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Exploration of information literacy, technological pedagogical and content knowledge and technological integration self-efficacy abilities of preservice chemistry teachers

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Abstract: Teachers' competence to master information literacy and integrate technology into the learning process is essential in the era of the industrial revolution. The purpose of this study is to describe the profile of information literacy (IL), Technological Pedagogical and Content Knowledge (TPACK), and Technology Integration Self-Efficacy (TISE) abilities of preservice chemistry teachers. This study employed a survey research method involving 70 preservice chemistry teachers in the Study Program of Chemistry Education at the State University of Surabaya, all of whom had completed an educational internship course. Data were collected through information literacy ability tests, TPACK, and TISE questionnaires. The data were analyzed using both descriptive and correlation analyses. The results indicated that the three research instruments demonstrated high validity and reliability. The preservice chemistry teachers' IL, TPACK, and TISE abilities were categorized as high, with average scores of 79.47, 80.86, and 80.07, respectively. Additionally, the study found positive and significant correlations between IL and TPACK, IL and TISE, as well as between TPACK and TISE among preservice chemistry teachers. The findings imply that IL, TPACK, and TISE are crucial competencies that need to be developed in preservice chemistry teachers to enhance their overall teaching competence.
Keywords: *Information literacy, Preservice chemistry teachers, TISE, TPACK.*

1. Introduction

The rapid development of science and technology in the era of the industrial revolution 4.0 presents a major challenge for the education system to produce a generation with greater critical thinking and creativity [1, 2]. The learning process implemented by teachers must prepare students to face the challenges of the 21st century, enabling them to solve real-world problems that are constantly changing and increasingly complex. Hence, students should be equipped with 21st-century skills, namely creativity and innovation, critical thinking and problem solving, communication, and collaboration. Consequently, the schools' learning process is expected to make students more productive, creative, innovative, and effective [3].

Teachers become crucial agents in efforts to improve the quality of education because they are the spearhead of educational planning and learning in schools [4-6]. In other words, the quality of teachers greatly determines how the learning process is carried out. Many empirical studies have successfully revealed a positive relationship between teacher quality and student success [7]. This

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implies that teachers play a key role in determining student success. The presence of professional and qualified teachers is essential to improving the quality of education in Indonesia.

The development of information technology in the era of the industrial revolution 4.0 demands the availability of human resources who master science and technology [8-10]. A good understanding of technology must be acquired by teachers so they can utilize it for the learning process [11]. Teachers' mastery of technology is an important factor in determining the quality of a teacher [12]. Various technological products can be in the form of goods or hardware, such as computers, smartphones, televisions, projectors, and other systems, as well as software, including Windows, Android, internet applications, PowerPoint, video player applications (e.g., Windows Media Player), and other applications [13]. Thus, a teacher must be able to master and integrate technology into the learning process to achieve learning objectives effectively. One of the latest concepts used in integrating technology into learning is known as Technological Pedagogical and Content Knowledge (TPACK).

TPACK is a development of Pedagogical Content Knowledge (PCK), which was first proposed by Shulman [14] and Rahmadi [13]. PCK is a concept used as a benchmark for the quality of a teacher's professionalism. However, the PCK concept has not received adequate support because it has not been linked to technological integration. PCK consists of Content Knowledge (CK), Pedagogical Knowledge (PK), and a combination of the two, Pedagogical Content Knowledge (PCK) itself. To address the lack of technological integration in the PCK concept, the TPACK framework was proposed.

In addition, Bandura proposed a theory related to self-efficacy or self-confidence, which states that increasing teacher knowledge will enhance self-confidence or self-efficacy, thereby improving the use of technology in learning [15]. The level of self-confidence or self-efficacy of teachers in integrating technology into the learning process is called Technology Integration Self-Efficacy (TISE). TISE can then be an indicator that has a major influence on the success of implementing technology in learning activities. TISE and TPACK can influence teacher performance in integrating technology into learning.

Learning in today's era of rapid information presents a challenge for teachers to have information literacy skills, which can be implemented to achieve learning objectives effectively and efficiently. Prior studies show that learners who are familiar with information literacy and IT achieve improved learning outcomes [16]. The results of Muthmainnah [17] conclude that there is a very strong positive correlation between understanding digital/information literacy and writing originality in English Language Education students. Another study, namely the application of the "Empowering Eight" information literacy model in research methods courses, can improve problem-solving skills, critical thinking skills, and also learner confidence [18].

Therefore, this study aims to explore and analyze the information literacy, TPACK, and TISE abilities of preservice chemistry teachers. Research on TPACK ability has been reported on preservice chemistry teachers and chemistry teachers [19-21]. However, these prior studies have not been supported by an analysis of information literacy and TISE. Therefore, this study aims to examine the profile of information literacy, TPACK, and TISE abilities of preservice chemistry teachers and analyze the relationship between these three competencies.

2. Literature Review

2.1. Information Literacy

Information literacy is a set of skills that requires individuals to recognize when information is needed and to have the ability to find, evaluate, and use the required information effectively [22]. Meanwhile, according to Doyle, information literacy is the ability to access, evaluate, and use information from various sources, both in digital and print. Information literacy serves as a foundation for lifelong learning [23].

Information literacy can be applied across all disciplines, learning environments, and educational levels. Mastery of these skills enables students to understand content and broaden their inquiry, making them more independent and better able to take control of their own learning [22]. A person's mastery of information literacy can be measured using specific assessments, such as the standards issued by

ACRL, namely the Information Literacy Competency Standards for Higher Education. An individual is considered information literate if they meet five competency standards: (1) the ability to determine the extent of information needed; (2) the ability to access the required information effectively and efficiently; (3) the ability to evaluate information and its sources critically and to organize and integrate selected information into their knowledge base; (4) the ability to use information effectively to achieve specific goals; (5) an understanding of the economic, legal, and social issues surrounding the use of information, including the ability to access and use information ethically and legally, as well as to determine the nature and scope of information [24].

2.2. Technological Pedagogical and Content Knowledge (TPACK)

TPACK is a framework designed to integrate technology, pedagogy, and teaching materials into the learning process [25, 26]. It is considered a conceptual model that connects the use of technology with classroom teaching and learning. TPACK emerged as an extension of the Pedagogical Content Knowledge (PCK) framework, which previously did not give sufficient attention to the role of technology in learning [25]. In the era of the Fourth Industrial Revolution, teachers are required to master technology so that it can be effectively integrated into the learning process [26, 27].

TPACK is divided into three core components: technological knowledge (TK), content knowledge (CK), and pedagogical knowledge (PK). These three components interact with one another in practice. The interaction among these components generates additional forms of knowledge, namely PCK, TCK, and TPK, as well as the integrated framework known as TPACK [25, 26]. TPACK has functions that extend beyond the earlier PCK concept, making it a useful framework for analyzing teachers' knowledge related to the integration of technology into the learning process [25, 28].

The success of the learning process can be measured using the TPACK framework, as it reveals the level of understanding and mastery that teachers or pre-service teachers have in comprehending, utilizing, and integrating technology into the learning process [26, 28]. There are several benefits that researchers or teachers can obtain from measuring TPACK, including (1) identifying a teacher's TPACK profile, (2) providing a basis for reflection in the learning implementation process, and (3) determining the impact of learning interventions related to technology integration [25]. The TPACK framework can also support the development of teacher professionalism in addressing the challenges of 21st-century learning, particularly those related to technology-enhanced instruction [29].

2.3. Technology Integration Self-Efficacy (TISE)

The type of the current study is a survey research because it is intended to describe data on information literacy, TPACK, and TISE abilities of preservice chemistry teachers. The population of this study consisted of preservice chemistry teachers in the Chemistry Education study program, Faculty of Mathematics and Natural Sciences, State University of Surabaya, class of 2022, who had taken an educational internship course in a senior high school. Among them, 70 preservice chemistry teachers agreed to participate in the study [22].

TISE can be measured using a questionnaire consisting of two indicators: (1) the ability to use technology strategically and (2) the external influence of computer technology use [30]. The first indicator relates to a teacher's belief in their own skills to use technology as a tool that supports the learning process. The second indicator concerns a teacher's belief that external factors may influence their ability to use technology. Researchers have suggested that self-efficacy regarding computer use and technology integration in the learning process influences a teacher's ability to create an effective and meaningful learning environment.

3. Methodology

3.1. Research Design and Samples

The type of the current study is a survey research because it is intended to describe data on information literacy, TPACK, and TISE abilities of preservice chemistry teachers. The population of this study consisted of preservice chemistry teachers in the Chemistry Education study program, Faculty of Mathematics and Natural Sciences, State University of Surabaya, class of 2022, who had taken an educational internship course in a senior high school. Among them, 70 preservice chemistry teachers agreed to participate in the study [31].

3.2. Instruments of Data Collection

The data required in this study consist of information literacy, TPACK, and TISE abilities of preservice chemistry teachers. Data on information literacy, TPACK, and TISE abilities were obtained using information literacy tests, TPACK questionnaires, and TISE questionnaires, respectively. The information literacy test was adapted from the standards issued by ACRL, namely the Information Literacy Competency Standards for Higher Education. The test contains 15 items that measure five indicators of information literacy, namely: (1) Ability to determine the extent of information needed, (2) ability to access the information needed effectively and efficiently, (3) ability to evaluate information and its sources critically, (4) ability to organize and combine selected information into their knowledge base, (5) ability to use information effectively to achieve certain goals, and (6) ability to understand economic, legal, and social issues surrounding the use of information, accessing and using information ethically and legally, and determining the nature and scope of information [24].

The TPACK questionnaire contains seven indicators, namely Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Pedagogical Knowledge Technology Knowledge (TPK), and Pedagogical and Content Technology Knowledge (TPACK). The TPACK questionnaire contains 38 items, consisting of TK, CK, PK, PCK, TCK, TPK, and TPACK indicators with 9, 4, 6, 5, 3, 7, and 4 items, respectively [28]. The TPACK scores obtained are categorized as very high (VH) (86-100), high (H) (76-85), moderate (M) (60-75), low (L) (55-59), and very low (VL) (less than 55) [32]. Meanwhile, the TISE questionnaire contains two indicators with 21 items, measuring (1) the ability to use technology strategically (16 items) and (2) the external influence of the use of computer technology (5 items) [24, 30]. Before being used to collect data, the information literacy test, TPACK questionnaire, and TISE questionnaire for preservice chemistry teachers were validated by three chemistry education experts. The obtained data were analyzed using descriptive quantitative methods [31].

3.3. Data Analysis

3.3.1. Validation Analysis

Three measurement instruments were developed, namely the information literacy test, the TPACK questionnaire, and the TISE questionnaire for preservice chemistry teachers. Before being used for data collection, the three instruments were validated by three experts in science education. Instrument validity was measured using the Aiken value, calculated using the following equation:

$$V = \frac{\Sigma s}{n\,(c-1)}$$

Note: V = Validity of item (Aiken value), s =The score given by the validator is subtracted from the lowest score (r – lo), where r = Score given by the validator, c = Highest validity score (in this case = 4), lo = Lowest validity score (in this case = 1), n = Number of validators. The obtained Aiken value is interpreted for validity according to the criteria presented in Table 1.

Table 1.
Interpretation of the Aiken value.

Aiken value (V)	Criteria
> 0.8	High
0.4 ≤ V < 0.8	Medium
< 0.4	Low

Source: Nurjanah et al. [33].

Meanwhile, the reliability of the instruments is assessed based on the interobserver agreement obtained from the statistical analysis of the percentage of agreement (PA).

$$PA = \left[1 - \frac{A-B}{A+B}\right] x\ 100\%$$

Note:
A = The frequency of the aspect observed by the observer, giving a high frequency
B = The frequency of the aspect observed by the observer, giving a low frequency
Observer in this study is a validator. The results of the validation of the instruments are reliable if they have a percentage ≥ 75% [34, 35].

3.3.2. Correlation Analysis

To determine the relationship between information literacy and TPACK, information literacy and TISE, and between TPACK and TISE of preservice chemistry teachers, a simple linear regression analysis was conducted using SPSS. Before analyzing the correlation, each data point was tested for normality. The level of correlation strength was classified as shown in Table 2.

Table 2.
Interpretation of the correlation coefficient.

Correlation coefficient (*r*)	Level of correlation strength
0.00 - 0.199	Very weak
0.200 - 0.399	Weak
0.400 - 0.599	Medium
0.600 - 0.799	Strong
0.800-1.00	Very strong

Source: Handini [29].

4. Results and Discussion

4.1. Validity of the Instruments

This study used three instruments for data collection: an information literacy test, the TPACK questionnaire, and the TISE questionnaire for preservice chemistry teachers. Validation results from three science education experts yielded validation scores expressed as Aiken's V. Meanwhile, the reliability of the validators' assessments was expressed as a percentage of agreement (PA). The results of the research instrument validation are presented in Table 3.

Table 3.
Validity of research instruments.

No	Research instrument	Type of validity	Validity		Reliability	
			Aiken value	Category	*R* (%)	Category
1	Information Literacy Ability Test	Content validity	0.93	High	95.24	Reliable
		Construct validity	0.92	High	94.28	Reliable
Average scores			0.93	High	94.76	Reliable
2	TPACK questionnaire	Content validity	0.89	High	90.47	Reliable
		Construct validity	0.88	High	92.06	Reliable
Average scores			0.89	High	91.27	Reliable
3	TISE questionnaire	Content validity	0.89	High	93.65	Reliable
		Construct validity	0.94	High	95.77	Reliable
Average scores			0.92	High	94.71	Reliable

Based on the validation results in Table 3, it can be stated that the information literacy test, TPACK, and TISE scores have Aiken values of 0.93, 0.89, and 0.92, respectively. Because the Aiken value is greater than 0.8, the validity of the three research instruments is categorized as high [30]. Moreover, the reliability of the validator's assessment results for the three research instruments is greater than 75%, so all three instruments are categorized as reliable [34, 35]. Thus, the three instruments are valid and reliable, enabling their use in data collection.

4.2. Preservice Chemistry Teachers' Information Literacy Ability

Preservice teachers' information literacy skills were measured using an information literacy test containing five indicators with fifteen items [24]. Table 4 shows the results of the preservice teachers' information literacy ability.

Table 4.
Preservice chemistry teachers' information literacy ability.

Preservice chemistry teachers (*N*)	**Score of information literacy ability indicators**					**Average score**	**Category**
	1	**2**	**3**	**4**	**5**		
70	78	53	86	91	97	79.47	High

The preservice chemistry teachers' information literacy ability ranged from 33 to 100. Of the 70 preservice chemistry teachers, 4 teachers (5.71%) had very low information literacy ability, 16 teachers (22.86%) had medium, 18 teachers (25.71%) had high, and 32 teachers (45.71%) had very high levels of information literacy. The average score of information literacy among preservice chemistry teachers was 79.47, categorized as high [32]. The average score of each indicator of information literacy is presented in Figure 1.

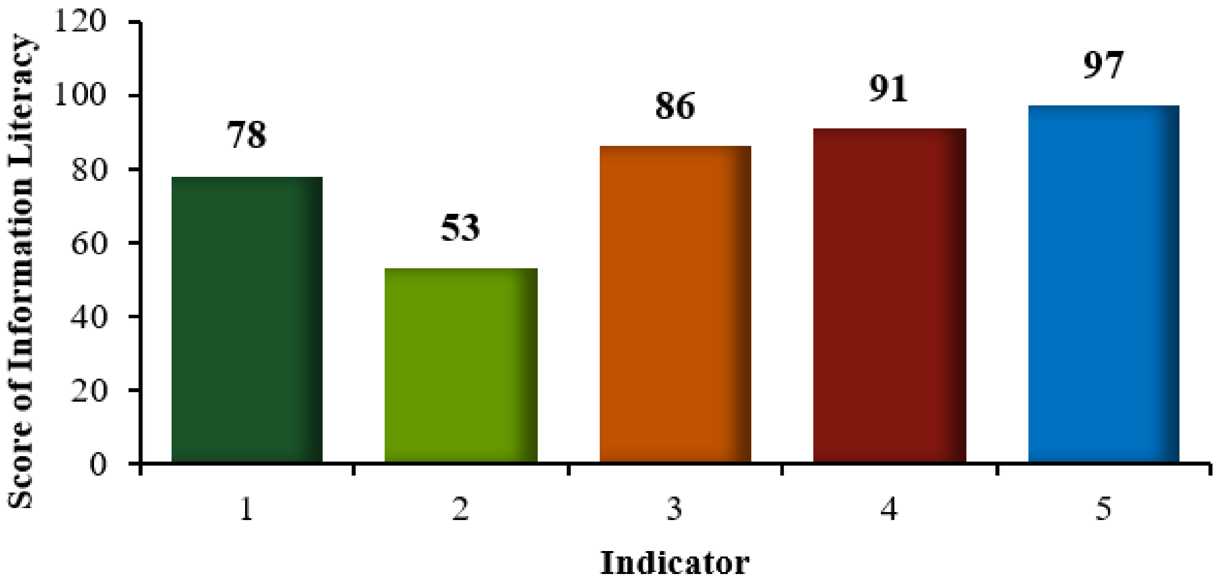

Figure 1.
Average score of preservice chemistry teachers' information literacy per indicator.

The fifth indicator, namely understanding economic, legal, and social issues surrounding the use of information, accessing and using information ethically and legally, and determining the nature and scope of information, obtained the highest score with an average of 97. The fourth information literacy indicator obtained the second-highest average score, namely, using information effectively to achieve certain goals, with an average score of 91. Meanwhile, the second indicator, namely being able to access the required information effectively and efficiently, obtained the lowest score with an average score of 53.

4.3. Preservice Chemistry Teachers' TPACK Ability

Preservice chemistry teachers' TPACK abilities were measured using a TPACK questionnaire containing seven indicators with 38 items [32]. Table 5 shows the results of the preservice teachers' TPACK ability.

Table 5.
Preservice chemistry teachers' TPACK ability.

Preservice chemistry teachers (*N*)	Score of the TPACK ability indicator							TPACK score	Category
	TK	CK	PK	PCK	TCK	TPK	TPACK		
70	83	79	77	77	86	82	85	80.86	High

Preservice chemistry teachers' TPACK ability ranges between 59 and 96. Of the 70 preservice chemistry teachers, only one preservice teacher (1.42%) had low TPACK ability, 18 preservice teachers (25.71%) had medium TPACK ability, 27 preservice teachers (38.57%) had high TPACK ability, and 24 preservice teachers (34.29%) had very high TPACK ability. The average score of the preservice chemistry teachers' TPACK ability was 80.86, categorized as a high level [32]. Figure 2 presents the average score of each indicator of TPACK ability.

The TPACK indicator has the highest score, with an average of 85, followed by the TPK indicator with an average of 82. Meanwhile, the PCK and TCK indicators show the lowest scores, at 76. The average score of the seven TPACK indicators perceived by preservice chemistry teachers exceeds 76, thus strongly supporting the achievement of TPACK in the high category.

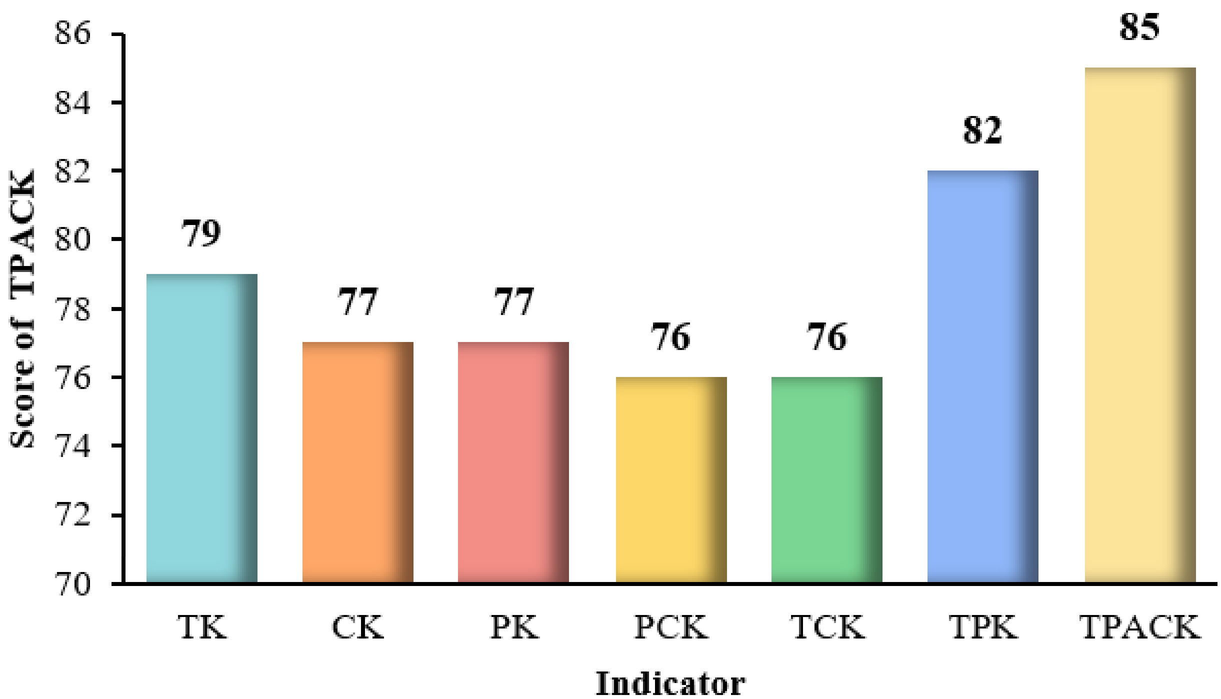

Figure 2.
Average score of each indicator of TPACK skills

4.4. Preservice Chemistry Teachers' TISE

In this study, preservice chemistry teachers' TISE was obtained using a TISE questionnaire containing two indicators with 21 items [30]. Table 6 portrays the results of the preservice chemistry teachers' TISE.

Table 6.
Preservice chemistry teachers' TISE.

Preservice chemistry teachers (*N*)	Score of the TISE indicator		TISE score	Category
	Indicator 1	Indicator 2		
70	79.16	80.97	80.07	High

Preservice chemistry teachers' TISE scores range from 46 to 98. Of the 70 preservice chemistry teachers, 3 (4.29%) had very low TISE, 2 (2.86%) had low TISE, 16 (22.85%) had medium TISE, 25 (35.71%) had high TISE, and the remaining 24 (34.26%) had very high TISE. The average TISE score of the preservice chemistry teachers is 80.07, categorized as high level [32]. Figure 3 shows the average score of each TISE indicator.

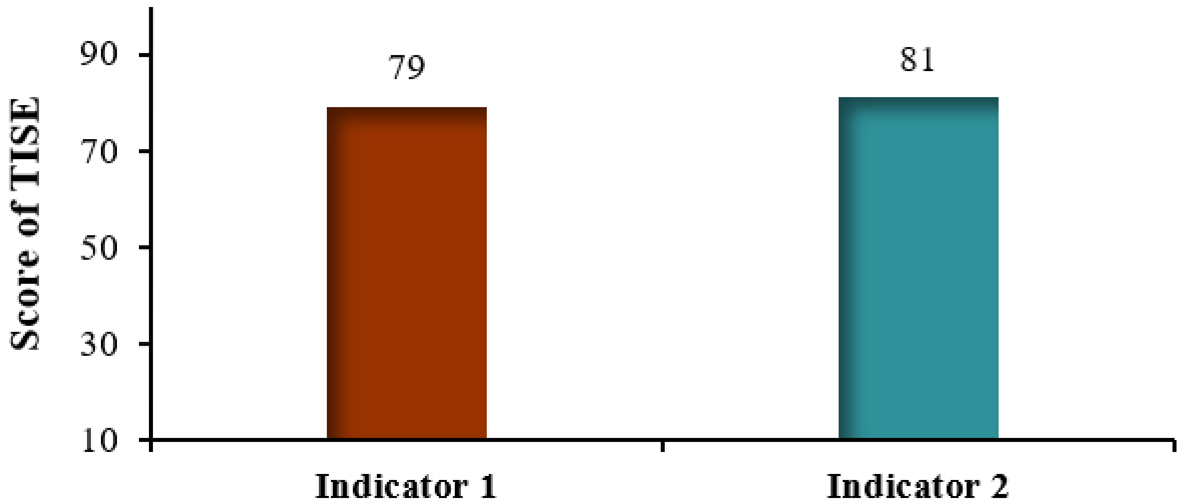

Figure 3.
The average score of each TISE indicator.

The second TISE indicator, namely the external influence of computer technology use, showed a higher score than the first indicator, namely the ability to use technology strategically, but the difference was not large. The average score of the two TISE indicators for preservice chemistry teachers (80.07) was categorized as high [32].

4.5. Correlation Analysis

The correlation analysis between preservice chemistry teachers' information literacy, TPACK, and TISE abilities was conducted using simple linear regression of two variables with SPSS [36]. Before conducting the correlation analysis, the data on information literacy, TPACK, and TISE abilities were tested for normality. Table 7 shows the results of the normality tests.

Table 7.
Results of the normality tests.

Samples (N = 70)	Kolmogorov-Smirnov				
	Data	Statistic	*df*	*p*-value	Description
Preservice chemistry teachers	Score of information literacy	0.055	70	0.200	Normal
	Score of TPACK	0.044	70	0.200	Normal
	Score of TISE	0.075	70	0.200	Normal

Based on the results of the normality test using the Kolmogorov-Smirnov test (Table 7), the *p*-value for the information literacy, TPACK, and TISE scores is 0.200 each. Because the *p*-value is greater than

0.05, the data on the information literacy, TPACK, and TISE scores are normally distributed [37]. Thus, a simple linear regression can be conducted. Table 8 shows the results of the correlation analysis between preservice chemistry teachers' information literacy, TPACK, and TISE abilities.

Table 8.
The results of the simple linear regression analysis.

No	Correlated variable	*N*	Correlation coefficient (*r*)	*p*-value	Description
1	Preservice chemistry teachers' information literacy and TPACK abilities	70	0.506	0.000	Significant
2	Preservice chemistry teachers' information literacy ability and TISE	70	0.281	0.019	Significant
3	Preservice chemistry teachers' TPACK ability and TISE	70	0.270	0.024	Significant

Table 8 showed that the correlation coefficient values between information literacy and TPACK abilities, information literacy and TISE abilities, and TPACK and TISE abilities are 0.506, 0.281, and 0.270, respectively. The correlation coefficient values are significant because all three *p*-values are smaller than 0.05. The correlation between information literacy and TPACK abilities is categorized as moderate [38]. Meanwhile, the correlation between information literacy and TISE abilities and the correlation between TPACK with TISE abilities are categorized as low [37]. Thus, the three skills, namely information literacy, TPACK, and TISE, are crucial for training preservice chemistry teachers to improve their competence. This finding is supported by previous research, which showed that teachers' ability to integrate technology significantly impacts their pedagogical skills and creativity in learning.

5. Conclusion

This study concludes that the three developed instruments, namely the Information Literacy Test, the TPACK Questionnaire, and the TISE Questionnaire for preservice chemistry teachers, demonstrated strong psychometric properties, evidenced by high levels of validity and reliability. This study also found that preservice chemistry teachers exhibit consistently high levels of information literacy skills, TPACK skills, and TISE, with mean scores of 79.47, 80.86, and 80.07, respectively. Correlational analyses indicate positive and significant relationships among the three constructs, with moderate to weak yet meaningful associations between information literacy and TPACK abilities (r = 0.506), information literacy and TISE abilities (r = 0.281), and TPACK and TISE abilities (r = 0.270). Collectively, these findings provide empirical support for the theoretical interrelatedness of these competencies and underscore the need for future studies to explore causal pathways, longitudinal development, and instructional interventions that can strengthen the integrated development of information literacy skills, pedagogical–technological competence, and teacher self-efficacy in preservice chemistry teacher education.

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Institutional Review Board Statement:

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Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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