Research Article

Two Approaches to Investigate Preservice Teachers' TPACK Competencies and Self-Regulated Learning Skills in Turkiye and the United States

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Article Info	Abstract
	In this study the investigators used two different approaches to investigate preservice teachers' Technological Pedagogical Content Knowledge (TPACK) competencies and self-regulated learning skills (SRL). The first study was conducted at Ahmet Keleşoğlu Education Faculty, Necmettin Erbakan University (NEU), Konya, Turkiye and the second study was conducted at Arkansas Tech University (ATU), Arkansas, the United States. The data from the participants at NEU was collected from 375 preservice teachers to examine the correlation among preservice teachers' TPACK competencies, SRL and their gender and years of study. Although the findings revealed that preservice teachers' TPACK competencies differed by their gender and year of study, there was no significant difference in their SRL skills. Finally, the results indicated that there were positive and significant relationships between the preservice teachers' TPACK competencies and their self-regulated learning skills. The data from the ATU participants was collected from 66 preservice teachers (54 undergraduates, 12 graduate). The ATU study examined the impact of employing project-based learning (PBL) on students' TPACK competencies, self-efficacy (SE), and SRL in different learning environments. The findings indicated that the use of PBL does enhance preservice teachers' SRL skills in all learning environments. Finally, the findings indicated that students' TPACK competencies significantly increased after using PBL.

Introduction

Preservice teachers are expected to incorporate technology in teaching to effectively achieve their educational roles (Callister & Dunne, 1992; Montague, 2007). However, the technology integration process in teaching is becoming increasingly complex and requires teachers to seamlessly connect between three learning components (Chai et al., 2013).

One of the most discussed concepts to integrate technology in teaching is the Technological Pedagogical Content Knowledge framework (TPACK). Mishra and Koehler (2009) argue that successful teaching with technology rests on the relationships between content, pedagogy & technology, and how it is applied in the classroom. Furthermore, teachers must be creative and flexible in combining these three teaching elements and understanding their interaction. Although technology integration was long found to enhance students' participation in learning, a successful technology integration in a classroom is a hard process (Mishra & Koehler, 2006). Additionally, COVID-19 academic interruption showed that there is greater need for systematic technology integration to assist teachers to conduct their work successfully and maximize students' learning (Drugova et al., 2021; Hodges et al., 2020).

The Purpose of the Study and Research Questions

The purpose of these two studies is to examine preservice teachers' TPACK competencies and SRL skills from two different perspectives: The study at NEU was to examine the relationship between preservice teachers' TPACK competencies, SRL skills, gender, and years of study. The study at ATU was to examine the impact of using PBL on preservice teachers' TPACK competencies, SE, and SRL skills in different learning environments.

Research Questions

The proposed research questions at NEU study include:

● Do preservice teachers' self-regulated learning skills and TPACK proficiency levels differ based on their gender and year of study?

● Is there a significant relationship between preservice teachers' self-regulated learning skills and TPACK competencies?

● What are the levels of preservice teachers' self-regulated learning skills and TPACK proficiency at NEU?

Research questions at ATU study include:

● Does the use of project-based learning an effective teaching strategy to improve preservice teachers' self-regulated learning skills?

● How does the use of project-based learning teaching strategy affect preservice teachers' self-regulated learning skills in face-to-face, hybrid and online learning environments?

● How does the use of project-based learning teaching strategy affect preservice teachers' self-efficacy to integrate technology in teaching?

Literature Review

Technological Pedagogical Content Knowledge (TPACK)

According to the TPACK literature, teachers are required to use three components to integrate technology in teaching, namely: Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK). Out of the interaction between these three components, other components will become apparent, namely, Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) (Graham, 2011; Koyuncuoglu, 2021; Mishra & Koehler, 2006; Mishra et al., 2009).

Self-regulated learning (SRL) and Self-efficacy (SE)

SRL is the self-direction processes that enable students to translate their emotional capacities into academic performance (Zimmerman, 2008). Therefore, SRL is very important competence for students during learning that can have a wide impact on areas such as social achievement, multiple competencies, and performance. Researchers assert that SRL is central for successful learning and consists of two main processes (Vancouver et al., 2017): Motivation and metacognitive strategies. Therefore, self-regulated learning skills are essential to help learners plan, implement, monitor, and organize learning strategies in all education levels (Panadero, 2017). The first process is learners' motivation, which generally influenced by their self-efficacy beliefs and relates to the intensity of their desire to pursue a particular goal. As such, motivation can determine the learner's commitment to achieve their goals and becomes the basis for their self-control strategies and the level of their performance (Kavussanu, 2011). The second process is learners' metacognitive strategies, which is learners' ability to reflect on the adequacy of the learning level to achieve learning goals (Zimmerman, 2008). Therefore, teachers' SRL to use technologies in teaching are essential for their instruction (Akgun & Öztürk, 2014; Cosnefroy & Carré, 2014; Önal, 2016).

Method

Method used at NEU

The study conducted at NEU used quantitative method and utilized a convenience sampling technique to recruit the participants. The participants were 385 preservice teachers (286 female and 99 male). Participants were majoring in teaching different content areas such

as special education, social studies, science, art, and languages such as English, Turkish and German. The distribution of the participants includes 11.55% first year students, 26.80% were in the second year, 15.06% in the third year and 14.02% were in the fourth year.

Method used at ATU

The study conducted at ATU employed a within-subject design. The study was conducted with preservice teachers in different learning situations, traditional face-to-face (F2F), hybrid (mixed of F2F and online) and fully online. The participants were undergraduate and graduate preservice teachers. The distribution of the participants in this study were: 54 undergraduates, 12 graduate, 5-male, 61-female. Students ages were 45 students (18-21 years), 10 students (22-25 years), 6 students (26-30 years), 2 students (31-40 years), and 3 students (41or above).

Instruments

Self-Regulatory Skills Scale

The investigators at NEU used a scale to measure preservice teachers perceived self-regulatory skills developed by Arslan and Gelişli (2015). The validity and reliability of the scale was carried out on 604 students.

Metacognitive Awareness Inventory (MAI)

The investigators at ATU designed two questionnaires, Metacognitive Awareness Inventory (MAI) and self-efficacy questionnaire. The first instrument is a modified version of MAI (Schraw & Dennison, 1994). The purpose of the MAI is to collect information about participants' metacognitive regulation (Hammann & Stevens, 1998). The survey consists of 52 items (true or false statements).

Self-efficacy Survey

The SE survey included 11-point scale ranges from "Cannot do at all" at zero to "Highly certain can do" at 100. The SE survey was adopted from Bandura's "Guide to the construction of self-efficacy scales" (2006).

Findings

Findings from NEU study: Descriptive Analysis

The obtained quantitative data were analyzed by the SPSS package program. Data were analyzed using descriptive statistics, independent samples t-test and one-way analysis

of variance. In addition, Pearson correlation analysis and regression analysis were used to investigate the relationship between TPACK competencies and self-regulatory skills.

The analyses showed that the preservice teachers have a moderate mean score of perception in the dimensions of Technological Knowledge (TK), Content Knowledge-Math (CTm) and Content Knowledge-science (CKsci). However, analyses indicated that preservice teachers have a high mean scores perception in the dimensions of Pedagogical Knowledge (PK), Technology-Supported Pedagogical Knowledge (TSPK), Technology-Supported Pedagogical Content Knowledge (TSPCK), Content Knowledge-social (CKs) and Pedagogical Content Knowledge (PCK). Additionally, preservice teachers have the highest level of efficacy perception in the Content Knowledge Literacy (CK-Lit) dimension. Table 1 summarizes the results of these analyses.

Table 1. Descriptive analysis of preservice teachers' TPACK scores

	N	Min.	Max.	$\bar{X}$	Ss
PK	385	2	5	3.95	0.56
TSPK	385	2.25	5	3.77	0.52
TK	385	1.43	5	3.35	0.6
CK-lit	385	2	5	4.22	0.59
TSPCK	385	1.83	5	3.45	0.6
CKs	385	1	5	3.67	0.79
CKm	385	1	5	3.01	0.97
CKsci	385	1	5	3.13	0.81
PCK	385	1	5	3.69	0.63

The analyses of this study found that the participants had a high level of mean score in the total scores and subscales of their self-regulated learning skills. Table 2 summarizes the results of this analysis.

Table 2. Descriptive analysis of preservice teachers' self-regulated learning skills scores

	N	Min.	Max.	$\bar{X}$	Ss
Being open	385	1.73	5	3.4	0.66
Help-seeking	385	1.4	5	3.9	0.47
Self-Regulation	385	2.05	4.9	3.65	0.45

First question

Do preservice teachers' self-regulated learning skills and TPACK proficiency levels differ based on their gender and year of study?

The analyses found that there is a significant difference between male and female preservice teachers in the PK, TK, CK-literacy, CK-science and PCK dimensions of the scale (p<0.05). Furthermore, the analyses found that male preservice teachers had significantly higher mean scores in the dimensions of technological knowledge and content knowledge, whereas the scores of female preservice teachers were higher in the dimensions of Pedagogical Knowledge, Content Knowledge-literacy and Pedagogical Content Knowledge were significant. Table 3 summarizes the results of this analysis.

Table 3. Comparison of preservice teachers' TPACK scores by gender

Gender		N	$\bar{X}$	Ss	T	p
PK	1	286	3.99	0.54	2.6	0.01
	2	99	3.82	0.6		
TSPK	1	286	3.79	0.51	1.21	0.23
	2	99	3.72	0.54		
TK	1	286	3.27	0.59	-4.34	0
	2	99	3.57	0.57		
CK-lit	1	286	4.27	0.55	2.59	0.01
	2	99	4.09	0.67		
TSPCK	1	286	3.44	0.57	-0.58	0.56
	2	99	3.48	0.65		
CK-s	1	286	3.65	0.79	-0.88	0.38
	2	99	3.73	0.81		
CK-m	1	286	2.96	0.96	-1.84	0.07
	2	99	3.16	0.98		
CK-sci	1	286	3.07	0.79	-2.26	0.02
	2	99	3.29	0.84		
PCK	1	286	3.74	0.58	2.62	0.01
	2	99	3.55	0.74		

Second Question

Is there a significant relationship between preservice teachers' self-regulated learning skills and TPACK competencies?

The analysis of the Pearson Correlation Coefficient found that there are significant and positive correlations between all dimensions of the TPACK and the scores of the self-regulated learning skills, except for the Content Knowledge-mathematics dimension. Specifically, preservice teachers' PK, PCK, CK-literacy and TSPCK competencies showed the highest correlation with self-regulated learning skills. Table 4 summarizes the results of this analysis.

Table 4. Relationship between preservice teachers' self-regulated and TPACK competence

		Help-seeking	Being Open	Self-Regulation
PK	R	.318**	.342**	.410**
	P	0	0	0
TSPK	R	.200**	.306**	.306**
	P	0	0	0
TB	R	.165**	.125*	.185**
	P	0.001	0.014	0
CK-lit	R	.229**	.314**	.331**
	P	0	0	0
TSPCK	R	.192**	.205**	.247**
	P	0	0	0
CK-s	R	.130*	.277**	.240**
	P	0.011	0	0
CK-m	R	0.101	0.002	0.08
	P	0.059	0.962	0.119
CK-sci	R	.131*	0.069	.131**
	P	0.01	0.178	0.01
PCK	R	.268**	.221**	.311**
	P	0	0	0

Third Question

What are the levels of preservice teachers' self-regulated learning skills and TPACK proficiency at NEU?

The analyses revealed that there were no significant differences in both the total scores of the self-regulatory skills scale and its sub-dimensions based on gender variable. Table 5 summarizes the results of this analysis.

Table 5. Comparison of preservice teachers' self-regulated skills scores by gender

		N	$\bar{X}$	Ss	T	p
Being open	1	286	3.41	0.66	0.72	0.47
	2	99	3.36	0.65		
Help-seeking	1	286	3.92	0.45	1.66	0.1
	2	99	3.83	0.52		
Self-regulation	1	286	3.67	0.45	1.4	0.16
	2	99	3.59	0.46		

The analyses showed that there were significant differences in the dimensions of the preservice teachers' Pedagogical Knowledge and Content Knowledge by the years of study. Further analyses revealed that the preservice teachers enrolled in the 3rd and the 4th years of the training program achieved significantly higher scores than their peers in the 1st and the 2nd year of the same training program in these two dimensions. Table 6 summarizes the results of this analysis.

Table 6. Comparison of preservice teachers' TPACK scores by the year of study

	Year of Study	N	$\bar{X}$	Ss	F	p
PK	1	160	3.93	0.58		
	2	103	3.86	0.49	3.72	0.01
	3	58	4.29	0.55		
	4	54	4.12	0.47		
TSPK	1	160	3.79	0.53	1.01	0.39
	2	103	3.71	0.49		
	3	58	3.86	0.46		
	4	54	3.9	0.37		
TK	1	160	3.33	0.55	2.21	0.09
	2	103	3.33	0.67		
	3	58	3.53	0.69		
	4	54	3.73	0.48		
CK-lit	1	160	4.19	0.6	1.72	0.16
	2	103	4.23	0.59		
	3	58	4.32	0.56		
	4	54	4.57	0.48		
TSPCK	1	160	3.47	0.62	1.9	0.13
	2	103	3.37	0.55		
	3	58	3.43	0.57		
	4	54	3.77	0.47		
CK-s	1	160	3.61	0.81	1.98	0.12
	2	103	3.75	0.72		
	3	58	3.77	0.95		
	4	54	4.09	0.76		
CK-m	1	160	3	0.98	0.22	0.88
	2	103	2.98	0.98		
	3	58	3.11	0.84		
	4	54	3.18	0.83		
CK-sci	1	160	3.16	0.78	3.17	0.02
	2	103	2.97	0.84		
	3	58	3.28	0.84		
	4	54	3.64	0.71		
PCK	1	160	3.69	0.66	1.07	0.36
	2	103	3.65	0.57		
	3	58	3.79	0.6		
	4	54	3.98	0.59		

Finally, the analysis of this study showed that there were no significant differences in all scores of the preservice teachers' self-regulated learning skills across all students' years of study. Table 7 summarizes the results of this analysis.

Table 7. Comparison of preservice teachers' self-regulated learning scores by year of study

		N	$\bar{X}$	Ss	F	p
Being open	1	160	3.38	0.65	1.09	0.35
	2	103	3.38	0.68		
	3	58	3.63	0.65		
	4	54	3.23	0.63		
Help-seeking	1	160	3.89	0.5	0.54	0.66
	2	103	3.93	0.45		
	3	58	3.98	0.37		
	4	54	3.8	0.25		
Self-regulation	1	160	3.63	0.45	1.15	0.33
	2	103	3.65	0.46		
	3	58	3.81	0.45		
	4	54	3.52	0.39		

Findings from ATU study

First question

Is PBL an effective teaching strategy for improving preservice' self-regulated learning skills?

The investigators used one-sample t-test to answer this question and found that the preservice teachers who engaged in PBL activities reported higher metacognitive skills scores in all learning environments (M =45.56, SD = 5.61) compared to their scores before their engagement in the PBL activities, $t(60) = 63.37$, $p = .000$. These findings indicates that the PBL activities improved preservice teachers' metacognitive skills. Table 8 summarizes the results of the analysis.

Table 8. Descriptive Statistics: Before and after the project-based teaching strategy

Outcome	M	SD	n	95% CI for Mean Dif.	t	df
Students' metacognitive (before)	42.5	7.3	66	11.53, 41.22	47.33	65
Students' metacognitive (after)	45.6	5.6	61	-0.08, 0.02	63.38*	60

Note: * p < .000.

Second question

Does PBL affect preservice' self-regulated learning differently in face-to-face, hybrid and online learning environment?

The investigators used One-way ANOVA to answer this question. The findings indicated that the use of PBL strategy has nonsignificant difference on students' metacognitive skills in all learning environments $F (2, 58) = .378$, $p = .687$. These results

suggest that when students engage in the PBL activities, their metacognitive skills scores improved at the same level, regardless of the learning environments. Table, 9 summarizes the analysis of variance results.

Table 9. Results of ANOVA of students' metacognitive scores in F2F, hybrid and online

Metacognitive Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.33	2	12.16	0.38	0.69
Within Groups	1866.72	58	32.19		
Total	1891.05	60			

Note: Significance set at $p < .05$.

Third question

Is PBL an effective teaching strategy for improving preservice' self-efficacy to integrate technology in teaching?

The investigators used one-sample t-test to answer this question. The results of the analysis found that preservice teachers reported higher self-efficacy scores after engaging in PBL learning strategy in F2F, hybrid and online (M =869.51, SD = 115.47) compared to their scores before engaging in the PBL learning activities, $t(60) = 58.81$, $p = .000$. These findings indicate that the use of PBL activities enhanced students' SE scores. Table 10 summarizes the one-samples t-test results.

Table 10. Descriptive statistics for students' SE scores before and after the use of PBL

Outcome	M	SD	n	95% CI for Mean Diff.	t	df
SE Before	544.6	178.4	66	500.7	24.8	65
SE After	869.5	115.5	61	839.9	58.8*	60

Note: * $p < .000$.

Discussion

Discussion the NEU findings

The present study investigated preservice teachers' TPACK competencies and self-regulated learning skills in two conditions. The first study examined the relationship between preservice teachers' TPACK competencies, self-regulated learning skills and their gender and year of study. The study found that preservice teachers' TPACK competencies differed by their gender and year of study. The results also showed that there were no significant differences in preservice teachers' self-regulated learning skills. Finally, the results indicated that there were positive and significant relationship between the preservice teachers' TPACK competencies and their self-regulated learning skills.

The first primary findings of this study revealed that the preservice teachers' perceptions of TPACK proficiency, in general, were above the moderate level. However, the preservice teachers had a moderate and low perception level in Technological Knowledge as well as the math and science Content Knowledge. Finally, the findings showed that the preservice teachers have high level of competencies in other areas such as Pedagogical Knowledge, Technology Supported Pedagogical Knowledge, Technology Supported Pedagogical Content Knowledge, Content Knowledge-social and Pedagogical Knowledge, and Content Knowledge-literacy. These results confirm the findings found in the other studies regarding preservice teachers' TPACK competencies (e.g., Koyuncuoglu, 2021; Terpstra, 2009). Additionally, Kaleli (2020) found that the preservice teachers showed a moderate or lower perception of technological proficiency in music. Similarly, while teachers in primary education and social branches show partially low technological competencies, they show high competencies in subject areas and pedagogical knowledge (Cox, 2008). A possible interpretation for these findings is that preservice teachers are exposed to training programs mainly that include content knowledge, pedagogical content, and practices. This interpretation is aligned with the findings found in the study conducted by Gülcü et al. (2013), where they concluded that it is necessary for teachers to use new information technologies by making connections between their lessons and new technologies, such as the use of Web 2.0 tools, that can offer many opportunities for teachers to integrate new technologies in their classes.

Another primary finding of this study is related to the comparison of preservice teachers' TPACK competencies by gender and year of study. According to the results of the analysis, male preservice teachers' proficiency in technological knowledge is higher than their female peers. However, female preservice teachers showed higher proficiency in pedagogical content knowledge. These results confirm earlier research findings (e.g., Arslan; Karakaya & Yazici, 2017). Additionally, other studies found that males tend to display their technological competencies at a higher level compared to female (e.g., Dogru, 2020; Kara, 2020; Karakaya & Yazici, 2017). However, Mahmutoğlu's (2019) found that female teacher candidates had stronger pedagogical competencies and were more comfortable and had effective interactions with their students. Tuncer and Bahadır (2016) also found that female teacher candidates are higher in their pedagogical skills and attitudes towards teaching profession compared to their male peers.

Another important finding of the present study is that the students in the 3rd and 4th year of college of education have significantly higher TPACK competencies scores compared to the students in the 1st and the 2nd year in the same college. These findings corroborate the findings of other studies (e.g., Dogru, 2020; Karakaya & Yazici, 2017). A possible interpretation of this finding is that 3rd and 4th year students receive more information during courses and practices that contributed to their higher TPACK competencies. These courses include teaching principal methods, special teaching methods, instructional technologies, and material development.

This study also found that the preservice teachers' self-regulated skills were significantly higher. A possible interpretation for this finding is that preservice teachers' self-regulated skills were greatly improved through using strategies and self-control after being exposed to courses such as theoretical and practical contents, learning strategies, and techniques (Zimmerman, 2008).

Another important finding in the present study is that the preservice teachers' self-regulated learning skills did not differ significantly by gender and year of study. These findings confirm other findings found in other studies (e.g., Gürşimşek, 2002). Similarly, Zimmerman (2008), concluded that while female students at primary and secondary school levels exhibit higher self-regulated learning skills, gender differences in upper grades decrease.

Finally, the first study found a significant and strong correlation between preservice teachers' TPACK competencies and their self-regulated learning skills, where the increase of their self-regulated learning skills corelates with the increase of their TPACK competencies. These findings corroborate with many other studies (e.g., Bakaç & Raşit, 2018; Heo, 2000; Min-hsun & Duo, 2010; Üredi & Üredi, 2005). A possible interpretation for this finding is that preservice teachers gained theoretical, technical knowledge and cognitive strategies and they use it in the learning process effectively. Consequently, it is possible that the preservice teachers with high self-regulated learning skills use different strategies and stronger technological, content, and pedagogical knowledge in their learning.

Discussion the ATU findings

The aim of the second study was to explore the influence of using PBL on preservice teachers' SRL skills and SE in different learning environments. The first result of this study indicated that the use of the PBL has positive affect on preservice teachers' SRL skills. A

possible interpretation for this result is that when students participate in the PBL activities to learn about new concepts they engage in creation of realistic and authentic products and therefore they become motivated to learn due to the personalized and fun activities. This interpretation is aligned with the finding of other studies indicating that students are more likely to take part in PBL due to that students perceive these learning activities as authentic, valuable and challenging (e.g., Blumenfeld et al., 1991).

The second result of the study indicated also that students' SE was enhanced significantly after participating in PBL class activities. A possible interpretation for this result is that the PBL activities helped students to engage efficiently in variety of cognitive activities with their peers and the learning content. As a result of these class activities, students were able to gain self-confidence to conduct the class activities and to achieve higher course scores. This interpretation is consistent with other studies regarding the positive affects of engagement in authentic and fun learning activities on individuals' SE (e.g., Bandura, 2006).

Finally, the result of the study indicated that the PBL class activities equally improved preservice teachers' SRL, regardless of the learning environment they are using. A possible interpretation of this results because students engaged in autonomous learning and self-assessment during the PBL activities in all three learning environments. Consequently, students were able to work on their own pace and enhance their time planning, SRL skills and motivation as well as improve their academic performance. This interpretation is consistent with other studies regarding the PBL as an effective approach to enhance student learning (e.g., Chen & Yang, 2019; Duke et al., 2016; Guo et al., 2020).

Recommendations

Both studies presented the results regarding preservice teachers' TPACK competencies and self-regulatory skills. Both studies highlighted the important role these concepts are playing in enriching education programs both qualitatively and quantitatively. Therefore, it is highly recommended to use TPACK, project-based learning and self-regulatory skills together with better planning, appropriate and complementary studies in teacher education faculties. It is also recommended to provide workshops and planned practices in various subject areas so that prospective teachers can improve their TPACK

competencies and self-regulatory skills. Finally, preservice teachers' TPACK and self-regulatory skills can be investigated through qualitative research techniques.

Ethical Committee Permission Information

Name of the board that carries out ethical assessment: Arkansas Tech University Committee: Institutional Review Board

The date and number of the ethical assessment decision: 02.06.2022/Ibrahim-020617

Author Contribution Statement

Mevlüt AYDOĞMUŞ*: Conceptualization, literature review, methodology, implementation, data analysis, translation, and writing.*

Mohamed Ibrahim*: Conceptualization, literature review, methodology, implementation, data analysis, translation, and writing.*

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