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Fostering Preservice Chemistry Teachers' Digital Competence Through a Socio Scientific Issue-Based Technology Embedded Scientific Inquiry Model

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Abstract

A teacher who possesses digital competence will be able to use technology to support learning objectives in an effective and secure manner. Integrating socio scientific issue (SSI) approach in chemistry learning through technology embedded scientific inquiry (TESI) model can make students more active in discussing by using scientific evidence to make decisions regarding a problem. The preservice chemistry teachers' digital competence is measured using a questionnaire adapted from DigComEdu. The sample of the research was 61 preservice chemistry teachers in a state university in Yogyakarta, Indonesia, who took the environmental chemistry course at 2022/2023 academic years. An analysis of the normality of data is a prerequisite for statistical tests. Based on the research, it can be concluded that there were a significant different of digital competence between preservice chemistry teacher who follow environmental chemistry courses with the implementation of the SSI-based TESI and those who do not. The implementation of the SSI-based TESI model in environmental chemistry courses can foster the preservice chemistry teachers' digital competence before and after learning.

Keywords: *Digital Competence, Preservice Chemistry Teacher, Technology Embedded Scientific Inquiry.*

INTRODUCTION

The legal system in Indonesia states that professional teachers, including chemistry teachers, must have 4 competencies, namely professional competence, pedagogic competence, social competence and personality competence. These teacher competencies are not necessarily possessed by a teacher, but rather through cultivation and learning processes when a teacher is still studying as a teacher candidate at the higher education level.

A preservice teacher's mastery of ICT has received special attention, due to teachers' failure to use ICT in learning (Fulgence, 2020). Nevertheless, teachers realize that ICT contributes to the learning process (Gómez-Galán, 2020) as well as new learning methods (Bellou, et al, 2018). Integrating ICT in science learning can provide benefits, such as (1) growing and maintaining interest in learning over a long period of time, (2) teachers can convey material more easily, including abstract concepts that are difficult for students to understand, (3) expanding coverage. material taught by teachers, (4) facilitates students' learning styles, (5) fosters learning independence, and (5) encourages students to further develop conceptual and procedural knowledge (Mandal, 2019).

However, the rapid progress of ICT in education raises various concerns and challenges for people involved in the world of education (Toto, 2018), including the lack of real interaction between students in online learning (Nortvig, et al, 2018), the tendency to plagiarism (Arkorful & Abaidoo, 2015), a lack of reality in practicum activities, especially in the fields of science and medicine (Ma & Nickerson, 2006). The challenges related the integration of ICT in learning are (1) limited accessibility and internet network connections, (2) limited technical support in many schools, (3) lack of effective training for teachers, (4) limited time for teachers to use ICT in learning, and (5) lack of teacher digital competence (Ghavifekr, et al, 2016). Digital competence includes technical aspects related to hardware and software management, as well as cognitive abilities related to knowledge and education (Krumsvik, 2012). In the educational context, digital competence is defined as the use of technology in a convincing, appropriate and safe way to achieve learning and educational goals. Based

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on the terms of reference from Digcom Edu (Punnie, 2017), there are at least six digital competencies that teachers feel need to be mastered and pursued, which are:

Professional engagement, especially a competence that includes the use of digital technology as an effort to increase teacher professionalism.

Digital resources, especially competencies that include digital content creation and are related to various skills for developing, integrating and reelaborating digital content including protecting students' digital data.

Teaching and learning, especially competencies that include the use and monitoring of learning activities through digital content.

Assessment, especially competencies that include assessing aspects of digital learning.

Empowering learners, especially competencies that include empowering students in learning activities using digital content.

Facilitating learners' digital competence, especially competence that includes efforts to equip students with ethics and digital skills.

Technology in chemistry learning, such as Computer Assisted Instruction (CAI), which focuses more on independent learning through drill and practice or tutorials, is now being used less in educational institutions (Çalik & Ebenezer, 2018). This is due to a lack of support for 21st century skills identified by the National Education Association, which are critical thinking, communication, collaboration and creativity (Rahayu, 2017). In fact, simple but innovative technology that converts text into digital, such as Smartboard, PowerPoint and Podcasts, is more recommended for use (Çalik & Ebenezer, 2018).

In science learning, including chemistry, the scientific process is fundamental to the inquiry approach that is commonly used (NRC, 2012). The ICT integration model in chemistry learning that facilitates the basic inquiry approach is the Technology-embedded Scientific Inquiry (TESI) model (Çalik & Ebenezer, 2018). The TESI model has 3 components, which are (1) technology-embedded scientific conceptualization, (2) technology-embedded scientific investigation, and (3) technology-embedded scientific communication (Çalik & Ebenezer, 2018). The TESI model contributes greatly to the aspect of students' technological fluency, which is part of digital competence (Dias-Trindade & Gomes Ferreira, 2020).

Chemistry as part of science is used to solve various problems in students' environments through the scientific skills they acquire (Şimşek & Kabapınar, 2010). Students' mastery of scientific process skills will influence their point of view when discussing controversial issues that develop in society due to advances in science and technology (Anagün & Özden, 2010) or more often called Socio-scientific Issues (SSI). SSI-based learning is carried out to present social problems contextually (Nuangchalerm, 2010), so that students are faced with various problems in the environment around them and try to find solutions to overcome these problems, such as global warming and climate change (Sadler & Zeidler, 2009).

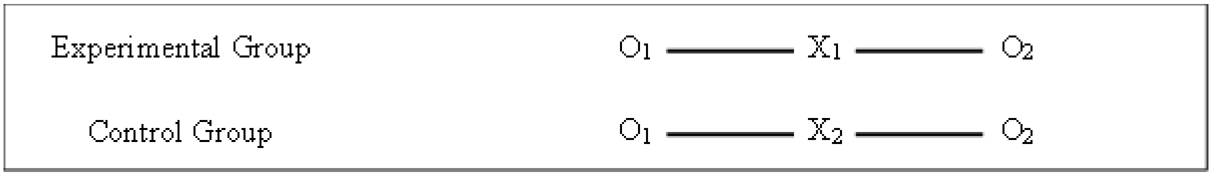
The SSI-based TESI model is intended to integrate SSI steps in the inquiry process in chemistry learning, which are (1) problem approach and analysis, (2) problem clarification through practicum activities, (3) continuing social problem issues, (4) discussion and evaluation, and (5) metareflection (Marks & Eilks, 2009). This model is expected to be able to increase both of preservice chemistry teachers' understanding of contextual problems in the environment and the digital competence.

Methods

Research Design

The method used in this research was quasi-experimental with a pretest-posttest design of a nonequivalent control group (Nicolaidou et al., 2021). The experimental design is showed in Figure 1. The symbol O1 and O2 represented the pretest and posttest, respectively. X1 and X2 were learning processes in environmental chemistry course with SSI-based TESI model and group discussion, respectively.

Figure 1 Experimental Design of Quasi-Experimental with Pretest-Posttest Design of Non-equivalent Control Group



Sample and Data Collection

The sample of the research was 61 preservice chemistry teachers in a state university in Yogyakarta, Indonesia, who took the environmental chemistry course at 2022/2023 academic years. The subject sample was divided into two groups, which were control, and experimental groups. The control group was a group of students who attending the environmental chemistry course using discussion model. In other hand, the experiment group was a group of students who attending the environmental chemistry course using SSI based TESI model.

The digital competence of preservice chemistry teachers is measured using a questionnaire adapted from DigComEdu (European Commission, 2019). Modifications were made by changing the indicators into Indonesian and adjusting them to the research respondents, which is preservice chemistry teachers. The aspects measured in digital competence of preservice chemistry teachers are shown in Table 1.

Table 1. The aspects of preservice chemistry teacher digital competence

Aspects of digital competence		Count of indicators
1.	Professional engagement	3
2.	Digital resources	3
3.	Teaching and learning	4
4.	Assessment	2
5.	Empowering learners	3
6.	Facilitating learners' digital competence	4

Data Analysis

An analysis of the normality of data is a prerequisite for statistical tests because normal data is an underlying assumption in parametric testing. The data of preservice chemistry teachers' digital competence was analyzed for normality using the Shapiro-Wilk Test. This test was chosen because the number of samples from each group in the research was less than 50 and its good power properties (Mendes & Pala, 2003). If the data obtained is normally distributed, then parametric statistical analysis is carried out on data of preservice chemistry teachers' digital competence, which are independent sample t-test and paired sample t-test.

RESULTS

The analysis of the initial data (pretest) of preservice chemistry teacher' digital competence is showed at Table 2 below. Based on Table 2, the Sig. value is higher than 0.05, so it can be concluded that the initial data (pretest) of preservice chemistry teacher' digital competence is normally distributed.

Table 2. The analysis of the initial data (pretest) of preservice chemistry teacher' digital competence

Groups	Data			Shapiro-Wilk		
	Minimum	Maximum	Mean	Statistic	df	Sig.
Control	65	89	76.33	0.972	30	0.590
Experiment	66	87	76.26	0.966	31	0.411

Furthermore, the analysis of the final data (posttest) of preservice chemistry teacher' digital competence is showed at Table 3 below. According to Table 3, the Sig. value is higher than 0.05, so it can be concluded that the final data (posttest) of preservice chemistry teacher' digital competence is normally distributed.

Table 3. The analysis of the final data (posttest) of preservice chemistry teacher' digital competence

Groups	Data			Shapiro-Wilk		
	Minimum	Maximum	Mean	Statistic	df	Sig.
Control	65	86	77.17	0.978	30	0.761
Experiment	72	89	79.94	0.957	31	0.247

Both data of preservice chemistry teacher' digital competence is normally distributed, then parametric statistical analysis is carried out on these data. Table 4 is shown the independent sample test of the final data (posttest) of preservice chemistry teacher' digital competence in control group and experiment group.

Table 4. The result of independent sample test

Variable	Sig. (2-tailed)
digital competence	0.034

Based on Table 4, the Sig. (2 tailed) value of independent sample test on the final data (posttest) of preservice chemistry teacher' digital competence in control group and experiment group is lower than 0.05. It means that there were a significant different between the final data (posttest) of preservice chemistry teacher' digital competence in control group and experiment group. Moreover, a paired sample test was carried out to find out whether there were significant differences in the final (posttest) and initial (pretest) of preservice chemistry teacher' digital competence in both the control and experimental group. The summary is shown at Table 5.

Table 5. The summary of paired sample test

Paired sample test	Sig. (2-tailed)
Posttest-pretest (control group)	0.256
Posttest-pretest (experiment group)	0.000

According to Table 5, the Sig. (2 tailed) value of paired sample test on the data of preservice chemistry teacher' digital competence in control group is higher than 0.05. It means that there were no significant different between the final data (posttest) and initial data (pretest) of preservice chemistry teacher' digital competence in control group. While in experiment group, the Sig. (2 tailed) value of paired sample test is lower than 0.05. It can be concluded that there were a significant different between the final data (posttest) and initial data (pretest) of preservice chemistry teacher' digital competence during the implementation of SS-based TESI model.

DISCUSSION

The initial model framework of this model refers to the TESI (technology embedded scientific inquiry) model (Çalik & Ebenezer, 2018) which is a simplification of the steps of the science process approach in learning (NRC, 2012). The integration of SSI approach in the TESI model aims to improving scientific inquiry of students. The SSI approach in learning chemistry is an effort to qualify and contextualize chemistry when discussing controversial issues in society due to advances in science and technology (Anagün & Özden, 2010; Ke, et al, 2021). In this research, the implementation of the SSI-based TESI model was carried out in environmental chemistry course to increase the digital competence of preservice chemistry teachers who directly related to mastery of technology that supports scientific inquiry ability. The syntax of SSI-based TESI model is showed at Figure 2 below.

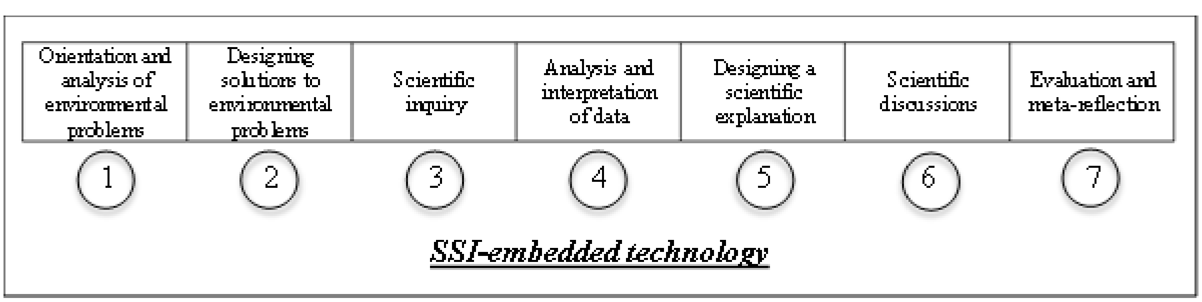


Figure 2. The syntax of SSI-based TESI model

The implementation of this model is carried out on 6 lecture topics, which are (1) particulate matter 2.5 and the quality of air, (2) green-house gases and climate change, (3) ozone depletion, (4) acid deposition, (5) ocean acidification and (6) microplastic. In this research, the control group carried out lectures using a group discussion model, while the experimental group followed the stages in the SSI-based TESI syntax.

Based on the research, it can be concluded that student who followed SSI-based TESI model have a better digital competence rather than student who took a lecture used discussion model. The results of statistical analysis have proven this claim. The digital competence of preservice chemistry teachers will not be useful if they do not understand how to apply their knowledge to solve problems in the surrounding environment. Therefore, the orientation of ICT-based chemistry learning must be directed at deep learning. Technological aspects play a big role in deep learning, especially using various information channels and providing gradual learning experiences in the learning process (Kim & Hannafin, 2011; Gardner, 2018).

The SSI-based TESI model is in line with the progressivism theory, where a learner is an active constructor of knowledge and learns through direct experience and primary sources. The SSI-based TESI model emphasizes the inquiry process, where learning is carried out by connecting the material learned in the classroom with real world situations and encouraging students to make connections between the knowledge they have and its application in everyday life (King, 2012). The implementation of this model is very relevant in chemistry learning, because the main goal of chemistry learning as part of science learning is to make connections between real life and chemical content (Ultay & Calik, 2012).

The implementation of the SSI-based TESI model learning provides a learning experience that is more than ordinary learning so that it can improve students' scientific literacy. Learning that uses the SSI approach can make students more active in discussing by using scientific evidence to make decisions regarding a problem.

CONCLUSION

The implementation of the SSI-based TESI model in environmental chemistry courses aims to make students more active in discussing by using scientific evidence to make decisions regarding a problem. Based on the research, it can be concluded that there were a significant different of digital competence between preservice chemistry teacher who follow environmental chemistry courses with the implementation of the SSI-based TESI and those who do not. The implementation of the SSI-based TESI model in environmental chemistry courses can foster the preservice chemistry teachers' digital competence before and after learning.

Ethics Statements

The design of this study was reviewed and approved by the institutional review board at Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta.

Conflict of Interest

The authors declare no conflict of interest.

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