

# The Relationship between the Pre-Service Science Teachers' Self-Efficacy towards Science Teaching and Tendency to Use Technology in Classes

Afilla Temur<sup>1</sup>, Alper Durukan<sup>✉2</sup> & Huseyin Artun<sup>3</sup>

<sup>1,2</sup> Department of Science Education, Van Yuzuncu Yil University, Van, Turkey

<sup>3</sup> Department of Primary School Education, Van Yuzuncu Yil University, Van, Turkey

✉ A@alperdurukan.com

**Abstract.** The effectiveness of science instruction undoubtedly relies heavily on the teacher. Moreover, international guidelines for science teacher training and the standards for their competencies emphasize the adequate utilization of instructional technologies. In this light, sophisticated instruction of science demands a teacher who has a high self-efficacy perception and is fluent in the use of instructional technology during the classes. Given these motives, this quantitative correlational study examined the relationship between senior pre-service science teachers' self-efficacy perceptions towards teaching science and their tendency to use technology in class. The study sample consisted of 91 undergraduate students enrolled in the Science Education program of a state University in the Eastern Anatolian region of Turkey. The data was collected using two Likert-type scales subjected to Pearson Correlation analysis. The findings implied a positive, although the relatively weak linear relationship between the tendency to use technology in class and self-efficacy perceptions towards teaching science. Moreover, the calculated coefficient of determination value implies that either of the factors only infers 8% of the total variance of self-efficacy & tendency to use technology. Finally, the implications and potential underlying factors affecting this relationship are discussed.

**Keywords:** science education, science teacher training, self-efficacy, instructional technology, correlational research

## 1. Introduction

Although regarded as one-directional, the relationship between instructional technology and science teaching should be considered a two-directional interplay in which technology and science instruction affect each other dynamically. Novel technology is shifting the way society operates and humanitarian services by changing long-coming practices. One of the significant advancements in science teaching is the development and diffusion of digital technology in classrooms.

The reflection of basic sciences upon daily life within the scope of science and disciplines related to engineering contributes significantly to societies' development. In addition, the latest advancements in technology, materials, and emerging opportunities also affect science teaching by making it easier for learners to comprehend and remember science concepts. Therefore, considering science educators' training, the close contact between instructional technology and science teaching has become a prominent topic (Oliveira et al., 2019).

### 1.1. Problem Statement

Many propositions and findings holistically address pre-service science teachers' competencies, such as TPACK, which are abundant in the science education literature. Moreover, relatively plentiful research examining relationships between teacher candidates' competencies in instructional technologies and teaching, attitudes, and self-efficacy perceptions are also available. However, particularly due to the effects of the COVID-19 outbreak on the former education paradigm, which was declared a pandemic by the World Health Organization, rational use of technology has become a necessity rather than a supplementary tool for science teaching (Sá & Serpa, 2020).

It is known that the orientation toward the utilization of instructional technology is relatively reflected in the perceptions (Durukan & Sungur, 2020) and self-efficacy beliefs toward teaching (Hall et al., 2019; Joo et al., 2018), particularly in pre-service teachers. Based on this idea, pre-service science teachers' tendencies to use instructional technologies and digital materials in their lessons are thought to be related to their perceptions of their competency as an educator (Kavanoz et al., 2015; Lee & Tsai, 2010; Yerdelen-Damar et al., 2017).

Revealing the interplay between the tendency to use educational technology in science teaching affairs and the self-efficacy perceptions towards science teaching for pre-service science teachers will benefit the current and future pre-service science teacher training practices. For instance, it is acknowledged that a positive image of science teaching self-efficacy tends to be reflected in sophisticated instructional practices in the classroom (Khanshan & Yousefi, 2020; Poulou et al., 2019). Despite this, there are also contrary findings reported in the literature, concluding that the perception of a high-level self-efficacy toward science teaching could not be reflected in the actual teaching skills in the classroom for pre-service science teachers (Yildiz & Arıcı, 2021). Considering this sophistication in the science teaching practice also includes the rational and effective utilization of the instructional technology in the classroom, the importance of the orientations of the pre-service science teachers towards utilizing instructional technology in their future teaching practices also acquires an essential role in science teacher identity (Badia & Iglesias, 2019). Regarding this, pre-service and in-service training of science teachers in the context of using instructional technology, as well as designing and developing digital instructional materials, positively contribute to the self-efficacy perceptions of science teachers (Lumpe & Chambers, 2001; Watson, 2006). However, the extent of the interplay between the self-efficacy perceptions of pre-service science teachers toward science teaching and their tendency to use technology in their instructional practices demands further exploration (Velthuis et al., 2017). Backing this, even though teachers approve and admit the advantages of instructional technology utilization in the classroom, they also express insufficient self-esteem and technological pedagogical proficiency when it comes to using these technologies in the classroom (Abel et al., 2022).

In addition to helping pinpoint the potential directions in order to facilitate the self-efficacy perceptions and familiarity of pre-service science teachers towards implementing instructional technologies in their instructional practices, disclosure of the magnitude of the influence between these two factors also redirects the research and practice to explore further factors that may in play in this equilibrium of science teacher competency. Therefore, it is thought that the present study, which examined the relationship between pre-service teachers' self-efficacy perceptions toward teaching science and their tendency to use technology in classes, will contribute to the current body of literature.

## **1.2. Related Research**

National and international standards for the training of science teachers emphasize teacher competencies such as proficiency in the use of instructional technology and adequate perception of teaching self-efficacy. The 2020 Standards for Science Teacher Preparation, announced by the National Science Teacher Association (NSTA) and Association for Science Teacher Education (ASTE), adopt the competencies of pre-service teachers in employing context-based instructional technologies in the fields of Content Knowledge and Content Pedagogy (Morrell et al., 2020). Concerning the local context of Turkey, for instance, within the framework of the 2023 Education Vision announced by the Ministry of Education (MoNE), it is emphasized that all teachers, regardless of their field of teaching, should be able to use and develop digital instructional materials effectively (MoNE, 2017). Considering that the respective criteria for teacher competence tend to be shaped in accordance with society's demands, it is crucial to develop pre-service science teachers' technological knowledge to be compatible and integrated with their pedagogical content knowledge (Kiray et al., 2018).

Research on the relationship between self-efficacy perceptions and technology use of pre-service science teachers is relatively scarce as the studies typically orientated around self-

efficacy towards technology utilization (Birisci & Kul, 2019; Conrad & Munro, 2008) rather than the teaching of a specific discipline.

Various variables are supported in the literature with regard to the predictors and related factors to the pre-service and in-service teachers' use of technology in the classroom. For instance, teacher's attitudes (Celik & Yesilyurt, 2013) and orientations (e.g., technology self-efficacy) (Drossel et al., 2017), teacher's perceptions of whether the utilization of instructional technology is beneficial for student learning (Teo, 2009; Tondeur et al., 2008), and most prominently, the perceived self-competence of the pre/in-service teachers towards utilization of instructional technology in the classroom; also thought to be linked to the expertise and attitude in general (Drossel et al., 2017). Concerning the pre/in-service science teacher's expertise and general attitude thought to be related to the technology used in the classroom, the relationship between the teacher's knowledge and affective orientations extends to the self-efficacy beliefs of pre-service science teachers (Senler, 2016) and also demands further elaboration.

### 1.3. Research Objectives

The research problem and related hypothesis are presented below.

**Research Problem:** Is there a positive relationship between pre-service science teachers' self-efficacy toward teaching science and their tendency to use technology in their lessons?

**H<sub>a</sub>:** There is a positive relationship between pre-service science teachers' self-efficacy perceptions towards teaching science and their tendency to use technology in classes.

## 2. Theoretical Framework

Even though being prominent, the tendency to use instructional technologies should not be considered separately from the contexts of content knowledge and pedagogical knowledge of science teaching. In this sense, it is important to emphasize not just individual competence with instructional technologies but also their perceptions of their competence in science instruction. For instructional technologies, it is argued that the properties of the instructional material and individual characteristics are effective in using technology in lessons. In this respect, teachers' positive attitudes and self-efficacy perceptions are among the main factors determining their use of instructional technologies (Herman, 2002; Kinzie & Delcourt, 1991). More specifically, it is pointed out that self-efficacy perception in the context of instructional technologies also indirectly affects teachers' adoption of these technologies (Holden & Rada, 2011).

For pre-service science teachers, having a sufficient level of teaching self-efficacy translates to using their strengths effectively and striving for self-development of relative weaknesses in teaching (Senler & Sungur-Vural, 2013). Therefore, a science teacher with a relatively higher perception of self-efficacy would also be open to experiences that can improve proficiency in instructional technologies (González et al., 2018). Therefore, it is expected that pre-service teachers who consider themselves proficient in Pedagogical, Technological, and Technological-Pedagogical-Content Knowledge (TPACK) have a high tendency to use technology in their lessons (Aydın-Günbatır et al., 2017; Tezci, 2011).

### 2.1. Science Teaching Self-Efficacy

It is indisputable that the teacher plays a decisive role in using instructional technologies in science courses. Especially considering the place of instructional technologies in eliminating existing classroom constraints, the initiatives of science teachers, in this sense, determine the effectiveness of their teaching. It is understood that a teacher who can take the initiative to incorporate technology into education despite arising difficulties potentially has a relatively higher teaching self-efficacy perception.

Self-efficacy perception is defined as a belief in self-control over situations that affect the life course of that individual (Bandura, 1997, 2010). In light of this definition, it could be stated that an individual with a high level of self-efficacy perception has a more positive attitude towards

intervening in the processes that affect his/her life. In science teaching, teacher self-efficacy refers explicitly to their perception of the capacity to support students' learning through effective teaching strategies. Regarding this, there are various factors highlighted in the literature that influence pre/in-service science teachers' self-efficacy perceptions, such as:

- Age (Kiremit & Gökler, 2010),
- Gender (Kahraman et al., 2014; Riggs, 1991),
- Grade-level in pre-service teachers (Kahraman et al., 2014),
- Cognitive-pedagogical expertise as teachers (Palmer, 2006),
- Previous learning experiences (Ramey-Gassert et al., 1996),
- Academic achievements in the pedagogical learning process (Azar, 2010),
- Satisfaction with the profession of teaching (Şaracaloğlu & Yenice, 2009), and
- Past opportunities for teaching experience (Dalioglu & Adiguzel, 2016).

## 2.2. Adopting Instructional Technology in Science Teaching

The Technology Acceptance Model (TAM), which was put forward by Davis (1989) and which deals with individuals' approaches to using technology, also provides essential insights into the adoption of instructional technologies. As shown in Figure 1, in the model, it is claimed that the components of *Perceived Ease of Use* and *Perceived Usefulness* have a significant influence on the attitude towards technology use and the behavioral tendency towards using technology (Davis, 1989; Scherer et al., 2019; Straub, 2009; Teo et al., 2011). In particular, it was revealed that the component of perceived usefulness directly affects individuals' acceptance of computer technology and the tendency to use computer technologies (Aypay et al., 2012; Davis et al., 1989; Scherer et al., 2019; Straub, 2009; Teo, 2009).

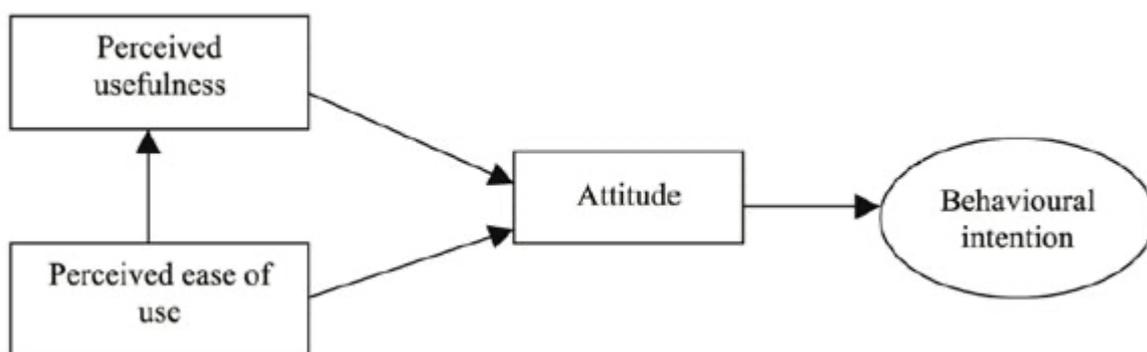


Figure 1. Technology Acceptance Model (Davis, 1989)

Besides competence, a pre-service science teacher's tendency and belief to demonstrate this competence determine the effectiveness of the teaching activities that will be performed (Cakiroglu et al., 2005; Velthuis et al., 2017). Using instructional technologies in lessons, especially for pre-service science teachers, requires technological pedagogical content knowledge and a tendency to use these technologies (Joo et al., 2018). As a matter of fact, for a science teacher, the tendency to use instructional technologies is determinative in benefiting from these technologies in science lessons.

## 3. Method

### 3.1. Research Design

The study was carried out using the correlational research design, namely a quantitative research model. In its simplest terms, correlational research aims at generalizing without inferring a cause-effect relationship by determining the extent and direction between two variables within a sample (Fraenkel et al., 2012). In order to reveal a potential relationship between pre-service science teachers' self-efficacy towards teaching and their tendencies toward technology use in their lessons, the correlational research design was considered an appropriate method to be applied in this study.

### 3.2. Sample

The research sample included 91 pre-service science teachers for third and fourth grade enrolled at a state university in the Eastern Anatolia region of Turkey during the 2017-2018 Fall semester. The mean ages of the 16 male and 75 female participants, who constituted the research sample, were found to be approximately 22. The sample individuals were selected among the third and fourth grade pre-service science teachers who completed undergraduate courses related to educational sciences, content knowledge, domain-specific instruction, and instructional technologies.

### 3.3. Data Collection

The research data were gathered using the Self-Efficacy Towards Teaching Science Scale (STSS) and the Tendency Scale for Technology Use in Class (TSTUC). STSS is a 5-point Likert-type instrument developed by Kaya et al. (2014), consisting of 14 items and three sub-dimensions. The first sub-dimension of the scale was determined as "Self-efficacy in subject knowledge ( $\alpha=0.80$ )"; the second sub-dimension was "Self-efficacy in realizing in-class activities (performance) ( $\alpha=0.59$ )"; and the third sub-dimension as "Self-efficacy in laboratory knowledge ( $\alpha=0.87$ )".

TSTUC was developed by Gunuc and Kuzu (2014). The 5-point Likert-type scale, included 16 items and two sub-dimensions: Emotional tendency and Behavioral tendency, was applied to 796 pre-service teachers studying at Anadolu University. The sub-dimensions of the scale were found to explain the variance with a ratio of 60%, and Cronbach's alpha reliability coefficient was calculated as .93 through exploratory factor analysis and as .95 as a result of confirmatory factor analysis.

### 3.4. Data Analysis

The response categories were rated as follows:

- 1 point for "Strongly Disagree",
- 2 points for "Disagree",
- 3 points for "Undecided",
- 4 points for "Agree", and
- 5 points for "Strongly agree".

The total scores across the scales were analyzed, and the total scores were derived from two scales matched for each subject for data analysis.

### 3.5. Validity and Reliability

In the study, IBM SPSS 26, Jamovi, and JASP statistical analysis software were used to determine the data distribution regarding the variables examined, confirm the assumptions required for the parametric correlation analysis, and conduct the descriptive, inferential analyses. As a result of the findings obtained in preliminary analyses, assumptions of homoscedasticity, conformity to normal distribution, and linearity were fulfilled. Next, the matched total scores were examined through Pearson product-moment correlation coefficient analysis. Afterward, the coefficient of determination was calculated to reveal the extent to which each of the variables explained the total variance.

By conducting the reliability analysis of the data gathered as a result of the application of the STSS, the Cronbach's Alpha reliability coefficient of the sample data in the present study was .82. As a result, it was found that the STSS scale had sufficient reliability in the context of the present study (Büyüköztürk, 2017).

Therefore, the calculated Cronbach's-alpha reliability coefficient value of the data obtained from the present study sample for TSTUC was .93. Consequently, the scale was found to be reliable for the context of our research (Büyüköztürk, 2017).

## 4. Findings

This section will describe the findings comprehensively and build them into sub-findings or themes based on the research method and design.

### 4.1. Descriptive Statistics

The descriptive data regarding the research sample are presented in Table 1 based on the variables analyzed.

**Table 1.** Descriptive Statistics

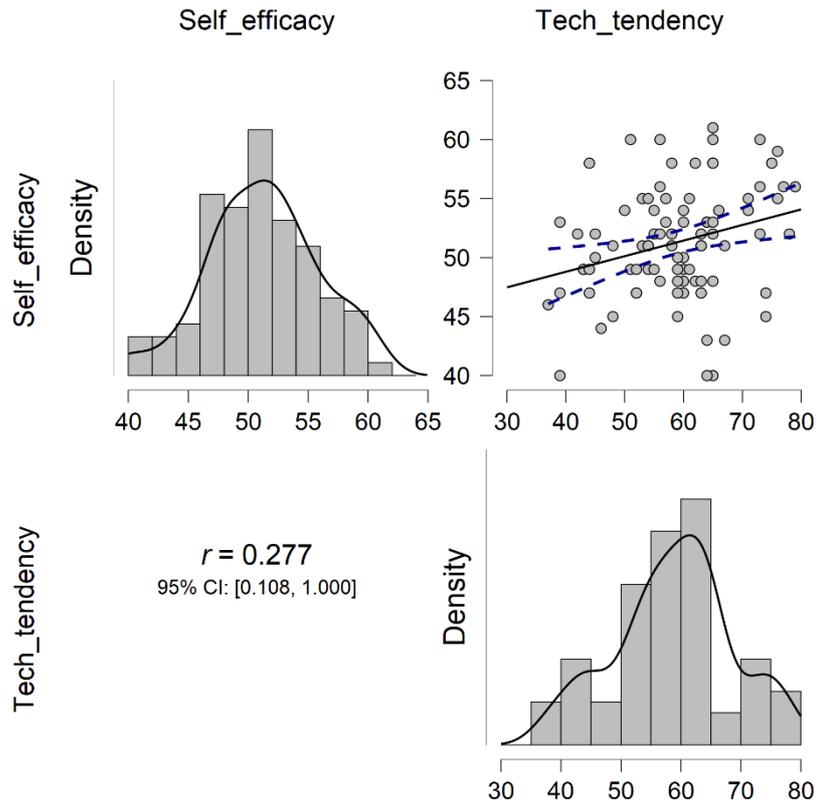
Descriptive	Self_efficacy	Tech_tendency
N	90	90
Missing	0	0
Mean	51.29	58.84
Median	51.00	59.50
Mode	49.00	65.00
Standard deviation	4.68	9.81
Variance	21.92	96.31
Minimum	40.00	37.00
Maximum	61.00	79.00
Skewness	-0.11	-0.14
Std. error skewness	0.25	0.25
Kurtosis	-0.07	-0.32
Std. error kurtosis	0.50	0.50
Shapiro-Wilk W	0.98	0.98
Shapiro-Wilk p	0.213	0.140

<sup>a</sup> More than one mode exists; only the first is reported

Table 1 shows that the mean of the participants' total scores for STSS was 51.29, and the standard deviation was calculated as 4.68. In addition, the mean was 58.84 in TSTUC, while the standard deviation regarding the data for the scale was 9.81. The p values found for the Shapiro-Wilk test also indicated that the data did not show a significant deviation from the standard distribution curve.

### 4.1. Inferential Statistics

The results were obtained by subjecting the collected data to the inferential statistics of Pearson Correlation analysis presented in Figure 2 and Table 2.



**Figure 2.** Pearson's Correlation Plot

Figure 2 shows a positive linear relationship between the pre-service science teachers' self-efficacy toward teaching science and their tendency to use technology in classes. Therefore, the null hypothesis was rejected, which indicated no positive linear relationship between them.

**Table 1.** Correlation Matrix

Variable		Self_efficacy	Tech_tendency
Self_efficacy	Pearson's r	—	
	p-value	—	
	95% CI Upper	—	
	95% CI Lower	—	
	N	—	
Tech_tendency	Pearson's r	0.28	**
	p-value	0.004	—
	95% CI Upper	1.00	—

Variable	Self_efficacy	Tech_tendency
95% CI Lower	0.11	—
N	90	—

Note. H<sub>a</sub> is a positive correlation

Note. \* p < .05, \*\* p < .01, \*\*\* p < .001, one-tailed

Table 2 shows the relationship between the pre-service science teachers' self-efficacy toward teaching science (as measured in the STSS and their tendencies to use technology in classes (as measured by TSTUC) was tested with Pearson's Correlation analysis. As a result of the analyses, a relatively weak positive and linear relationship was found between the variables,  $r = .28$ ,  $n = 90$ ,  $p < .05$ . In other words, it was concluded that a high level of self-efficacy toward teaching science was associated with a high level of the tendency towards technology use in classes.

The coefficient of determination value ( $r^2$ ) was calculated to determine the extent to which self-efficacy in science teaching explained the variance in the tendency to use technology in classes.

$$r^2 = 0.28^2 = 0.08$$

According to the value of 0.08 found, although there is a weak positive correlation between self-efficacy for science teaching and the tendency to use technology in classes, only 8% of the change in the self-efficacy factor for science teaching explains the variance of the tendency to use technology in classes. In other words, a 100% increase in self-efficacy toward teaching science can explain 8% of the variance of the increase in the tendency to use technology in classes.

## 5. Discussion

The use of technology in science teaching is essential in eliminating existing limitations, enriching the course content, and facilitating students' acquisition of desired outcomes and skills. However, the rational use of instructional technologies in lessons requires a high level of self-efficacy perception as it primarily takes place in line with the teacher's initiative (Herman, 2002). At the same time, a positive relationship exists between self-efficacy perception and competence in instructional activities for a novice teacher (Jamil et al., 2012; Joo et al., 2018). Therefore, self-efficacy perceptions toward teaching science could be considered a factor that predicts the feasibility of the instructional practices of pre-service science teachers.

The findings revealed that a positive, linear, and relatively subtle relationship is evident between self-efficacy toward teaching science and the tendency to use technology in classes. In other words, a high level of self-efficacy perception toward science teaching was associated with a high tendency to use technology in lessons. Although the literature focuses on instructional technologies and science teaching on cognitive outcomes rather than affective/behavioral perceptions and beliefs, some studies directly (Sang et al., 2010) and indirectly support our findings. For example, a reciprocal and positive relationship can be observed between the perception of self-efficacy toward teaching and the behavioral tendency, especially toward using instructional technologies (McLoughlin et al., 2008; Watson, 2006). Moreover, it was revealed that the factors that most predicted the self-efficacy perception levels of pre-service teachers in using internet resources were their self-efficacy in terms of including students in the course, employing teaching strategies, and classroom management (Gürol & Aktı, 2010). Especially when the acceptance of instructional technologies is considered, it is believed that

a pre-service teacher who considers himself competent to use these opportunities can also perceive the use of the relevant technological material as relatively easy and useful within the framework of the TAM model (Teo et al., 2011; Teo et al., 2012). Considering that perceived ease of use is also reflected in the technology acceptance of pre-service teachers (Teo, 2009), it is expected that it will indirectly and positively affect their tendency to use technology in their classes.

The fact that the relationship is weak, though positive, made it necessary to question the level of explaining the common variance for both other variables regarding the self-efficacy perceptions of pre-service science teachers and their tendency to use technology. The fact that the coefficient of determination value calculated was 0.08 indicates that a 100% increase in any of the levels of the tendency to use technology ↔ self-efficacy creates an effect of only an 8% change on the other. This result brings into mind the significant share(s) of external factors in this relationship. As we focused on a relatively specific factor in such a broad spectrum of determinants for the pre-service science teachers' intentions for using technology in classrooms, the influence of institutional (e.g., related to the school, faculty, and infrastructure) and environmental (e.g., related to the peer collaboration, availability of technical support as needed and the readiness of the students towards the integration of instructional technology) also take credit in this manner.

## 6. Conclusion

When pre-service science teachers are considered, it could be stated that in predicting the acceptance of and usage tendencies towards instructional technologies, TAM is a valid model close to the context of the research sample and emphasizes the perceived usefulness factor. For a pre-service teacher to perceive a specific instructional technology as applicable, it is stated as a prerequisite that the individual should have a formidable familiarity and sufficient experience in using these technologies and, therefore, become literate in this manner. Especially within the context of TPACK self-efficacy, it was asserted that the component with the most significant impact on technology integration for science teachers is their self-efficacy perceptions towards pedagogical content knowledge. Moreover, self-efficacy perception regarding pedagogical content knowledge appears to be a direct influencer of an individual's self-efficacy belief regarding teaching the concepts within the scope of a science course. However, when it is considered separately from its context, there are also conclusions in the literature that propose that the tendencies of pre-service teachers from various branches towards technology use are affected by the factors of perceived usefulness, attitude towards computer use, and perceived ease of use within the framework of the TAM model. Based on the fact that the factors mentioned above are related to the relevant technological material in the general framework rather than the scope of science teaching and technological knowledge, it is thought that the 92% unexplained variance in the tendency to use technology in classes may point to the components of TAM model, apart from the perception of self-efficacy towards teaching science in the context of pre-service science teachers from Eastern Anatolian Region of Turkey.

### Limitation

1. The properties of the sampled pre-service science teachers from the Eastern Region of Turkey might have influenced the inferences derived from this study. Therefore, the inferences are limited to the generalizable and accessible population of the current study.
2. The study was done with the third grade pre-service science teachers from the Eastern Region of Turkey; hence, the context and the socio-demographic properties of the sample may not be exactly projected to the international scale.
3. Items in the tendency to use technology in classes scale portray a discipline-independent picture, whereas items in the self-efficacy scale are specific to the discipline of science instruction. Therefore, the iterations of this study may be particularly dependent on the coverage of the items in these two data instruments.

4. The relatively broad variance that cannot be inferred in this study is thought to be related to the components of TAM model, in addition to the third-party factors yet to be revealed.
5. The relatively low number of subjects in the study sample might have influenced the statistical significance and explained the variance in this study.

### Recommendation

It would be adequate to study with a sample to associate the pre-service science teachers' self-efficacies with their use of instructional technologies. In this way, there is a potential to be created by the competencies of pre-service science teachers and their perceptions of their competencies. It is hoped that the main factors determining the extent to which this potential will be reflected in the classrooms will also be revealed.

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### Conflict of Interest

The authors declare that there is no conflict of interest.

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