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An Investigation of Change in Mathematics, Science, and Literacy Education Pre-service Teachers' TPACK

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Abstract This quasi-experimental research study aimed to investigate the effect of technological, pedagogical, and content knowledge (TPACK)-based course design on mathematics, science, and literacy education pre-service teachers' TPACK. Participants in the study consisted of 31 mathematics, 32 science, and 38 literacy education pre-service teachers who attended introduction to computers. To collect data, the technological pedagogical content knowledge self-efficacy instrument (TPACKSEI) developed by Graham et al. (2009) was applied before and after the course. The results showed significant improvements in all groups of pre-service teachers' mathematics, science, and literacy education self efficacy on their TPACK. Moreover, there were no significant differences between natural science (mathematics and science education) and social science (literacy) for pre-service teachers' TPACK. However, there were significant differences between natural science and social science pre-service teachers' technological knowledge and technological content knowledge.

Keywords TPACK · Quasi-experimental research · Mathematics–science–literacy pre-service teachers

Introduction

The 21st Century is a period of transformation for education programs and schools. Leng (2008) claims that the information and communications technology (ICT) is in every facet of the societies and schools are seen as vehicle for keeping pace with ICT developments in the societies. For that reason, many countries have invested an important amount of the resources to donate schools with ICT (Leng 2008). Lee and Finger (2010) describe the schools of this new age as "digital schools." Similarly, Pea (1987) states that technology has changed schools in terms of used methods. However, the question of whether these changes will enhance students' learning remains unanswered (Mishra et al. 2009). Educational technology offers many failed examples of enhancing students' learning (Mishra et al. 2009; Reiser 1987), but it continues to make promises, as indicated by De Corte et al. (1994), who detail the fact that computer programs can provide drills and practice, tutorials, instructional games, simulations, spreadsheets, word processing, and database management throughout the teaching and learning process.

Many research studies have investigated reasons for failures. One attribution is the availability of technology (Mishra et al. 2009). Ertmer (1999) counts inadequate equipment as a first-order barrier; however, Dwyeret al. (1991) and Cuban (2001) both found that teachers could not use technology effectively even when it was available. The literature focuses primarily on teachers' technology use, which Ertmer (1999) identifies as a second-order barrier. According to Clements (2002), technology use and its classroom integration are essential to extracting its potential. Lee and Finger (2010) point to the same needs for digital schools. Mishra et al. (2009) advocate that integrating technology appropriately into subject matters is more fundamental than the technology itself.

Mishra and Koehler (2006) believe that oversights about technology integration can be attributed to the lack of theory developing the integration process, so they developed a framework, technological, pedagogical, content knowledge (TPACK), as the result of their five-year study. According to

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Mishra and Kohler, this framework can lead to the design of pedagogical strategies and an analytic lens through which to study changes in educators' knowledge about successful teaching with technology. Özgün-Koca et al. (2010) address the popularity of the TPACK framework with mathematics as an example: "As teachers decide whether and how to use advanced digital technologies in their teaching, they need to consider the mathematical content that they will teach, the technology that they will use, and the pedagogical methods that they will employ" (p. 10).

Theoretical Background

TPACK has made a significant impact on the educational technology field (Cox and Graham 2009). It explains teachers' knowledge and skills related to technology integration (Mishra and Koehler 2006; Niess et al. 2009). Nelson et al. (2009) describe TPACK as a conceptual framework depicting the characteristics of teacher knowledge and technology integration in education.

The TPACK framework was extended from pedagogical content knowledge, or PCK (Doering et al. 2009; Mishra and Koehler 2006). Shulman (1986) states that PCK represents a way of thinking based on content and pedagogy that is not exclusive, blending "content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman 1986, p. 8).

With the penetration of technology to educational institutions, effective technology integration has been the concern of many research studies. Mishra and Koehler (2006) added technology knowledge to the PCK framework. The core of TPACK is a transactional relationship between curriculum content, specific pedagogy, and educational technologies used to produce effective discipline-based teaching (Angeli and Valanides 2008; Shin et al. 2009). As seen in Fig. 1, the components of TPACK are (a) content knowledge (CK), which is subject matter to be learned or taught; (b) pedagogical knowledge (PK), which are practices of teaching regarding educational purposes; (c) pedagogical content knowledge (PCK), which is awareness of teaching methods appropriate to subject matters; (d) technological knowledge (TK), which is the skill to use both standard and more advanced technologies; (e) technological content knowledge (TCK), which is familiarity with the properties of technology for specific subject matters; (f) technological pedagogical knowledge (TPK), which is knowing the capabilities and components of technologies and how to use them; and (g) TPACK, which includes three components (content, pedagogy, and technology) but extends beyond them as individual components (Cox 2008; Mishra and Koehler 2006; Shin et al. 2009). Polly and Brantley-Dias (2009) state, "TPACK gives a holistic perspective of the knowledge associated with effectively integrating technology into learning environments, accounting for what teachers know and what teachers do" (p. 46). Harris et al. (2007) emphasize that the three components are dependent and that each one affects the others. In other words, pedagogy and technology are decided according to content and how the content is taught is decided according to technology (Mishra et al. 2007).

Finger et al. (2010) state that in the modern digital age, teacher education programs are required to improve pre-service teachers' TPACK. For that purpose, Harris and Hofer (2009) suggest using instructional planning to form curriculum-based technology integration.

Many scholars point out the importance of teachers' TPACK assessments (Finger et al. 2010; Harris et al. 2010; Koehler et al. 2012). Many studies have aimed to assess teachers' and pre-service teachers' TPACK. Harris et al. (2010) presented a new rubric for assessing the quality of lesson plans in terms of technology integration. Similarly, Finger et al. (2010) claim that TPACK is the outcome of teacher development and should be measured with a reliable tool, so they proposed the TPACK confidence survey (TCS). Chai et al. (2011) developed a TPACK survey including 7 constructs of TPACK frameworks as TK, CK, PK, TPK, TCK, PCK, and TPACK. Hu and Fyfe (2010) conducted a pre-test/post-test design to investigate the effect of a new curriculum on pre-service teachers' TPACK by implementing the adapted version of Schmidt et al. (2009) survey. Shin et al. (2009) also conducted the Schmidt et al. (2009) survey to investigate how pre-service teachers' TPACK changed in a pre-test/post-test research design. This study also aimed to investigate whether mathematics, literacy, and science education pre-service teachers' TPACK changed in a pre-test/post-test research design by administering Graham et al. (2009) survey. Four research questions shaped this goal:

(1) Is there any significant difference in mathematics pre-service teachers' TPACK scores before and after instruction?
(2) Is there any significant difference in science pre-service teachers' TPACK scores before and after instruction?
(3) Is there any significant difference in literacy pre-service teachers' TPACK scores before and after instruction?
(4) Is there any significant difference between natural science (mathematics and science) and social science (literacy) pre-service teachers in terms of TPACK scores?

Methodology

This study was a quasi-experimental study. The uniqueness of experimental studies stems from them being the only

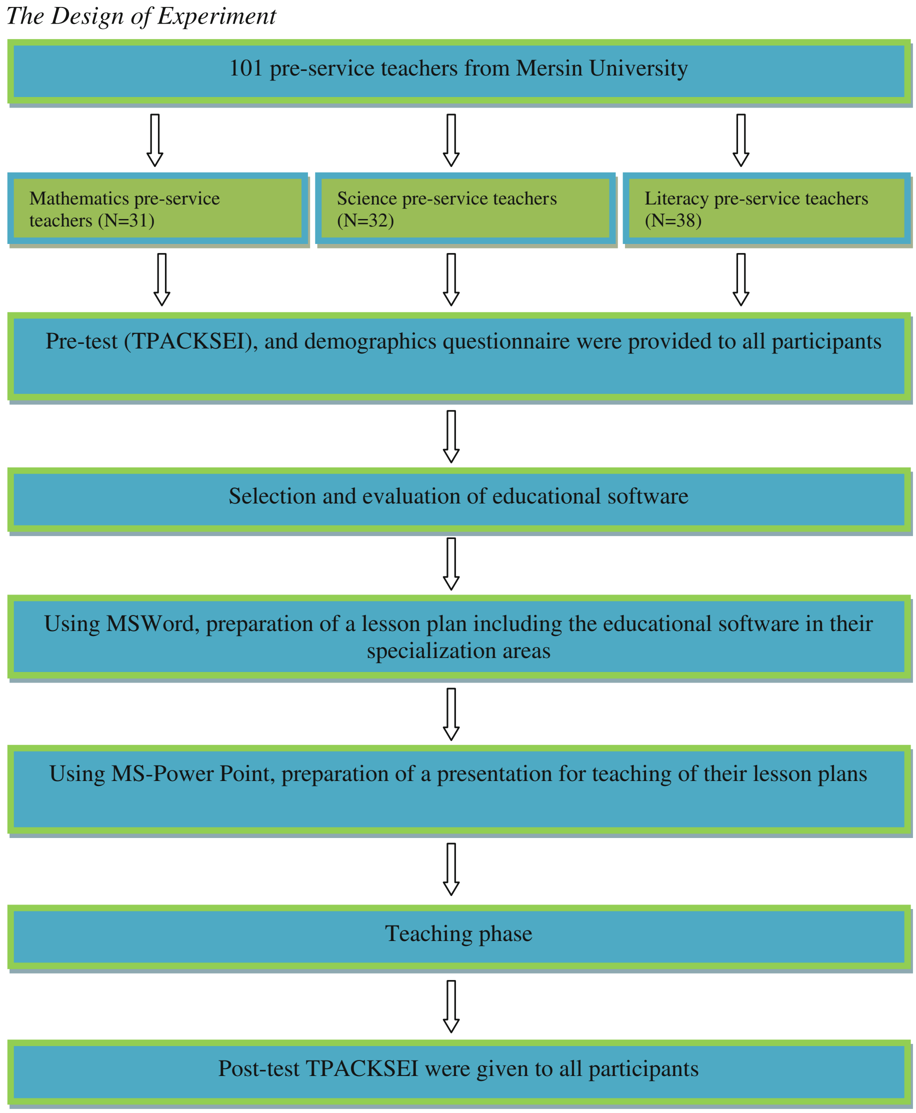

Fig. 1 The design of experiment

research type that directly attempts to influence a particular variable (Fraenkel and Wallen 2000). Experimental research manipulates an independent variable and assesses its effect on a dependent variable. In this study, the pre-service teachers' self efficacies in terms of their TPACK scores were the dependent variable, while instruction (including TPACK-based activities) was the independent variable.

Sampling Procedure

The researchers applied convenience sampling strategies to select study participants. A sample of 101 pre-service teachers registered for *Introduction to Computers* participated.

Background information on the pre-service teachers was collected via a demographic questionnaire. Participants consisted of 31 pre-service teachers in mathematics education, 32 pre-service teachers from science education, and 38 pre-service teachers from literacy education (see Table 1). The instructor was from mathematics education. Two experts, one in science education and the other in instructional technology, helped the instructor design the course and analyze the data.

Among the pre-service teachers from mathematics education, 19 were female, while 12 were male ($N = 12$) with a mean age of 19.7. Mathematics pre-service teachers had an average GPA of 3.22 out of 4. They reported a length of computer use ranging from 1 to 12 years, with an average of 4.05. Mathematics pre-service teachers also stated that they used a computer an average of 8 h a week. They

Table 1 Descriptive statistics of participants

Groups	*N*	Mean	SD
Science	32	91.37	22.53
Mathematics	31	83.6	8.34
Literacy	38	81.71	12.51

described using computers during their courses to prepare reports, search the web, and present their work.

The science pre-service teachers who participated in the study were made up of 24 females and 8 males. They had an average age of 19.6 and an average GPA of 2.92. Science pre-service teachers' experience with the computer ranged from 2 to 11 years, with an average of 6.6. They used computers an average of 9.1 h/week; similar to the mathematics pre-service teachers, science pre-service teachers used computers to search the internet and prepare and present their work.

A total of 38 literacy pre-service teachers (25 females, 13 males) participated in the study. Their ages averaged 20.7, and their GPAs had a mean of 2.93. They had been using computers from 1 to 10 years ($M = 5.4$ years). The demographic results showed that the average computer use of literacy pre-service teachers was 9.7 h a week. During their academic training, literacy teachers' also used computers to search the web and present their work.

Instruments

Two instruments were used to collect data in this study. First, a questionnaire developed by the researchers was used to collect demographic data. The questionnaire included questions about age, gender, department, enrolled courses, class level, GPA, home computer usage, and coursework or other activities requiring computer usage.

The second instrument was a literacy version of Graham et al. (2009)'s technological pedagogical content knowledge self-efficacy instrument (TPACKSEI), translated by Timur and Taşar (2011). The TPACKSEI was developed to measure pre-service teachers' self efficacy in terms of TPACK and consists of four subscales: the technological pedagogical content knowledge (TPACK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological knowledge (TK).

Table 2 presents the number of items in the TPACKSEI and its subscales with possible scores for each. TPACKSEI, which includes 31 positively worded items, has a Likert scale with six response categories (1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, 5 = strongly agree; items 16–20 also included 0 = I do not know these kind of technologies). The TPACK subscale includes eight items with possible scores ranging from 8 (8×1) to 40 (8×5); the TPK subscale consists of seven items with scores ranging from 7 (7×1) to 35 (7×5); the TCK subscale has five items with scores ranging from 0 to 25; the TK subscale includes 11 items and possible scores from 11 to 55. Moreover, the Cronbach's alpha coefficients of each subscales were found 0.95, 0.91, 0.97, and 0.92 orderly.

Timur and Taşar (2011) presented the instrument to 393 science and technology teachers and found its Cronbach's alpha coefficient to be 0.92. Moreover, they found the Cronbach's alpha coefficients of each subscales 0.89, 0.87, 0.89, and 0.86 (Timur and Taşar 2011).

Table 2 Number of items and possible scores on TPACKSEI instrument

	Number of items	Possible scores
TPACKSEI	31	26–155
TPACK	8	8–40
TPK	7	7–35
TCK	5	0–25
TK	11	11–55

Procedure and Course Design

This study took place during a 16-week semester and featured several hands-on activities (Fig. 1). The participants took the course with peers in their program and the same instructor taught all the courses using the same course design. In other words, the instructor offered three program pre-service teachers in different sections. The classroom in which the experiment was conducted was a computer laboratory. The mathematics education pre-service teachers took the course Monday morning during 4 h with 2 breaks with 15 min each; science and technology education pre-service teachers Wednesday morning during 4 h with 2 breaks with 15 min each; and literacy education pre-service teachers Friday morning during 4 h with 2 breaks with 15 min each.

The participants were initially given the TPACKSEI instrument and a cyclical diagram of TPACK (Fig. 1). They were also given a demographics questionnaire developed by the researchers. They were voluntarily divided into groups of five or six for future discussions and collaborative activities. Technological information about MS Word and PowerPoint was provided via work sheets during the lessons (TK), leading to four activities designed to develop the pre-service teachers' self-efficacy scores on their TPACK: required participants first to discuss the criteria to use. Next, they were introduced to Heinich et al. (2002) software checklist; working in groups, they created detailed criteria for each main criterion in the checklist, which they posted on a blog created by the instructor. The final step was to find educational software related to their academic subject and present its characteristics, including its educational aim, to the other groups. The other pre-service teachers evaluated software based on their own detailed criteria list and posted their scores on the blog web page.

TPACK

During the second activity, each pre-service teacher prepared a lesson plan in their subject area using MS Word while using the educational software selected in the first activity. Groups had discussions about how to select or prepare the best plan among those prepared by the members and published the best plan on the blog. Each participant was required to post comments on the lesson plans regarding content knowledge (subject), technology (educational software), and pedagogy.

TCK + TPK

The third activity included the preparation of PowerPoint materials based on the lesson plans prepared during the second activity. Individually prepared presentations for teaching a specific subject matter were chosen from the national curriculum and discussed within groups, and one was chosen for the final presentation. The pre-service teachers posted the final versions of their presentations on the blog web page and shared comments in terms of design and content.

TPACK

The last activity was the teaching phase, which required each group to teach the lesson using their presentations. Each participant evaluated the other groups using a rubric focused on TPACK dimensions and posted their scores and observations on the blog. Each participant was given the TPACKSEI instrument and TPACK diagram again at the end of the course.

Data Analysis

The TPACKSEI instrument contained four sub-sections: TPACK, TPK, TCK, and TK. Therefore, the data analysis results focused first on the pre-service teachers' self efficacy for each sub-scale, then on the TPACKSEI as a whole. SPSS 17.0 was used to present the inferential statistics. A paired samples t test was used to compare the pre- and post-test scores within the same group to determine whether a score change occurred. An independent samples t test was conducted to compare the change of gain between groups.

Internal Validity

Johnson and Christensen (2004) state that, for experimental studies, researchers "must be alert to the influence of potentially confounding extraneous variables that can threaten the internal validity of the study" (p. 276). These threats include history, maturation, testing, instrumentation, and regression artifacts (Fraenkel and Wallen 2000). These threats and how they were coped with within the study, are discussed in more detail below:

History was only a minor problem in the study because no unplanned event that might influence the post-measurement of the dependent variable occurred between the pre-test and post-test measurement of the dependent variable.

Maturation or "any physical or mental change that occurs over time that affects performance on the dependent variable" (Fraenkel and Wallen 2000, p. 236) was controlled for in the current study.

Testing was only a minor problem in this study, as problems can occur when participants respond to an instrument more than once.

Regression artifacts were controlled for in the current study since there was no tendency for very high scores to become lower or very low scores to become higher during post-testing.

Ethical Issues

This experimental study had no harmful applications for the pre-service teachers. Each participant was provided with the same information during the treatment and was assigned a pseudonym since the researcher was also the instructor of the course. Moreover, the data were not analyzed until after the course ended. All the participants were volunteers to participate in the study.

Results

The analysis of data was conducted over two steps. First, in the data-cleaning process, the researchers examined missing cases and outliers using descriptive statistics (percentage, frequency, mean, and SD). In the second step, separate inferential statistics (such as independent sample t test) were performed.

Non-equivalent comparison-group design always possesses a potential differential selection bias because groups are not equal, and "pretest allows exploration of the possible size and direction of the bias on any variable measured at pretesting" (Johnson and Christensen 2004, p. 303). An independent samples t test using a two-tailed .05 criterion was conducted to check the initial TPACK self-efficacy levels of participants (see Table 3). There was no significant difference in scores for science ($M = 91.97$, $SD = 22.53$) and literacy [($M = 81.71$, $SD = 12.51$); $t\ (68) = 2.26$, $p = .08$]. In addition, statistically significant differences were not detected for science ($M = 91.97$, $SD = 22.53$) and mathematics [($M = 83.6$, $SD = 8.34$); $t\ (60) = 1.82$, $p = .09$]. Similar results were found between mathematics ($M = 83.6$, $SD = 8.34$) and literacy [($M = 81.71$, $SD = 12.51$); $t\ (66) = 0.71$, $p = .48$].

Table 3 An independent samples *t* test in comparison of pretest results for TPACK self-efficacy instrument

	t	*df*	*p*
Science–Literacy	2.263	68	.08
Mathematics–Science	1.823	60	.09
Mathematics–Literacy	0.711	66	.48

$p < .005$

Table 4 Paired-sample *t* test results for mathematics pre-service teachers' self efficacy on TPACK

	t	*df*	Effect size
TPACK	10.131*	30	.64
TPK	10.570*	30	.65
TCK	8.603*	30	.56
TK	18.654*	30	.85
TOTAL SE	22.396*	30	.89

* $p < .005$

Table 5 Paired-sample *t* test results for science pre-service teachers' self efficacy on TPACK

	t	*df*	Effect size
TPACK	3.246*	31	.14
TPK	5.194*	31	.31
TCK	3.235*	31	.14
TK	3.263*	31	.15
Total SE	4.061*	31	.21

* $p < .005$

Table 6 Paired-sample *t* test results for literacy pre-service teachers' self efficacy on TPACK

	t	*df*	Effect size
TPACK	7.061*	37	.40
TPK	5.361*	37	.28
TCK	5.686*	37	.30
TK	5.742*	37	.31
Total SE	8.683*	37	.51

* $p < .005$

Inferential Statistics for Pre-Service Teachers' Self-efficacy Based on TPACK

Table 4 shows statistically significant differences between pre and post application of the TPACK instrument for the mathematics pre-service teachers ($p = .000$). For all of the subcategories, the η^2 statistic (.64, .65, .56, .85, and .89) indicated large effect sizes (Cohen 1988), high enough results to warrant practical significances for the subcategories of the TPACK instruments.

As shown in Table 5, there were statistically significant differences between pre and post application of the TPACK instrument for the pre-service science teachers ($p = .000$). For all of the subcategories, the η^2 statistic (.14, .31, .14, .15, and .21) indicated large effect sizes (Cohen 1988), warranting practical significances for the subcategories of the TPACK instruments.

The results (Table 6) showed that between pre and post application of the TPACK instrument for the literacy pre-service teachers indicated statistically significant differences ($p = .000$). The η^2 statistics computed for all of the subcategories (.40, .28, .30, .31, and .51) indicated large effect sizes (Cohen 1988), once again proving practical significances for the subcategories of the TPACK instruments.

Comparative Inferential Statistics for Change of Gain in Pre-service Teachers' Self-Efficacy on TPACK

As seen in Table 7, the TCK and TK dimensions show statistically significant differences between pre and post application of the TPACK instrument for the natural science background teachers and social science background teachers. The TCK results showed significant difference in scores for natural science ($M = 5.43$, SD = 4.79) and social science teachers [($M = 3.31$, SD = 2.59); t (98) = 2.25, $p = .01$]. The η^2 statistic (.05) indicated moderate effect sizes (Cohen 1988). Effect sizes were high enough to warrant practical significances for the TCK dimension. Similar findings in the TK dimension showed a significant difference in scores for natural science ($M = 11.95$, SD = 10.11) and social science teachers [($M = 7.26$, SD = 6.79); t (98) = 2.47, $p = .01$]. The η^2 statistic (.05) indicated moderate effect sizes (Cohen 1988), and this result is high enough to warrant practical significance. On the other hand, the other dimensions had no significant difference in scores for natural science and social science pre-service teachers. For TPK, there was no significant difference in scores for natural science ($M = 6.29$, SD = 5.23) and social science teachers [($M = 5.21$, SD = 5.11); t (98) = .948, $p = .34$ (two-tailed)]. Similar results were detected for TPACK; there was no significant difference in scores for natural science (M = 7.19, SD = 7.14) and social science teachers [($M = 7.23$, SD = 6.31); t (98) = −.028, $p = .97$]. Finally, Table 7 shows that for the Total Self Efficacy scores, there were no significant differences in scores for natural science ($M = 30.54$, SD = 25.04) and social science teachers [($M = 23.02$, SD = 16.34); t (98) = 1.81, $p = .07$].

Table 7 An independent samples t test in comparison of changes in pre-test–post-test results for TPACK instrument

	Pre-service teachers with natural science background (mathematics and science) ($N = 62$)		Pre-service teachers with social science background (literacy) ($N = 38$)		t	Effect size
	M	SD	M	SD		
TPACK	7.19	7.14	7.23	6.31	−.028	–
TPK	6.29	5.23	5.21	5.11	.948	–
TCK	5.43	4.79	3.31	2.59	2.258*	.05
TK	11.95	10.11	7.26	6.79	2.473*	.05
Total SE	30.54	25.04	23.02	16.34	1.816	–

* $p < .05$, $df = 98$

Discussion and Conclusion

The current research study aimed to investigate the effect of TPACK-based instruction on mathematics, science, and literacy pre-service teachers' self efficacy on TPACK. Moreover, the differences between the nature of science (science and mathematics) and literacy pre-service teachers' in terms TPACK after the instruction was examined. The goal of the course was to improve pre-service teachers' TPACK by exposing them to TPACK-based activities. Jang (2010) emphasizes the importance of equipping teachers in the 21st century with TPACK, calling it "professional teacher knowledge." According to Finger et al. (2010), the work of preparing pre-service teachers lies in their education programs: "Pre-service teacher education programs have the responsibility for preparing future teachers who are likely to be teaching their students in a world characterized by ongoing technological changes (p. 114)." Mishra and Koehler (2006) observe that teachers' competencies integrating technology into instruction promote students' learning.

The two instruments applied to collect data were a demographics questionnaire and the Turkish version of TPACKSEI developed by Graham et al. (2009) and translated into Turkish by Timur and Taşar (2011). The demographic questionnaire was administered at the beginning of the course, while the TPACKSEI and TPACK diagrams were presented at the beginning and end. To analyze data, the paired samples t test and the independent t test were applied. The paired samples t test was applied to compare the pre- and post-test scores within the same group to investigate whether changes occurred in TPACK scores. The independent samples t test was conducted to compare the change of gain between the nature of science and social science groups.

The researchers first examined whether the groups (science, mathematics, and literacy education pre-service teachers) differed in terms of their TPACK at the beginning of the study, and independent samples t-tests were applied. According to Johnson and Christensen (2004), groups should be equal in terms of investigated variables to eliminate a potential differential selection bias. They suggest using a pre-test to explore the bias of any variables. Pre-test analysis showed no significant difference between science, mathematics, and literacy pre-service teachers in terms of TPACK.

The results of the study showed significant differences between pre-test and post-test TPACK scores of science, mathematics, and literacy pre-service teachers. The three groups showed a difference at the $p = .000$ level with large effect size. These results agree with previous studies investigating whether ICT course experiences enhance teachers' TPACK (Chai et al. 2010; Doering et al. 2009; Shin et al. 2009).

The results related to investigating significant differences between natural science (science and mathematics) and social science (literacy) pre-service teachers' TPACK at the end of the experiment showed no significant difference in scores (t (98) $= -.28$, $p = .97$). However, there were significant differences between natural science and literacy pre-service teachers' scores in the TCK and TK dimensions. For TK, there was a significant difference between natural science ($M = 11.95$ with SD $= 10.11$) and literacy ($M = 7.26$ with SD $= 6.79$) pre-service teachers in scores at t (98) $= 2.47$, $p = .01$. Similarly, in the TCK dimension, natural science and literacy pre-service teachers' scores significantly differed at t (98) $= 2.25$, $p = .01$. These results agreed with Doukakis et al. (2010) study examining secondary computer science teachers' perception on their TPACK by applying the Schmidt et al. (2009) instrument and finding that they were confident with TK and CK. However, Doukakis et al. (2010) concluded that teachers need assistance on the TPK dimension. Doering et al. (2009) conducted a study investigating the change in social studies teachers' metacognitive awareness of their TPACK after their participation in a program that enabled them to teach in an online environment. According to the results, the teachers' perception of their TPACK changed positively; their TK was most improved. Doering et al. (2009) further state that technology has potential for teaching and learning that which is not realized by social studies. In this study, the teachers realized technology's potential.

Koehler and Mishra (2008) state that technological knowledge means both the ability to use technological tools and the knowledge behind them. In other words, according to them, beyond using the technological tools, teachers also should understand the situations the information technology can help them for achieving a goal. Moreover, in their study Finger et al. (2010) concluded that "Those limited levels of TK confidence were found to translate into limited TPACK capabilities to integrate ICT for curriculum applications" (p. 124).

Although TK is necessary for successful application of technology, especially for TPK, TCK, and TPACK, solid TK does not guarantee success in these intersections. Chuang and Ho (2011) claim, "Technological knowledge alone could not make a good TPACK and that the choice of technology and pedagogy in a particular subject must take into account the dynamic combination between the components and the intersections such as TPK (Technological pedagogical knowledge), PCK (pedagogical content knowledge), TCK (technological content knowledge) among them" (p. 113).

Soong and Tan (2010) claim that TPACK-based course designs can contribute to successful technology integrations for teachers, and the literature can describe such designs. The current study can be considered a good example of TPACK-based course design. It tried to enhance pre-service teachers' basic computer competencies by providing them practice preparing lesson plans and presentations. Moreover, they were encouraged to think about how to select and integrate educational software into their teaching according to content and pedagogy. Another aim of the study was, as Koehler and Mishra (2008) emphasize, "Instead of applying technological tools to every content area uniformly, teachers should come to understand that the various affordances and constraints of technology differ by curricular subject-matter content or pedagogical approach" (p. 22).

The Current Study did have a Limitation

The sampling of the study was selected among volunteer pre-service teachers who attended *Introduction to Computers*, and convenience sampling was applied.

For further study, the reasons for differences between natural science and social science pre-service teachers' TK and TCK should be investigated. As Koh et al. (2010) state, "Pre- and post-course TPACK surveys can be used to supplement qualitative analysis of teachers' TPACK development during such kinds of programmes" (p. 571). Social science and natural science pre-service teachers' perception of TPACK should be investigated through both qualitative and quantitative approaches. Moreover, an in-depth investigation is needed to understand the relationships between the components of TPACK.

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