodology and findings in the upcoming sections.

Methodology

The research project used a mixed-methods approach to collect the data. It was underpinned by pragmatic research philosophy which combines both qualitative and quantitative data.

Selection of Provinces

Stratified Sampling/Multi-Stage Purposive Sampling

The population was purposively selected from ten 10 provinces. In each province, 15 secondary schools were purposively selected to reflect areas that cut across private, public, boarding, day, night, urban, peri-urban, rural, boys-only, and mixed schools. A total of 150 schools participated in the study. The DigComp survey instrument was sent to 3,000 secondary school teachers who taught various learning areas. In total, 2,263 questionnaires were returned.

Data Collection

The survey participants were secondary school teachers. The questionnaires captured the socio-demographic data of the teachers as well as the five DigComp dimensions.

Data Analysis Stage

The research team collated the questionnaires that were returned. The questionnaires were graded as “complete” or “incomplete”. A data input form and codebook were developed to guide the data entry process in Microsoft Excel spreadsheets.

Quantitative data were imported and cleaned using the Statistical Package for Social Sciences (SPSS) 27. Analytical tables for quantitative data were computed using SPSS – descriptive statistical analysis and multivariate analysis to aid the identification of factors associated with the use of digital literacy skills, as well as the relationships between each dimension.

Validity of the Instrument

Validity determines whether an instrument measures what it is supposed to measure. Quantitative data validity was improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data which is the optimism of perfection.

Design of the DigComp tool

The research team read key literature, such as the International Telecommunications Union [ITU] (2020) and Vuorikai et al. (2022), to design the DigComp questionnaire.

The DigComp 2.2 framework was selected because it is the most recent digital competency framework. The research team felt that this strength was adequate for measuring the target group, in line with international expectations.

Of the 250 DigComp 2.2 specific statements cover five dimensions: “Information and Data Literacy”, “Communication and Collaboration”, “Digital Content Creation”, and “Problem-Solving” and “Safety” (Vuorikai et al., 2022).

The five dimensions were then categorised into 21 statements that demote the overall statements respective to each dimension (Mattar et al., 2022; Vuorikai et al., 2022). The questionnaire contained 62 statements reflecting knowledge, skills, and attitudes (Dabengwa et al., 2024).

The following grading was agreed to reflect the digital competences that could be found in the Zimbabwean context:

1. **Non-proficient:** This level indicates a lack of proficiency, knowledge, and attitudes on a dimension.
2. **Novice:** Novice level suggests that individuals have just started learning and acquiring knowledge skills and attitudes.
3. **Intermediate:** Intermediate level signifies a moderate level of proficiency in knowledge, skills, and attitudes.
4. **Advanced:** The advanced level represents a high degree of proficiency in expertise, knowledge, skills, and attitudes on a dimension.
5. **Expert:** The expert level signifies the highest level of proficiency and mastery of knowledge skills and attitudes in the dimension.

The grading system was as follows:

B1.1 How do you rate your knowledge about identifying and retrieving relevant information from the Internet to solve your daily problems and duties?

- i. I am not aware of methods/tools for locating information on the Internet. (Non-Proficient)
- ii. I am aware that search engines are used to find information from the Internet. (Novice)
- iii. I know of the various procedures for locating online digital content (Intermediate)
- iv. I know several methods and use them as per need. (Advanced)
- v. I know that search results and content recommendations on the internet are influenced by a range of factors. (Expert)

Dabengwa et al. (2024) show the questions that were asked across knowledge, skills, and attitudes while following the grading of the skills from the tools. Further reference on the questionnaire will be according to the codes assigned per question, e.g., B1.1 “How do you rate your knowledge about identifying and retrieving relevant information from the Internet to solve your daily problems and duties?” was shortened to “B1.1.”

Stakeholder Engagement and User Feedback

A stakeholder meeting was held from the 16th to the 18th of March 2023 at Evelyn High School, Bulawayo, Zimbabwe. Representatives from the National University of Science and Technology (NUST), Ministry of Primary and Secondary Education (MoPSE), and teachers from selected schools attended the meeting. The designed DigComp tool was evaluated by the teachers for face validity which is a simple form of content validity in which the participants were asked to check whether the tool covered all areas and whether there was any ambiguity in the questions.

Reliability of the Instrument

Reliability is most often associated with the methods used to measure variables to determine whether the results are similar (accuracy and consistency) (Salkind and Frey. 2020).

Piloting the Instruments at Northlea High School, Bulawayo, Zimbabwe

Following stakeholder engagement and user feedback, the research team conducted a pilot study of the developed research instruments. Permission to conduct a pilot study at a conveniently selected school was sought through the MoPSE. The research team selected the Northlea High School, Bulawayo, and Zimbabwe.

Data entry from the pilot study was analysed to identify any flaws in populating the instruments. Guided by the results, the instruments were revised to address any shortcomings. One notable glitch was the choice of several options in the questionnaire, whereas the respondents were meant to choose one option. A review of the research literature on DigComp showed that this was possible in instances where the response requires the respondent to indicate their level of competence (e.g., <https://digcomp.digital-competence.eu/digcomp/en/survey/qid-1421/>). In this case, the highest-selected option was considered as the best choice. The team sought the means to address this issue.

Results

Sociodemographics of the Respondents

For a comprehensive representation, data were collected from all ten administrative provinces of Zimbabwe (see Table 1). Two districts were selected randomly from each district. A total of 2, 263 teachers from 134 schools participated in the questionnaire survey (July-October 2023). The highest number of teachers was recorded in Manicaland (320 teachers; 14.1%), and the lowest number was recorded in Midlands Province (150 teachers; 6.6%)

Table 2: Geographic Distribution of Teachers

Province	Number of Teachers	Percentage	District	Frequency	Percentage	Number of Schools
Midlands	150	6.6	Kwekwe	73	3.2	2
			Chirumanzu	77	3.4	7
Masvingo	213	9.4	Masvingo	122	5.4	6
			Zaka	91	4.0	6
Mat South	166	7.3	Mzingwane	83	3.7	6
			Mangwe	83	3.7	6
Mat North	187	8.3	Nkayi	108	4.8	6
			Bubi	79	3.5	5
Bulawayo	233	10.3	Khami	145	6.4	7
			Reigate	88	3.9	5
Harare	245	10.8	Chitungwiza	118	5.2	6
			Northern Central	117	5.2	5
Manicaland	320	14.1	Mutare	174	7.7	9
			Buhera	146	6.5	9
Mash East	203	9.0	Marondera	94	4.2	8
			Chikomba	119	5.3	10
Mash Central	282	12.5	Bindura	121	5.3	7
			Shamva	161	7.1	8
Mash West	264	11.7	Hurungwe	116	5.1	7
			Zvimba	148	6.5	9
Total	2263	100.0	Total	2263	100.0	134

Sociodemographic Details of the Respondents

A slightly higher percentage of respondents were female (59%), and 41% were male (Figure 1). The participants' data were organised according to MoPSE categories of learning areas. A higher percentage of teachers (41.1%) taught STEM subjects (see Figure 2). The learning areas with the lowest number of respondents were Visual and Performing Arts (0.9%), and 0.8% of the teachers did not indicate the subjects they taught. About 3.5% of teachers indicated that they had taught ICT or computers. Although there are few ICT teachers, most of them are male. A low number of females were found in the Visual and Performing Arts.

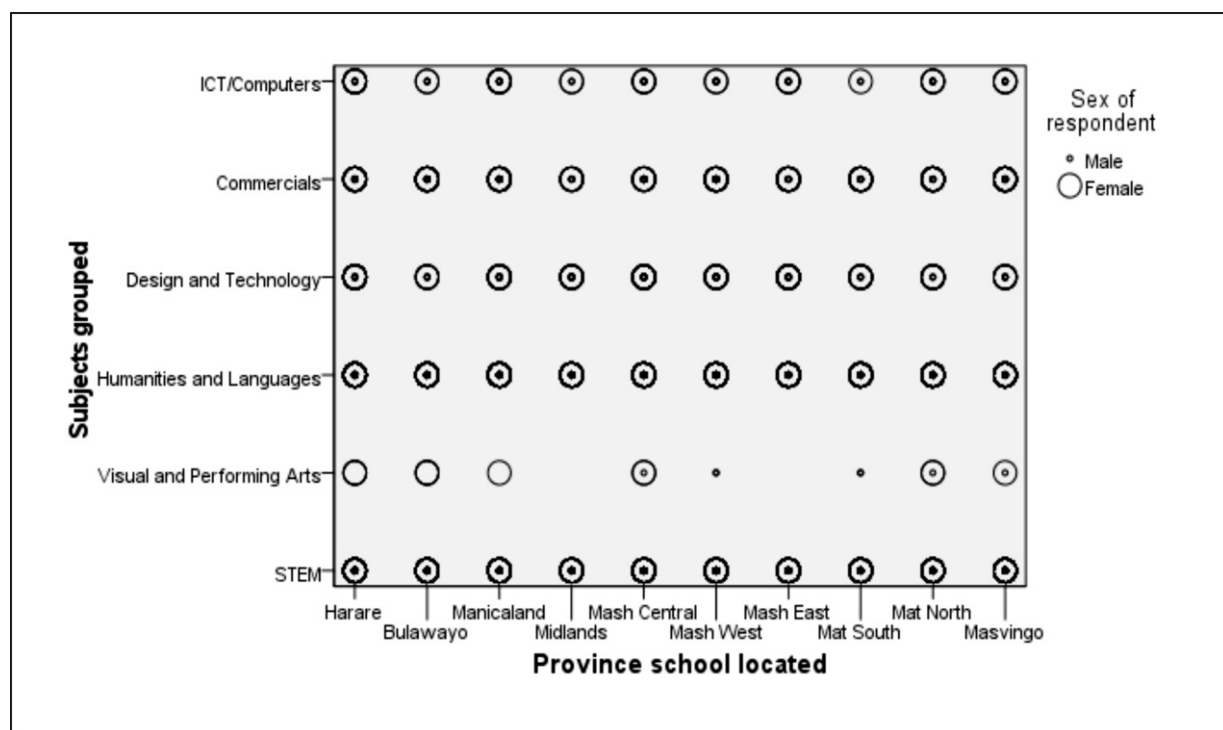


Figure 1: A Bubble of the Sociodemographic Details of the Respondents

Test for Normality on the Data

Some groups violated the assumption of normality. Hence, parametric tests cannot be performed.

Some of the conditions are as follows:

1. Skewness and kurtosis values must be within the interval (-1.96, 1.96);
2. The histograms should show a close-to-normal distribution; and
3. Q-Q plots should be close to linear

Therefore, the data should be analysed using non-parametric tests, such as the chi-squared test or Mann-Whitney U Test.

Test Results on Validity

The following sections present the test results for validity.

Consistency Analysis and Validation of the Instrument

Principal component analysis (PCA) was performed to check the internal consistency of the instrument used to collect data from Zimbabwean secondary school teachers. Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety and Problem Solving were the five primary components of the present study. Considering that these five primary components are affected by three factors—knowledge, skills, and attitude—there was a need to reduce the dimensions by engaging in PCA. Therefore, PCA played two important roles in this study: conducting a reliability analysis of the instrument and reducing the dimensions.

Content Validity Factor Analysis of the DigComp Questionnaire

Factor analysis was used to test the content validity of the instruments. The Kaiser-Meyer-Olkin measure of sampling adequacy test (KMO) is greater than 0.5 for all categories (see Table 2). A KMO value greater than 0.8 is also an indication of sampling adequacy. The significance level for Bartlett's test was not greater than 0.05 (Sig. <0.05) (Salkind and Frey, 2020).

Table 2: Validity Test Using Factor Analysis

	Item	KMO	Bartlett's Test
1	Information and Data literacy	0.871	Sig. 0.000
2	Communication and Collaboration	0.937	Sig. 0.000
3	Digital content	0.893	Sig. 0.000
4	Safety	0.883	Sig. 0.000
5	Problem-solving	0.915	Sig. 0.000

Factor analysis

Factor analysis is a common method used to reduce the number of underlying or latent variables or factors to manageable core items called latent factors. In content analytic research, these factors are often treated as the text's underlying themes (Weber 1990). Table 3 presents a summary of the factor analyses of the questionnaire components. Only 6 items were loaded:

Table 3: Summary of the Factor Analysis

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
B 1.1	24.804	40.007	40.007	24.804	40.007	40.007	19.324
B 1.2	8.926	14.396	54.403	8.926	14.396	54.403	11.265
B 1.3	2.574	4.151	58.554	2.574	4.151	58.554	15.361
C 1.1	1.805	2.911	61.465	1.805	2.911	61.465	10.957
C 1.2	1.174	1.894	63.358	1.174	1.894	63.358	15.027
C 1.3	1.110	1.791	65.149	1.110	1.791	65.149	9.455

Results on Reliability

The overall Cronbach's alpha for the DigComp tool is 0.975. The reliability analysis results suggest that the internal consistency of the four primary components is good while that of Information and data literacy is acceptable (see Table 4)

Table 4: Cronbach's Alpha with Confidence Intervals for the Five Dimensions

DigComp Component	2.2	Alpha	Lower Boundary	Upper Boundary	Remark
Information and Data Literacy		0.768	0.753	0.782	Accept
Communication and Collaboration		0.858	0.849	0.867	Good
Digital Content Creation		0.828	0.818	0.838	Good
Problem-Solving		0.863	0.855	0.872	Good
Safety		0.829	0.819	0.840	Good

Principal Component Analysis Results

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy test and Bartlett's test of sphericity were performed to check whether it was appropriate to conduct principal component analysis given the variables in the present study (see Table 5). For variables to be valid, the value obtained from the KMO measure of the sampling adequacy test must be greater than 0.5 ($KMO > 0.5$), and the p-value for Bartlett's test must not be greater than 0.05 (Sig. $< .05$) (Salkind & Frey, 2020).

Table 5 shows the KMO and Bartlett's test results on the five dimensions of DigComp 2.2. tool. The corresponding items in the questionnaire were ranked in that order.

Table 5: KMO and Bartlett's Test

	SIGNIFICANT QUESTIONNAIRE ITEMS (RANKED BY ORDER)	KMO AND BARTLETT'S TEST				
		Approx. Chi-Square	Df	Sig.	KMO Measure of Sampling Adequacy	Cumulative %
INFORMATION AND DATA LITERACY	B1.2; C1.1	8350,748	66	0.000	0.847	65,720
COMMUNICATION AND COLLABORATION	C2.4; C2.3; C2.6	20935,140	66	0.000	0.937	69.18
DIGITAL CONTENT CREATION	C3.1; C3.2	14046,794	66	0.000	0.893	65.20
SAFETY	C4.2; C4.1	14876,214	66	0.000	0,883	65.16
PROBLEM-SOLVING	C5.1; C5.4	12980,271	66	0.000	0,908	64.51

1. Information and data literacy

There were nine questions on this item. The KMO test and Bartlett's test suggest that the instrument is internally consistent and that it is valid since $KMO=0.847 (>0.5)$ and $Sig.<0.05$. The two principal components extracted explain the total variance of 65,72%. The scree plot showed that only two principal components had eigenvalues greater than one, and the rest had eigenvalues below one. Consequently, two components were loaded and seven components were removed (see Table 5).

2. Communication and collaboration

There are seventeen (17) questions included in this item. The KMO test and Bartlett's test suggest that the instrument is internally consistent and that it is valid since $KMO=0.937 (>0.5)$ and $Sig.<0.05$. The three principal components extracted explain the total variance of 69,18%. The scree plot showed that only two principal components had eigenvalues greater than one and the rest had eigenvalues greater than one. Consequently, three components were loaded and 14 components were removed (see Table 5).

3. Digital content creation

There were 12 questions (components) on this item. The KMO test and Bartlett's test suggest that the instrument is internally consistent and that it is valid since $KMO=0.893$ (>0.5) and $Sig.<0.05$. The two principal components extracted explain the total variance of 65,20%. The screen found that only two principal components had eigenvalues greater than one, and the rest had eigenvalues below one. Consequently, two components were loaded, and ten components were removed (see Table 5).

4. Safety

There are twelve (12) questions on this item. The KMO test and Bartlett's test suggest that the instrument is internally consistent and that it is valid since $KMO=0.883$ (>0.5) and $Sig.<0.05$ (Salkind and Frey, 2020). The two principal components extracted explain the total variance of 65,16%. Consequently, two components were loaded, and ten components were removed (see Table 5).

5. Problem solving

There were nine questions on this item. The KMO test and Bartlett's test suggest that the instrument is internally consistent and that it is valid since $KMO=0.908$ (>0.5) and $Sig.<0.05$. The two principal components extracted explained a total variance of 64,51%. Consequently, two components were loaded, and ten components were removed (see Table 5).

An Overview of the Digital Literacy Levels of Secondary School Teachers

Overall, the responses obtained from the survey participants suggest that the teachers who took part in the study possess an intermediate level of digital literacy knowledge (see Figure 3).

The Usage of the Mean and Mode to Determine Levels of Digital Literacy

Because the data were not normally distributed, the Median and the Mode were analysed to rank the survey participants into the levels of digital literacy. The results of the ranking still place the teachers' levels in the intermediate category (see Table 5)

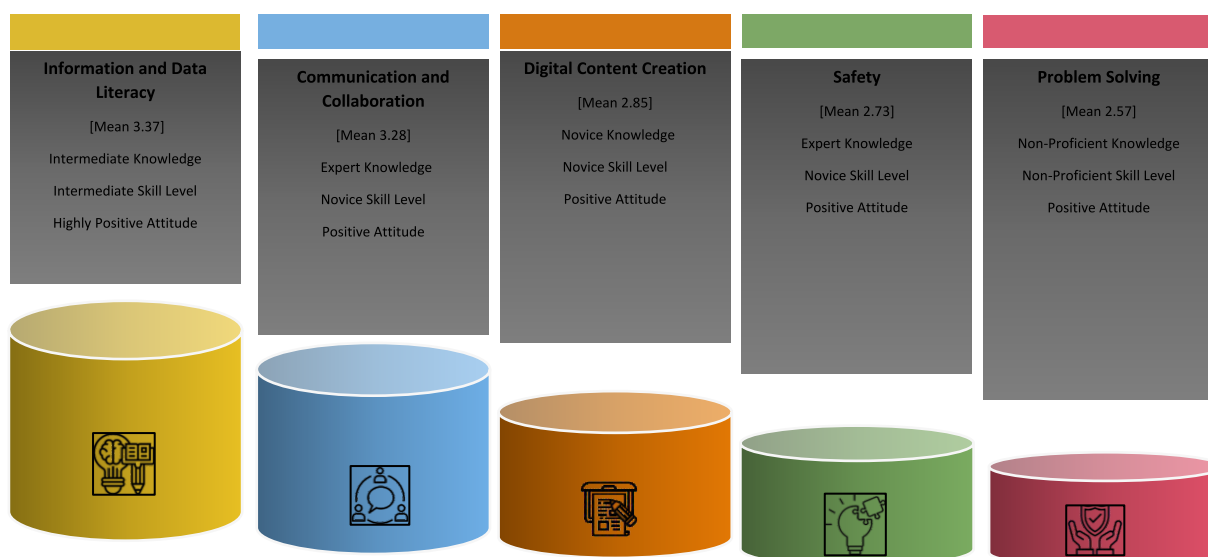


Figure 2: Summary of the Survey Results Based on the DigComp Framework

Table 6: Ranking of the Digital Literacy Levels using the Median and the Mode

	KNOWLEDGE	SKILLS	ATTITUDES
INFORMATION AND DATA LITERACY	B1.1 (Intermediate)	C1.1 (Intermediate)	D 1.1 (Positive)
	B1.2 (Intermediate)	C1.2 (Intermediate)	D 1.2 (Positive)
	B1.3 (Intermediate)	C1.3 (Intermediate)	D 1.3 (Very Positive)
COMMUNICATION AND COLLABORATION	B2.1 (Advanced)	C2.1 (Intermediate)	D 2.1 (Positive)
	B.22 (Advanced)	C2.2 (Intermediate)	D 2.2 (Positive)
	B2.3 (Intermediate)	C2.3 (Novice)	D 2.3 (Positive)
	B2.4 (Intermediate)	C2.4 (Novice)	D 2.4 (Positive)
	B2.5 (Advanced))	C2.5 (Intermediate)	D 2.5 (Very Positive)
	-	C2.6 (Intermediate)	D 2.6 (Positive)
DIGITAL CONTENT CREATION	B3.1 (Intermediate)	C3.1 (Novice)	D 3.1 (Positive)
	B3.2 (Intermediate)	C3.2 (Novice)	D 3.2 (Positive)
	B3.3 (Intermediate)	C3.3 (Novice)	D3.3 (Positive)
	B3.4 (Intermediate)	C3.4 (Novice)	D3.4 (Positive)
SAFETY	B4.1 (Novice)	C4.1 (Novice)	D 4.1 (Neutral)
	B4.2 (Intermediate)	C4.2 (Novice)	D4.2 (Neutral)
	B4.3 (Intermediate)	C4.3 (Novice)	D4.3 (Neutral)
	B4.4 (Novice)	C4.4 (Novice)	D4.4 (Neutral)
PROBLEM-SOLVING	B5.1 (Intermediate)	C5.1 (Novice)	D 5.1 (Neutral)
	B5.2 (Intermediate)	C5.2 (Novice)	D5.2 (Positive)
	B5.3 (Intermediate)	C5.3 (Novice)	D5.3 (Positive)
	B5.4 (Intermediate)	C5.4 (Novice)	D5.4 (Positive)

Creation, and Safety and Non-proficient on Problem-solving. The study also found that teachers with +56 years and +41 years of teaching experience seem to have low digital literacy levels [see Table 7(a) and (b)]. Another important finding is that males performed better than females in digital literacy scores. No differences were observed between provinces.

Mann-Whitney U Test

The Mann-Whitney U test was conducted to determine if there were differences between the ways in which males and females answered the DigComp questionnaire. Of the 62 items, 27 items were dropped because they supported the null hypothesis, while the remaining 35 items were retained.

Table 8 shows the results of the Mann-Whitney U Test and the corresponding significance of each statement categorised under each dimension. It can be seen that both males and females do not exhibit similarities when it comes to knowledge and skills in Communication and Collaboration.



Table 7(a): Median Values for the Digital Literacy Level of Secondary Teachers in Zimbabwe (Subjects, Sex, Province of the School)

		IDAL	CAC	DCC	S	PS	GRAND MEDIA N	DECISION
Subjects grouped	STEM	3.35	3.40	2.69	2.75	2.65	2.75	INTERMEDIATE
	Visual and Performing Arts	3.09	3.44	2.71	2.69	2.82	2.82	INTERMEDIATE
	Humanities and Languages	3.37	3.33	2.57	2.64	2.55	2.64	INTERMEDIATE
	Design and Technology	3.21	3.17	2.50	2.55	2.48	2.55	INTERMEDIATE
	Commercials	3.39	3.36	2.65	2.73	2.51	2.73	INTERMEDIATE
	ICT/Computers	4.20	4.25	4.15	4.08	4.15	4.15	ADVANCED
Sex respondent	Male	3.53	3.52	2.78	2.87	2.78	2.87	INTERMEDIATE
	Female	3.22	3.26	2.56	2.60	2.52	2.60	INTERMEDIATE
Province of school	Harare	3.80	3.65	3.07	2.95	2.83	3.07	INTERMEDIATE
	Bulawayo	3.28	3.38	2.64	2.66	2.56	2.66	INTERMEDIATE
	Manicaland	3.16	3.29	2.66	2.71	2.65	2.71	INTERMEDIATE
	Midlands	3.24	2.96	2.46	2.50	2.32	2.50	INTERMEDIATE
	Mash Central	3.64	3.47	2.70	2.85	2.76	2.85	INTERMEDIATE
	Mash West	3.44	3.40	2.56	2.70	2.65	2.70	INTERMEDIATE
	Mash East	3.59	3.60	2.74	2.87	2.64	2.87	INTERMEDIATE
	Mat South	3.37	3.43	2.65	2.69	2.64	2.69	INTERMEDIATE
	Mat North	3.19	2.96	2.48	2.51	2.48	2.51	INTERMEDIATE
	Masvingo	3.30	3.19	2.60	2.84	2.53	2.84	INTERMEDIATE
	Kwekwe	2.78	2.68	2.16	2.19	2.82	2.68	INTERMEDIATE
	Chirumanzu	3.87	3.65	2.81	2.86	3.00	3.00	INTERMEDIATE
	Masvingo	3.07	3.14	2.60	2.84	2.78	2.84	INTERMEDIATE
	Zaka	3.39	3.10	2.52	2.83	2.94	2.94	INTERMEDIATE



Table 7(b): Median Values for the Digital Literacy Level of Secondary Teachers in Zimbabwe (Experience in teaching, Age of Respondents)

		IDAL	CAC	DCC	S	PS	GRAND D MEDIA N	DECISION
Experience in teaching	6-10 years	3.45	3.53	2.73	2.82	2.77	2.82	INTERMEDIATE
	11-15 years	3.44	3.50	2.87	2.93	2.94	2.94	INTERMEDIATE
	16-20 years	3.15	3.30	2.57	2.66	2.42	2.66	INTERMEDIATE
	21-25 years	3.32	3.13	2.53	2.53	2.47	2.53	INTERMEDIATE
	26-30 years	3.21	3.12	2.33	2.36	2.24	2.36	NOVICE
	31-35 years	2.82	2.67	2.01	2.16	1.96	2.16	NOVICE
	36-40 years	3.24	3.38	2.48	2.68	2.15	2.68	INTERMEDIATE
	41-45 years	3.00	3.00	2.00	2.23	2.00	2.23	NOVICE
	46-50 years	2.75	2.80	1.78	2.27	1.82	2.27	NOVICE
	50 years and above	3.20	3.00	2.71	2.50	2.00	2.71	INTERMEDIATE
Age of respondent	20-25 years	3.84	3.91	3.06	3.42	3.17	3.42	INTERMEDIATE
	26-30 years	3.66	3.67	2.99	3.28	3.04	3.28	INTERMEDIATE
	31-35 years	3.61	3.61	2.87	2.87	2.97	2.97	INTERMEDIATE
	36-40 years	3.42	3.52	2.79	2.80	2.74	2.80	INTERMEDIATE
	41-45 years	3.25	3.31	2.65	2.66	2.47	2.66	INTERMEDIATE
	46-50 years	3.47	3.28	2.60	2.64	2.50	2.64	INTERMEDIATE
	51-55 years	3.35	3.17	2.52	2.48	2.44	2.52	INTERMEDIATE
	56-60 years	2.63	2.59	2.00	2.14	1.95	2.14	NOVICE
	61-65 years	2.81	3.00	2.22	2.47	1.92	2.47	NOVICE
	65 years and above	3.67	3.33	1.88	2.42	1.67	2.42	NOVICE

Table 8: The Mann-Whitney U Test Results with Corresponding Significance According to Questionnaire Items

	Information and Data Literacy	Communication and Collaboration	Digital Content Creation	Safety	Problem- Solving
Knowledge	B1.1 (0.004); B1.3 (0.001);	B2.3 (0.018); B2.4 (0.026); B2.5 (0.003); B2.6 (0.001);	B3.1 (0.007); B3.2 (0.004); B3.3 (0.001); B3.4 (0.015)	B4.1 (0.000); B4.2 (0.000); B4.4 (0.002)	S17 (0.000); S18 (0.000); S19 (0.003); S20 (0.005)
Skills	C1.1(0.009); C1.2 (0.041); C1.3(0.000)	C2.1 (0.000); C2.2 (0.006); C2.3 (0.027) C2.4 (0.033) C2.5 0.008); C2.6 (0.003)	C3.1(0.004); C3.2(0.013)	C4.2(0.013)	C5.2 (0.000); C5.3 (0.008) C5.4 (0.020)
Attitudes	D1.1 (0.035)	D2.3(0.011)	-	-	D5.4.1(0.0 10)

Discussion

Zimbabwe's findings are comparable with international evidence, as the Cronbach's alphas per dimension of the DigComp tool are within acceptable margins and do not deviate from those found in published studies (García-Vandewalle et al., 2023; Lim et al., 2021). The measures of Cronbach's Alpha with Confidence Intervals for the five Dimensions of the DigComp tool were all above 0.7. Values above 0.7 are generally acceptable (Nunnally & Bernstein, 1994). A 0.90 cut-off has been recommended for individual assessments (Hays & Revicki, 2005), where measurement error is of greater concern. Cronbach's alpha is arguably the most widely used reliability estimator. This finding means that the responses on the five dimensions by the respondents are acceptable without raising any dimensional bias raised on any of them.

Although the findings among Zimbabwean secondary school teachers are comparable to international evidence, what differs is how DigComp dimensions are ranked in each country, wherein the order may change. However, in most cases, Information and Digital Literacy are always at the top of the ranking, followed by Communication and Collaboration (García-Vandewalle et al., 2023; Lim et al., 2021; Nančovska Šerbec et al., 2016; Tsankov & Damyanov, 2019). The significance of these two dimensions was also shown in the Factor Analysis (see Table 4). Perhaps these two dimensions are significant among teachers as they impart knowledge and information, and some of these tasks require some form of collaboration. Although there is an interchange between problem-solving and safety, the latter seems to be ranked lower in most cases (García-Vandewalle et al., 2023; Lim et al., 2021; Nančovska Šerbec et al., 2016; Tsankov & Damyanov, 2019). This may be consistent with recent results from Hidayat et al. (2023), who established that problem-solving items are usually the hardest in the DigComp tool. Zhang et al. (2023) explained that the order in which the top three dimensions appear shows a significant positive relationship with the use of specific applications that teachers use daily, either for work or personal purposes. In addition, a systematic review by Torres-Hernández and Gallego-Arrufat (2022) found that teachers with lower scores on the safety dimension could be attributed to issues such as “management of digital identity”, “copyright and licences”, and “innovation and creative technology use”. Perhaps the lower scores on the management of digital identities can be closely identified in this study, whereas the other components are spread to other dimensions, such as copyright, licencing, innovation, and creative technology use in the Digital Content Creation dimension.

At the Intermediate level, the DigComp handbook states that this level of proficiency means that a person can explain, perform well-defined routines, illustrate what they can do, and

organise and describe tasks conducted using digital tools. Zimbabwean secondary school teachers seem to be at par with secondary school teachers from Spain (García-Vandewalle García et al. 2023) and Macedonia and Slovenia (Nančovska Šerbec et al. 2016) but above the level of Bulgaria (Tsankov and Damyanov 2019).

Regarding demographic composition, the noticeably larger percentage of STEM teacher's responses is because STEM teachers volunteer to participate due to their confidence in the computing gadgets. Most of those teachers have first degrees in STEM subjects, where the introduction to computers is a foundational course taught to all university first years. The Kaiser-Meyer-Olkin was greater than 0.8, implying that the sampling mechanism chosen was adequate to validate the results. Thus, the survey conducted is repeatable in other settings using the same sampling criteria and produced admissible results.

Fig 2 implies that the average teacher in secondary schools has an above-average understanding of information and data literacy, communication, and collaboration. This observation is as a result of the theoretical foundation on computing knowledge which is taught at training colleges and in books that are available at schools and the communication and collaboration knowledge are as a result of the penetration of mobile devices into the general public which are used for social medial communications and email services. The other three dimensions of content creation, safety, and problem-solving hover around the average mark, showing a lack of application of knowledge to solve educational and personal problems using digital skills. This is attributed to the low number of computing teachers and general lack of exposure. There is a lack of awareness programs to educate the public on safety issues. The lack of computing resources and teaching staff hampers content-creation skills in most schools. The poor salaries earned by teaching professionals lead to skills flight; those who have the skills of content creation leave the profession to join the private IT industry either locally or abroad.

The low digital literacy levels found in teachers with +56 years and those with +41 years of teaching experience are an indication of the teacher training that was in the earlier years fell short of digital skills. The fact that up to now, they are still exhibiting low digital skills competencies is a sign of resistance to change and failure to continuously learn. This also implies that there is no evidence of interventions by the parent ministry to capacitate senior staff on continuous learning programs. On a positive note, the higher digital skills competencies in the younger generation are an indication of the adaptive revised curriculum to incorporate digital skills at teacher training colleges, as well as the benefits of Generation Z which is born

in the digital age. Furthermore, the government in addition to recruiting and incentivising computing teachers can also take initiatives to capacitate schools with computing resources as well as electricity infrastructure to promote digital skills acquisition which are critical for competition in the fourth industrial revolution

Overall, the study findings on the DigComp questionnaire cannot explain the reasons for the gendered differences in the statements and dimensions of the scale. However, Jiménez-Hernández et al. (2020) is a typical study that explored the gendered differences in the DigComp tool among secondary teachers. Jiménez-Hernández et al. (2020) found that women scored lower than men in some categories of the scale. Jiménez-Hernández et al. (2020) found that this trend was higher in the Information and Data Literacy and Communication and Collaboration dimensions. The current study found similar results after performing CFA and Mann-Whitney U tests. However, comparisons of specific statements from DigComp cannot be made with this study because the number of items differs and the scale from Jiménez-Hernández et al. (2020).

Previous studies have applauded the DigComp tool for its ability to determine digital competences by age groups, thereby providing a space to study intergenerational differences. One noticeable trend is that Generation X (those born 1960-1980) often have the lowest scores on the DigComp tool (Khan and Vuopala 2019). The results of this study are consistent with the observation that the +56 years (Generation X) category was found to have overall novice skills, while other age groups had Intermediate Skills. In this study, Generation X had the lowest scores on the Problem-Solving dimension compared with the other dimensions and age groups. However, this is not relative to Generation X alone, as other age groups scored lower in this dimension. Khan and Vuopala (2019) made the same observation when comparing the scores of different age groups on the Problem-Solving dimension.

In summary, the findings of the study indicate that it is necessary to provide teachers at secondary schools with training and ongoing learning opportunities in digital skills. This is because the study revealed the importance of these skills for effective teaching and learning in the digital age. These teachers, in turn, will be able to teach and produce learners who are digitally competent and able to compete in the global sphere of innovation and industrialisation. Teacher training institutions should adapt to the fast-changing digital world through continuous curriculum reviews since teachers produce professionals who will contribute to Zimbabwe's economic growth and revolution.

Conclusions

This was the first assessment of secondary teachers using the DigComp tool in Africa. Previous studies conducted in Asia (China and Malaysia) and Europe (Macedonia, Slovenia, and Spain) have included mostly pre-service teachers instead of in-service teachers. When compared to other studies, this is the largest study considering our sample size. Therefore, the findings could be more accurate. However, comparisons with previous studies should be taken with caution as there are differences in the socio-economic contexts of other countries and the DigComp tools used (e.g., differences in Likert scales, number of statements, whether other studies consider the combination of knowledge, skill, attitude or if they focus their attention only on one of these, etc.). In the context of Zimbabwe, the findings are only generalisable to secondary school teachers and may not apply to other sectors of the economy or at least the general population. However, the study is proof of the richness of DigComp in assessing digital competences in Zimbabwe. The study's methods can be adapted and adopted in other facets of socio-economic life. There is insufficient data from the findings to support the reasons behind the differences in the gendered usage of digital competences. This may be an area that needs further exploration. There should also be a population-wide assessment of digital literacy to determine whether the results of the study are comparable to those of other sectors or different populations. Finally, the Government of Zimbabwe should consider a follow-up study targeting teacher-training institutions to evaluate the acquisition of digital skills by teachers at the training level.



References

- Alnasib, Badiyah N.M. 2023. “Digital Competencies: Are Pre-Service Teachers Qualified for Digital Education?” *International Journal of Education in Mathematics, Science and Technology* 11(1): 96–114.
- Arslantas, T.K., Gul, A. Digital literacy skills of university students with visual impairment: A mixed-methods analysis. *Educ Inf Technol* 27, 5605–5625 (2022). <https://doi.org/10.1007/s10639-021-10860-1>
- Dabengwa, I. M., Gashirai, T. B., Moyo, S., Ncube, S., Makaza, D., Makoni, P., Pasipamire, N., Chademana, G. K., Mufudzi, M., Mandaza, D., & Mapfumo, S. (2024). An Assessment of Digital Literacy Skills Among Secondary School Teachers Using the Digcomp Tool. Harare: Postal Regulatory Authority of Zimbabwe. Available at: <https://www.potraz.gov.zw/wp-content/uploads/2024/05/An-Assessment-of-Digital-Literacy-Skills-amongst-Secondary-School-Teachers-in-Zimbabwe-2024.pdf>
- van Deursen, Alexander, J.A.M., Ellen J Helsper, and Rebecca Eynon. 2014. “Measuring Digital Skills: From Digital Skills to Tangible Outcomes Project Report.” *From Digital Skills to Tangible Outcomes project report* (November): 1–50. www.oii.ox.ac.uk/research/projects/?id=112 (September 30, 2022).
- Europass. 2022. “Test Your Digital Skills.” <https://europa.eu/europass/digitalskills/screen/home> (September 4, 2022).
- García-Vandewalle García, José Manuel, Marina García-Carmona, Juan Manuel Trujillo Torres, and Pablo Moya Fernández. 2023. “Analysis of Digital Competence of Educators (DigCompEdu) in Teacher Trainees: The Context of Melilla, Spain.” *Technology, Knowledge and Learning* 28(2): 585–612. <https://doi.org/10.1007/s10758-021-09546-x>.
- Global Alliance to Monitor Learning. 2018. “Global Alliance to Monitor Learning.” https://gaml.cite.hku.hk/exec_summary/ (September 20, 2023).
- Godaert, E., Aesaert, K., Voogt, J., & van Braak, J. (2022). Assessment of students’ digital competences in primary school: a systematic review. *Education and Information*

- Technologies, 27(7), 9953–10011. <https://doi.org/10.1007/s10639-022-11020-9>
- Gümüş, M. M., & Kukul, V. (2023). Developing a digital competence scale for teachers: validity and reliability study. *Education and Information Technologies*, 28(3), 2747-2765.
- Hidayat, M. L. et al. 2023. “Science Learning in Answering Digital Competency Needs of Pre-Service Math and Science Teachers in the Stem Context.” *Jurnal Pendidikan IPA Indonesia* 12(3): 410–22.
- Khvilon, E. & Patru, M., 2002. Information and communication technologies in teacher education: a planning guide, UNESCO: United Nations Educational, Scientific and Cultural Organisation. France. Retrieved from <https://policycommons.net/artifacts/8863186/information-and-communication-technologies-in-teacher-education/9714667/> on 06 Aug 2024. CID: 20.500.12592/95x6b6p.
- International Telecommunications Union [ITU]. 2020. *Digital Skills Assessment Guidebook*. International Telecommunication Union. https://academy.itu.int/sites/default/files/media2/file/D-PHCB-CAP_BLD.04-2020-PDF-E_02 June 2020.pdf.
- Jiménez-Hernández, David et al. 2020. “Digital Competence of Future Secondary School Teachers: Differences According to Gender, Age, and Branch of Knowledge.” *Sustainability* 12(22): 9473. <https://www.mdpi.com/2071-1050/12/22/9473>.
- Khan, Fawad, and Essi Vuopala. 2019. “Digital Competence Assessment Across Generations.” *International Journal of Digital Literacy and Digital Competence* 10(2): 15–28.
- Lim, Yi Shern, Hasliza Abdul Halim, and T. Ramayah. 2021. “Agile or Not? The Upsurge of Digcomp and Social Media Usage among Teachers.” *Journal of Applied Structural Equation Modeling* 5(2): 1–21.
- Mattar, João, Daniela Karine Ramos, and Margarida Rocha Lucas. 2022. “DigComp-Based Digital Competence Assessment Tools: Literature Review and Instrument Analysis.” *Education and Information Technologies* 27(8): pp.10843–67.
- Nančovska Šerbec, I., Žerovnik, A., Juvan, N., Rečkoska-Šikoska, U., & Davčev, D. (2017). “Digital Competences of Selected University Students from Macedonia and

- Slovenia.” In: *STOJANOV, Georgi (ed.), KULAKOV, Andrea (ed.). ICT Innovations 2016 : web proceedings. 8th International Conference ICT Innovations 2016, 5th till 7th of September 2016, Ohrid, Macedonia. Skopje: ICT ACT, [2017?]. Str. 82-92, tabeli, graf. prikazi.* <https://drive.google.com/file/d/0B4RZn-jt9f60ak84NXBNN3BCSldaRC1iNzN6MkwwVGF0Mnpj/view>.
- Nunnally, J.C. and Bernstein, I.H. (1994) The Assessment of Reliability. *Psychometric Theory*, 3, 248-292.
- Peng, Danhua and YuA, Zhonggen.(2022). “Literature Review of Digital Literacy over Two Decades”. *Education Research International*. Vol. (2022), Article ID 2533413, pp. 1-8. <https://doi.org/10.1155/2022/2533413>
- Pérez-Navío, Eufrasio, María Teresa Ocaña-Moral, and María Del Carmen Martínez-Serrano. 2021. “University Graduate Students and Digital Competence: Are Future Secondary School Teachers Digitally Competent?” *Sustainability (Switzerland)* 13(15): 1–14.
- Revicki, DA & Hays, Ron. (2005). “Reliability and validity (including responsiveness)”. *Assessing Quality of Life in Clinical Trials: Methods and Practice*. 2. 25-39.
- Salkind, Neil J, and Bruce B Frey. 2020. *Study Guide to Accompany Salkind and Frey’s Statistics for People Who (Think They) Hate Statistics*. 7th ed. Los Angeles: SAGE Publications Inc.
- Nančovska Šerbec, I., Žerovnik, A., Juvan, N., Rečkoska-Šikoska, U., & Davčev, D. (2017). Digital competences of selected university students from Macedonia and Slovenia. *ICT Innovations 2016 Conference (September)*.
- Siddiq, F., Hatlevik, O. E., Olsen, R. V., Throndsen, I., & Scherer, R. (2016). Taking a Future Perspective by Learning from the Past - A Systematic Review of Assessment Instruments that Aim to Measure Primary and Secondary School Students’ ICT literacy. *Educational Research Review*, 19, 58–84. <https://doi.org/10.1016/j.edurev.2016.05.002>
- Tinmaz, Hasan, Yoo Taek Lee, Mina Fanea-Ivanovici, and Hasnan Baber. 2022. “A Systematic Review on Digital Literacy.” *Smart Learning Environments* 9(1). <https://doi.org/10.1186/s40561-022-00204-y>
- Torres-Hernández, N., & Gallego-Arrufat, M. J. (2022). Indicators to Assess Preservice

- Teachers' Digital Competence in Security: A Systematic Review. *Education and Information Technologies*, 27(6), 8583–8602. <https://doi.org/10.1007/s10639-022-10978-w>
- Tsankov, Nikolay, and Ivo Damyanov. 2019. "The Digital Competence of Future Teachers: Self -Assessment in the Context of Their Development." *International Journal of Interactive Mobile Technologies* (12): 4–18.
- Tugba Kamali Arslantas and Abdulmenaf Gul 2022, Digital literacy skills of university students with visual impairment: A mixed-methods analysis. *Education and Information Technologies* (2022) 27:5605–5625
- UNESCO. 2018. "A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2." *Information Paper n°51* (51): 146. <http://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf>. Consultado em 05fev2023, 17:45.
- United Kingdom Department of Education. 2019. "Essential Digital Skills Framework." <https://www.gov.uk/government/publications/essential-digital-skills-framework/essential-digital-skills-framework> (September 30, 2022).
- Vuorikai, Riina, Stefano Kluzer, and Yves Punie. 2022. *DigComp 2.2 - The Digital Competence Framework for Citizens*.
- Weber, Robert Philip. 1990. 82 *Journal of the American Statistical Association Basic Content Analysis*.
- Zhang, Shuting, Michelle Mingyue Gu, Wang Sun, and Tan Jin. 2023. "Digital Literacy Competence, Digital Literacy Practices and Teacher Identity among Pre-Service Teachers." *Journal of Education for Teaching* 00(00): 1–15. <https://doi.org/10.1080/02607476.2023.2283426>