RELATIONSHIP OF SELF-EFFICACY AND TECHNOLOGICAL, PEDAGOGICAL, CONTENT AREA KNOWLEDGE (TPACK) OF NATIONAL BOARD CERTIFIED TEACHERS (NBCTS)

Cheryl Martin, EdD, Dysart Unified School District

ABSTRACT

Elementary through twelve grade (K-12) teacher knowledge has changed significantly over the past 100 years. The pendulum has swung from focusing mainly on content-area knowledge to mainly on pedagogical strategies (Shulman, 1987). This dichotomy between these two distinct knowledge constructs influenced Shulman's (1986) research on pedagogical content-area knowledge (PCK). Shulman's PCK framework describes the intersection of both pedagogy and content area knowledge as a unique knowledge to the teaching profession. At the same time PCK was established, the Carnegie Forum on Education and Economy recommended creating a National Board of Professional Teaching Standards (NBPTS) to demonstrate Shulman's PCK framework. Furthermore, these new standards embraced Mezirow's (1991) transformative learning theory. They predicted that the 21st-century teacher would "not come to the school knowing all they have to know but knowing how to figure out what they need to know" (Carnegie Task Force, 1986, p. 25). Consequently, it was determined that what the 21st-century teacher needed to know was technology integration (Gentry et al., 2014; Ismaeel & Al Mulhim, 2022).

INTRODUCTION

Research indicates that teachers participating in professional development programs are likelier to have increased technological knowledge (Handler et al., 2021; Lehiste, 2015). The National Board Certification process, often "recognized as the gold standard in teacher certification" (National Board for Professional Teaching Standards, 2014, p. 1), is a year-long professional development process that helps to build teachers' confidence and knowledge through the integration of technology, pedagogy, and content to prepare teachers for contemporary 21st-century teaching (Handler et al., 2021; Lehiste, 2015).

Experiences and beliefs offer insight into defining 21st-century teacher knowledge. Historically, research indicates that teachers' perceptions of their own learning contribute to their aptitude and ability to teach (Bandura, 1977). Furthermore, the way that teachers interpret their own prior knowledge and classroom experiences is important to acquiring further pedagogical and content-area knowledge (Handler et al., 2021; Mezirow, 2000). Shulman's (1987) research on pedagogical and content-area knowledge integration influenced the idea that the 21st-century teacher must develop a deep understanding of both content and pedagogy to increase knowledge capacity in both areas.

However, PCK itself is not enough to describe the entirety of 21st-century teacher knowledge. The framework does not include technological

components that address how teachers integrate technology to transform their learning through technological experiences, critical reflection, and rational discourse (Abbit, 2011; Mezirow, 1991). In response, Mishra and Koehler (2006) developed the TPACK framework, which added four additional technologically interconnected domains to Shulman's original PCK. This created the technological, pedagogical, and content-area framework (TPACK), forming the basis for 21st-century teacher knowledge.

Research also indicated that teachers who had participated in professional development programs, such as the National Board Certification process, were more likely to have increased self-efficacy and TPACK, because the process helps to build teachers' confidence and knowledge (Handler et al., 2021; Lehiste, 2015). The NBCT certification demands that teachers "support content-related and pedagogical goals...and use instructional tools, including technology, within the curriculum" to support learning (National Board for Professional Teaching Standards, 2015, p. 13). Studies show that teachers who participated in professional development, such as NBPTS, not only increased their technological knowledge but began to evaluate the associations between pedagogy, content-area knowledge, and technology better (Kurt et al., 2013; Mulder, 2014).

REVIEW OF RELEVANT LITERATURE

Although many studies identify teacher knowledge perceptions regarding teachers' integrated TPACK, few have measured the dual constructs of self-efficacy and TPACK. Research reveals that "the greatest barrier to successful technological integration in instruction is related to teachers' efficacy-beliefs" (Giles & Kent, 2016, p. 33; Handler et al., 2021). Tweed's (2013) research on non-NBCTs specifically identifies technology as one of the highest areas of need, and that the perceptions of unpreparedness regarding technology are common among teachers. Research further demonstrates that teachers who have high self-efficacy purposefully challenge themselves within their learning and teaching (Cevik Kilic, 2015). This increases their self-efficacy and TPACK integration (Keser et al., 2015). The absence of information about the relationship between self-efficacy and TPACK for NBCTs is addressed in this study.

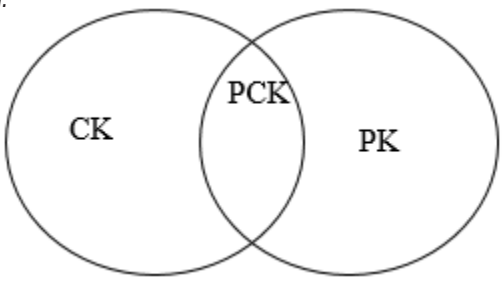
Theoretical Foundations.

Two theories frame this study. First, Mezirow's (1991) transformative learning theory provided the theoretical foundation for adult learning and teacher knowledge through the lens of the NBPTS process and TPACK. Transformative learning develops TPACK through a critical assessment of assumptions and reflections, which is necessary for NBCTs to learn and understand TPACK (Mezirow, 1991; Mishra et al., 2011). Second, Bandura's (1977) self-efficacy theory provided the theoretical foundation for teacher's beliefs in their learning abilities. Perceived self-efficacy strongly impacts a teacher's anticipated cognitive success, as learning is not just transformed through knowledge but also realized through the beliefs teachers have about their competency to acquire such knowledge (Bandura, 1999; Handler et al., 2021; Mezirow, 1991). Specifically, these frameworks provided an opportunity to examine the relationship between self-efficacy and each of the technology-integrated TPACK competencies for NBCTs.

TPACK Framework.

Shulman's (1986) research, comparing the knowledge of accomplished teachers to that of novice teachers, determined that the most knowledgeable teachers use a combination of both content-area knowledge and pedagogical knowledge to teach complex ideas (Shulman, 1987). Pedagogical knowledge (PK) is defined as knowing how to present the information for learning, and content knowledge (CK) is defined as subject matter knowledge. Thus, the intersection of PK and CK distinguishes teachers from just being content-area experts (Shulman, 1986). Shulman (1986) identified this as PCK or pedagogical content-area knowledge (Figure 1).

Figure 1.

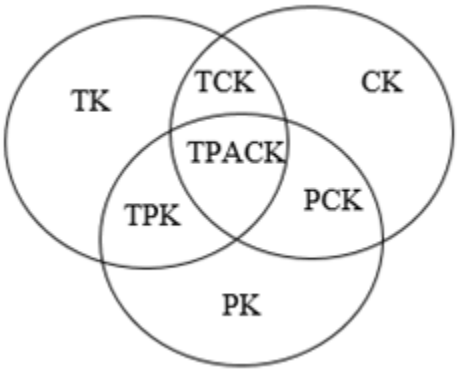


In 2006, Mishra and Koehler added technology to Shulman's original framework. Their research defined technology as a fluid concept, noting that

digital tasks could be done through information processing, communication, or problem-solving (Koehler & Mishra, 2009). More specifically, this updated framework adds four distinct areas of integrated technological knowledge to the PCK framework. First, technological knowledge (TK) is defined as knowing how to use technology (Mishra & Koehler, 2006). Secondly, technological pedagogical knowledge (TPK) is defined as the teachers' ability to determine what tools are best used for the lesson. Third, technological content-area knowledge (TCK) describes the knowledge of selecting the best technological tools for a specific subject area (Mishra & Koehler, 2006). Finally, like Shulman's earlier work, Mishra and Koehler (2006) theorized that the most effective teacher knowledge intersects from all points of the TPACK framework (Figure 2).

Figure 2.

Three Circle Representing the Intersection of TPACK



Note: Adapted with permission From Mishra & Koehler, 2006

National Board for Professional Teaching Certification

Shulman continued to recognize teachers as professionals by advocating for the creation of a national board of teacher certification. This board, comparable to medical and legal boards, would certify teachers on a national scale (Shulman, 1986). In 1986, Shulman and The Carnegie Forum on Education and Economy formally introduced a plan to create a National Board for Professional Teaching Standards to establish high standards for what teachers need to know and be able to do (Carnegie Task Force, 1986; National Board for Professional Teaching Standards, 2022). In 1987, the National Board of Professional Teacher Standards was established, granting certification to teachers who successfully demonstrated the knowledge and skills related to the PCK integrated framework (Sykes, 2022). Thus, the introduction of teacher knowledge as both pedagogy and content-area knowledge integration was formally established. Today, the NBCT standards also include integration technology (National Board Certification, 2022).

To become a National Board-Certified Teacher, an educator must have at least three years of full-time experience, submit a teaching portfolio, and submit a video of their authentic teaching practice to a peer-reviewed committee (National Board Certification, 2022). NBCTs must demonstrate their ability to know the subjects they teach and be able to integrate pedagogical strategies and technology within those subject areas (Handler et al., 2021). This process can take up to five years (National Board for Professional Teaching Standards, 2022). Presently, only 0.3% of teachers hold National Board Certification (National Board for Professional Teaching Standards, 2015).

Self-efficacy and TPACK

Teachers' self-efficacy perceptions affect teacher knowledge and TPACK integration. For instance, a lack of perceived confidence has contributed to a reduction of technology usage in the classroom (Blackwell et al., 2014; Minshew & Anderson, 2015). Moreover, teachers who do not have a high belief in their abilities to use technology in the classroom assign sporadic or stand-alone technology assignments (Byker, 2014), which do not correlate to using integrated TPACK competencies (Corkin et al., 2016). However, high self-efficacy levels do correlate to improved technology usage in the classroom (Gomez et al., 2022; Hines, 2013). Studies suggest that teachers with high self-efficacy have a positive effect on TPACK, specifically with the ability to support instruction within the areas of TK and TCK (Millen & Gable, 2016; Su et al., 2017). Moreover, previous studies indicate that NBCTs have high levels of self-efficacy (Handler et al., 2021; Hines, 2013), but no studies indicate NBCTs TPACK knowledge.

Changing Role of K-12 Teachers

Modern teaching shifts traditional methods of teaching through the integration of TPACK. In a modern classroom, technology unites the curriculum in the same way that reading and writing unite all subject areas (Gentry et al., 2014; Ismaeel & Al Mulhim, 2022). Technology opens doors for communication like never before (Sasseen et al., 2013). Today's students are expected to manipulate information within compelling learning environments (Archambault et al., 2022; McWilliam, 2017), in which teachers have a central role in creating instruction through their knowledge of technology and content (Handler et al., 2021; Harlow Shinas et al., 2013). In a modern classroom, technology develops within the lesson to transform pedagogy and its content (Bicen & Beheshti, 2022; Kazu & Erten, 2014). Therefore, the usage of technology is simply not enough. There needs to be a shift in K-12 education toward the integration of technology, pedagogy, and content-area knowledge.

TPACK Competencies

Technological knowledge constantly changes and encompasses a broad set of skills that are difficult to master. Technological knowledge must encompass ways to authentically use technology in the classroom to connect to the subject matter (Paciga et al., 2018). Research shows diverse results in the TK construct. For instance, teachers in six districts in China rated themselves lowest regarding TK (Liu et al., 2015), and parallel findings in New Zealand indicated that even after field experience, TK was the lowest construct noted in a post-survey (Nordin et al., 2013). However, teachers in Taiwan rated themselves highest in TK (Chang et al., 2014). These diverse results show just how varied and comprehensive technological skills are. This research study extended these results to include National Board Certified Teachers in the USA.

Pre-service teachers and non-NBCTs do show strong perceptions of technological pedagogical knowledge after practice and training. For instance, in their final year of university coursework, preservice teachers demonstrated high scores in TPK ($M = 4.71$) after constructivist-oriented training (Dong et al., 2015), and high scores in TPK ($M = 4.67$) after general teacher training (Kurt et al., 2013). Moreover, practicing elementary school teachers rated TPK highest out of all the technologically embedded competencies ($M = 3.54$), showing strong perceptions in this construct (Yi et al., 2015). Furthermore, in two separate studies in the United States, preservice teachers in Illinois ($M = 6.01$) and Nebraska ($M = 4.51$) saw marked improvements in TPK after training (Banas & York, 2014; Hofer & Grandgenett, 2012). National Board Certified Teachers participate in several years of professional training, and the results of this study revealed their TPK perceptions.

Although the technological content-area knowledge construct represents an integration of technology and content-area expertise, research reveals that even among a population of content experts, a high degree of TCK is difficult to master (Brantley-Dias & Ertmer, 2013; Trihastuti, 2022). Benson and Ward (2013) interviewed and observed content-area specialists and showed that only 33% of the instructors with specialized content and education training, integrated technology and content-area knowledge. Additionally, Akman and Guven (2015) found a medium direct relationship between CK and TCK, and a medium direct relationship between TK and TCK, indicating that 40% of the TCK perceptions could be explained by isolated CK and TK perceptions. However, none of these studies considered National Board Certification.

Overall, overall teaching experiences correlate to TPACK success. Integrated technology, pedagogy, and content-area knowledge are created through the different combinations of TPACK knowledge (Koehler et al., 2013). It takes practice and experience to become proficient. In a case study, Benson and Ward (2013) revealed that teachers with strong TPACK mastery differentiate instructional decisions in unique ways that foster student learning through technology. A mean analysis of all variables in TPACK indicated that non-NBCTs with experience scored over five points in all areas of TPACK on a Likert scale of seven, indicating high perceptions of all TPACK areas (Kim et al., 2013). Also, after field experience, preservice teachers increased TPACK by 0.63, indicating a medium effect and revealing that teaching experience plays a role in increasing TPACK (Nordin et al., 2013). This study revealed the TPACK knowledge of highly experienced NBCTs.

RESEARCH QUESTIONS

Before this study, little was known about the relationship between self-efficacy and TPACK among NBCTs specifically. TPACK studies for non-NBCTs typically focused on content-specific subjects or grade-level specific teachers (Beeson et al., 2014; Celik & Aytin, 2014; Utomo, 2022). Overall, preservice populations were more prevalent than any other teacher population studied within TPACK (Aldemir Engin et al., 2022; Jordan & Dinh, 2012; Young et al., 2014). Moreover, the literature review did not reveal a specific examination of National Board-Certified Teachers' self-efficacy in relation to their integrated TPACK knowledge. This study aimed to extend this empirical research by examining the relationship between self-efficacy and the technologically-integrated knowledge competencies of TPACK for NBCTs. The following research questions (RQs) guided the research study:

RQ1. Is there a statistically significant correlation between self-efficacy and technological knowledge (TK) of National Board Certified Teachers?

RQ2. Is there a statistically significant correlation between self-efficacy and technological, pedagogical knowledge (TPK) of National Board Certified Teachers?

RQ3. Is there a statistically significant correlation between self-efficacy and technological content-area knowledge (TCK) of National Board Certified Teachers?

RQ4. Is there a statistically significant correlation between self-efficacy and technological pedagogical content-area knowledge (TPACK) of National Board Certified Teachers?

METHODOLOGY

This study employed a quantitative correlational methodology. The research questions focused on the relationship between self-efficacy and the four technologically embedded TPACK competencies of NBCTs. Data was collected from a survey that was sent as an email link to all NBCTs in the state of Arizona. This study collected and measured interval data, which allowed for the testing of relationships between the variables (Ledermann & Kenny, 2017). The data was primary source data collected from self-reported surveys completed by individual NBCTs. The data collection procedures used two instruments to measure the research variables operationally. A survey method was used to collect data on the sample.

RESEARCH CONTEXT AND SAMPLE

The target population was comprised of 1,219 National Board-Certified Teachers in the state of Arizona, USA. The sample for this study included 84 National Board-Certified Teachers in Arizona. The data indicated that 84 participants were over the age of 18, held National Board Certification, and had over three years teaching experience. Data for each variable was collected through self-report and resulted in a range of responses based on two validated instruments, which were used to measure TPACK knowledge and self-efficacy beliefs. Participants completed each survey via a web-based survey system.

SURVEY INSTRUMENTS

The first instrument was the Teacher's Sense of Self-Efficacy Scale (TSES), which was used to collect information on perceived self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2001a). The TSES operationally defined and measured self-efficacy from 12 questions on a Likert scale with a range of 1 to 9 (Tschannen-Moran & Woolfolk Hoy, 2001a). The TSES is categorized into three subsets of four questions each: items 2, 3, 4, and 11 measure efficacies in student engagement; items 5, 9, 10, and 12 measure efficacies in instructional strategies; and items 1, 6, 7, and 8 measure efficacies in classroom management (Tavokal & Dennick, 2011). The instrument developer provided scoring instructions for a total score.

The second instrument was the Preservice Survey of Teachers' Knowledge of Teaching and Technology (TPACK survey), which was used to collect data on technological, pedagogical, and content-area knowledge integration (Schmidt et al., 2009). This survey instrument was used to operationally define and measure the knowledge teachers have within the TPACK framework from questions in four subcategories: technological knowledge, technological pedagogical knowledge, technological content-area knowledge, and technological pedagogical content area knowledge. A total of 24 questions in four subsets were measured on a Likert scale from 1-5 (Schmidt et al., 2009). The instrument developer provided scoring instructions for each subset.

RELIABILITY AND CONSISTENCY

Cronbach's alpha was computed to assess the internal consistency reliability for the five study variables. An alpha of 0.70 or greater was used to indicate an acceptable reliability (Torres et al., 2017). Internal consistency was measured based on the composite scores for the correlations between the twelve different items on the TSES instrument by evaluating Cronbach's alpha. Also, internal consistency reliability was measured based on the composite scores for each of the four technological subscales on the TPACK survey by evaluating Cronbach's alpha. This included the correlations between the seven items for the technological knowledge subset, the correlations between the four items for the technological content-area knowledge subset, the correlations between the five items for the technological pedagogical knowledge subset, and the correlations between the eight items for the technological pedagogical content-area knowledge subset.

Cronbach's alpha for the TSES scale was 0.93, with an error variance of 0.07. This demonstrated good internal consistency and was consistent with the Cronbach's alpha reported in the instrument's description ($\alpha = 0.90$). The reliability of the technological content-area knowledge subscale was 0.71, with an error variance of 0.29. This was in the acceptable range but yielded a lower score than reported in the instrument description ($\alpha = 0.86$). The reliability of the technological pedagogical content-area knowledge subscale was 0.84, with an error variance of 0.16. This demonstrated good internal consistency and was consistent with the Cronbach alpha for the individual scale reported for the instrument description ($\alpha = 0.89$). The reliability of the technological knowledge subscale was 0.93, with an error variance of 0.07. This demonstrated good consistency and was higher than the Cronbach alpha for the individual scales reported in the instrument description ($\alpha = 0.86$). Finally, reliability scores for the technological pedagogical knowledge subscales yielded a Cronbach's alpha of 0.82, with an error variance of 0.18. This also demonstrated good consistency but was lower than Cronbach alpha for the individual scales reported in the instrument description ($\alpha = 0.93$). Overall, the TPACK subscales and TSES yielded acceptable internal consistency reliability. Table 1 summarizes the Cronbach's alpha inter-reliability statistics for this study and the instrument descriptions.

PROCEDURES

This study focused on the relationship between perceived self-efficacy beliefs and the four technologically embedded TPACK knowledge domains for NBCTs. The researcher administered the combined TSES/TPACK survey through an online survey system as a combined instrument. An electronic survey was sent to the sample by email using a web-based software program. Participation was voluntary, and the survey was anonymous. The Institutional Review Board (IRB) at the institution where the research was conducted reviewed and approved all procedures.

A quantitative correlational approach was used to assess the bivariate correlations between TSES and TPACK scores for 84 NBCTs in Arizona. The predictor variable was self-efficacy, which was measured by the Teacher's' Sense of Self-Efficacy Scale. The criterion variables were the four-integrated technological, pedagogical, and content-area knowledge competencies (TK, TCK, TPK, and TPACK), as defined by the TPACK framework and measured by the Preservice Survey of Teachers' Knowledge of Teaching and Technology.

Data from the predictor variable, self-efficacy, was measured and collected from the TSES. The data were collected from a nine-point Likert

Table 1.

Cronbach's Alpha Statistics of Survey Instruments

Instrument/Subscale	Obtained Cronbach's alpha	Typical Cronbach's alpha	*N* of items
TSES overall	0.93	0.90	12
TK subscale	0.93	0.86	7
TCK subscale	0.71	0.86	4
TPK subscale	0.82	0.93	5
TPACK subscale	0.84	0.89	8

scale ranging from (1) nothing to (9) a great deal (Tschannen-Moran & Woolfolk Hoy, 2001a). The instrument developer provided scoring instructions. The criterion variable data, TK, TCK, TPK, and TPACK, were measured and collected from the TPACK survey. The original items were based on a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree (Schmidt et al., 2009). The instrument developer provided scoring instructions. The data were converted to a mean score for each subset in the TPACK survey: TK, TCK, TPK, and TPACK. Data were converted to a mean score for the total TSES.

After the data were collected and uploaded, tests for assumptions were completed. The tests indicated that not all the assumptions were met for the planned Pearson's *r* analysis. For all variables, normality and outlier assumptions were violated. Removing outliers and re-examining the data still indicated a violation of the normality assumption. These results suggested performing a non-parametric analysis rather than using the Pearson's *r*, as planned. The two primary non-parametric alternatives are Spearman's ρ and Kendall's τβ, and these were utilized to analyze the data. Still, since the deviations from normality are relatively small and Pearson's *r* is robust under such conditions, Pearson's *r* was also reported, including post hoc statistical power results (Bishara & Hittner, 2012).

RESULTS

This study focused on the relationship between perceived self-efficacy beliefs and the four technologically embedded TPACK knowledge domains for NBCTs. Therefore, the analysis of data evaluated the bivariate relationships between self-efficacy and the four-technology embedded TPACK subscales using a Pearson Product-Moment correlation.

The bivariate correlation results for RQ1 showed a very small correlation and non-significant result between self-efficacy and technological knowledge for National Board Certified Teachers. Both the parametric and non-parametric tests were consistent with their results ($r_t = 0.136$, $p > 0.05$; $r_s = 0.197$, $p > 0.05$ and $r = 0.106$, $p > 0.05$). The power analysis for the study was calculated post hoc using the Pearson *r* results. The statistical power was determined to be 0.16, which was well below the recommended 0.80 level. Based on these results, the researcher failed to reject the null hypothesis associated with the RQ1 (Table 2).

Table 2.

Results for RQ1

RQ1: TK		*p* value	Decision	Effect size
Kendall's Tau-b	0.136	0.07	Fail to reject H_0	Very small
Spearman's Rho	0.197	0.07	Fail to reject H_0	Very small
Pearson's *r*	0.106	0.34	Fail to reject H_0	Very small

The bivariate correlation results for RQ2 (Table 3) showed a small to medium statistically significant correlation between self-efficacy and technological pedagogical knowledge for National Board Certified Teachers. Both the parametric and non-parametric test results were consistent ($r_t = 0.212$, $p < .05$; $r_s = 0.301$, $p < 0.05$ and $r = 0.242$, $p < 0.05$). The power analysis for the study was calculated post hoc using the Pearson *r* results. The statistical power was determined to be 0.61. The lower power was due to the smaller-than-predicted effect size. Based on the results, the researcher rejected the null hypothesis associated with the second research question.

Table 3.

Results for RQ2

RQ3: TCK		*p* value	Decision	Effect size
Kendall's Tau-b	0.212	0.007	Reject H_0	Small
Spearman's Rho	0.301	0.005	Reject H_0	Medium
Pearson's *r*	0.242	0.020	Reject H_0	Small

The bivariate correlation results for RQ3 (Table 4) showed a small to medium statistically significant correlation between self-efficacy and technological content-area knowledge for National Board Certified Teachers. Both the parametric and non-parametric test results were consistent ($r_t = 0.251$, $p < 0.05$; $r_s = 0.332$, $p < 0.05$ and $r = 0.268$, $p < 0.05$). The power analysis for the study was calculated post hoc using the Pearson *r* results. The statistical power was determined to be 0.70. The lower power was due to the smaller-than-predicted effect size. Based on the results, the researcher rejected the null hypothesis associated with RQ3.

Table 4.

Results for RQ3

RQ3: TCK		*p* value	Decision	Effect size
Kendall's Tau-b	0.251	0.001	Reject H_0	Small
Spearman's Rho	0.332	0.002	Reject H_0	Medium
Pearson's *r*	0.268	0.010	Reject H_0	Small

The bivariate correlation results for RQ4 (Table 5) showed a small to medium statistically significant correlation between self-efficacy and technological pedagogical content-area knowledge for National Board Certified Teachers. Both the parametric and non-parametric test results were consistent ($r_t = 0.247$, $p < 0.05$; $r_s = 0.356$, $p < 0.05$ and $r = 0.265$, $p < 0.05$). The power analysis for the study was calculated post hoc using the Pearson *r* results. The statistical power was determined to be 0.69. The lower power was due to the smaller-than-predicted effect size. Based on the results, the researcher rejects the null hypothesis associated with RQ4.

Table 5.

Results for RQ4

RQ4: TPACK	*r*	*p* value	Decision	Effect size
Kendall's Tau-b	0.247	0.001	Reject H_0	Small
Spearman's Rho	0.356	0.002	Reject H_0	Medium
Pearson's *r*	0.265	0.002	Reject H_0	Small

DISCUSSION

This study was developed to bring advancement to the body of knowledge on self-efficacy, TPACK, and transformative learning theory. The significance of this study provided empirical data to school districts, universities, professional development administrations, and the National Board for Professional Teaching Standards organization. These organizations train and/or employ National Board Certified Teachers. Prior to this study, researchers focused on non-NBCTs and pre-service teachers. This study contributed by providing insight into transformative learning theory and demonstrating the knowledge NBCTs have in developing through transformative learning. The study also demonstrated that NBCTs have high self-efficacy and that these efficacious beliefs correlate to integrated technological knowledge. The potential practical applications could guide school districts, professional development trainers, and curriculum writers to understand the beliefs and knowledge that NBCTs have. This could lead to decisions about training modules and teacher leadership roles for NBCTs.

To become NBCTs, teachers must think systematically about their practice and learn from their experience by demonstrating the importance of developing authentic lessons that integrate technology, pedagogy, and content-area knowledge (National Board for Professional Teaching Standards, 2015). This study provides school administrators, universities, the Arizona K-12 center, and the National Board for Professional Teaching Standards with an evaluation of the beliefs and knowledge NBCTs have about self-efficacy and the four technologically embedded

TPACK competencies. The research questions for this study were designed to address this problem.

As the national certification is standardized and can be generalized to describe all NBCTs, this study is applicable beyond the local setting. Therefore, this study brings about essential information regarding NBCT knowledge. This study also produced valuable new information to the body of knowledge on developing teacher curriculums, planning professional development opportunities, and refining or redesigning the National Board of Professional Teaching Standards. The investigation of the relationship between NBCTs' beliefs through self-efficacy and their knowledge of the integrated technological domains of the TPACK is also important for school administrators to understand the specific knowledge NBCTs bring to their schools and districts.

LIMITATIONS OF STUDY

In examining this study, some limitations in the sample, methodology, and results are notable. A limitation in this study arose from the design. Correlational studies do not establish causation (Becker et al., 2016), and as a consequence, there was no way to apply the results to show a cause-and-effect relationship between the variables.

Another limitation was that the data was collected from a non-random sample of voluntary participants. A limitation of using volunteers was that volunteers might be more interested in the topic than the overall target population (McPeake et al., 2014). The consequence of this was that it might lead to difficulty in applying the findings to the general population.

Moreover, the study relied on self-report, which is a limitation as bias could manifest if the respondent strives for consistency or presents themselves more favorably due to current cultural norms (Dodd-McCue, 2010). The results could affect the generalizability because of skewed data.

The scope of this study was limited to National Board Certified Teachers in Arizona. Survey responses were based on the perceptions of Arizona teachers who were National Board Certified. The consequence of sampling one geographic location is that it might not be generalizable to other diverse areas (Neville et al., 2014) and could be seen as a limitation.

Also, due to the nature of the study and sampling strategy, the results of the study were not generalized to teachers outside of National Board Certified Teachers in the United States. The rationale to use NBCTs was justified through the gap, as the population was underrepresented in the literature. However, the consequence of this is that this study would not apply to teachers who do not hold National Board Certification, and this may not be generalizable to the entire teacher population.

Finally, limitations were revealed in the data analysis, specifically in the Pearson correlation assumptions tests. All variables were not normally distributed, and outliers were evident in all cases. There were limitations with removing the outliers, which could skew the data, affect the kurtosis, or affect the mean of the data (Pollet & van der Meij, 2017). However, the decision was made to eliminate the outliers to meet the normality assumptions of the Pearson *r* and to enhance the accuracy of the analysis (Osborne & Overbay, 2004). Even after outliers were removed, some of the data still could not be considered normally distributed. Therefore, non-parametric tests were used to analyze the data, which resulted in less power.

SUGGESTIONS FOR FURTHER RESEARCH

It is recommended that future research investigate the relationship between the two concepts using a qualitative design. Qualitative designs contribute to findings related to human behavior and experience and can generate new ideas to provide information for professional development interventions (Atieno, 2009). A qualitative design would also be helpful to understand how the National Board Certification process influences self-efficacy and TPACK knowledge.

It is also recommended to incorporate self-efficacy and TPACK with demographic variables, such as time spent as a certified NBCT, age, gender, and time spent as a teacher. Research suggests that mid-career teachers are more intentional about teaching and eager to learn new pedagogical strategies (Masuda et al., 2012). Also, teachers with higher scores in self-efficacy and technology usage are typically 31-35 years old (Dogru & Gencosman, 2015). Furthermore, findings on gender and TPACK have varied results, and females outnumber males in the teaching profession (Liu et al., 2015; Minshew & Anderson, 2015). Therefore, a recommended multiple regression procedure

would allow researchers to predict or explain these multiple variables.

Another recommendation for research is to compare the results of non-NBCTs and NBCTs. By comparing both populations through the self-efficacy and TPACK variables, the researcher could evaluate the differences and similarities in beliefs and knowledge. This would give the researcher insight into the effectiveness of the National Board of Professional Teaching Standards professional development program within the framework of this study's variables.

Furthermore, researchers could replicate the study to include NBCTs in other states to see if the results are generalizable across multiple NBCT populations.

CONCLUSIONS

This study was developed to bring advancement to the body of knowledge on self-efficacy, TPACK, and transformative learning theory for NBCTs. The significance of this study is that it provides empirical data to school districts, universities, professional development professionals, and the National Board for Professional Teaching Standards organization. These organizations train and/or employ National Board Certified Teachers. Prior to this study, research focused on non-NBCTs and pre-service teachers. This study contributes by providing insight into transformative learning theory and demonstrates the knowledge NBCTs have in developing self-efficacy and TPACK through transformative learning. The study demonstrated that NBCTs have high self-efficacy and that these efficacious beliefs correlate to integrated technological knowledge. The potential practical applications could guide school districts, professional development trainers, and curriculum writers to distinguish the beliefs and knowledge that NBCTs have. This could lead to decisions about training modules and teacher leadership roles for NBCTs.

References

Abbit, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about Technology Integration and Technological Pedagogical Content Knowledge (TPACK) among preservice teachers. *Journal of Digital Learning, 27*(4), 134–142.

Akman, O., & Guven, C. (2015). TPACK survey development study for social sciences teachers and teacher candidates. *International Journal of Research in Education and Science, 1*(1), 1–10.

Aldemir Engin, R., Karakuş, D., & Niess, M. L. (2022). TPACK development model for pre-service mathematics teachers. *Education and Information Technologies,* 1–26.

Archambault, L., Leary, H., & Rice, K. (2022). Pillars of online pedagogy: A framework for teaching in online learning environments. *Educational Psychologist, 57*(3), 178–191.

Atieno, O. P. (2009). An analysis of the strengths and limitation of qualitative and quantitative research paradigms. *Problems of Education in the 21st Century, 13*(1), 13–38.

Banas, J. R., & York, C. S. (2014). Authentic learning exercises as a means to influence preservice teachers' technology integration self-efficacy and intentions to integrate technology. *Australasian Journal of Educational Technology, 30*(6), 728–746.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215.

Bandura, A. (1999). Social cognitive theory: An agentic perspective. *Asian Journal of Social Psychology, 2,* 21–41.

Becker, T. E., Atinc, G., Breaugh, J. A., Carlson, K. D., Edwards, J. R., & Spector, P. E. (2016). Statistical control in correlational studies: 10 essential recommendations for organizational researchers. *Journal of Organizational Behavior, 37*(2), 157–167.

Beeson, M. W., Journell, W., & Ayers, C. A. (2014). When using technology isn't enough: A comparison of high school civics teachers' TPCK in one-to-one laptop environments. *The Journal of Social Studies Research, 38*(3), 117–128. https://doi.org/10.1016/j.jssr.2014.03.00

Benson, S. N., & Ward, C. L. (2013). Teaching with technology: Using TPACK to understand teaching expertise in online higher education. *Journal of Educational Computing Research, 48*(2), 153–172.

Bicen, H., & Beheshti, M. (2022). Assessing perceptions and evaluating achievements of ESL students with the usage of infographics in a flipped classroom learning environment. *Interactive Learning Environments, 30*(3), 498–526.

Bishara, A. J., & Hittner, J. B. (2012). Testing the significance of a correlation with non-normal data: Comparison of Pearson, Spearman, transformation, and resampling approaches. *Psychological Methods,* 17, 399–417. https://doi.org/10.1037/a0028087

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2014). Factors influencing digital technology use in early childhood education. *Computers & Education, 77,* 82–90.

Brantley-Dias, L., & Ertmer, P. A. (2013). Goldilocks and TPACK: Is the construct "Just right?" *Journal of Research on Technology in Education, 46*(2), 103–126.

Byker, E. J. (2014). Needing TPACK without knowing it: Integrating educational technology in social studies. *Social Studies Research and Practice, 9*(3), 106–117.

Carnegie Task Force. (1986). *A nation prepared: Teachers for the 21st Century. The report of the task force on teaching as a profession. Carnegie forum on education and the economy.* New York: Carnegie Corporation.

Celik, S., & Aytin, K. (2014). Teachers views on digital educational tools in English language learning: Benefits and challenges in the Turkish context. *The Electronic Journal for English as a Second Language, 18*(2), 1–18.

Cevik Kilic, D. B. (2015). Music teachers' computer anxiety and self-efficacy. *Educational Research and Reviews, 10*(11), 1547–1559.

Chang, Y., Tsai, M. F., & Jang, S. J. (2014). Exploring ICT use and TPACK of secondary science teachers in two contexts. *US-China Education Review, 4(*5), 298–311

Corkin, D., Ekmekci, A., White, C., & Fisher, A. (2016). *Teacher's self-efficacy and knowledge for the integration of technology and mathematics instruction at urban schools.* Paper presented at Proceedings of the 43rd Annual Meeting of the Research Council on Mathematics Learning, Las Vegas, NV.

Dodd-McCue, D. (2010). Self-report response bias: Learning how to live with its diagnosis in chaplaincy research. *Chaplaincy Today, 26*(1).

Dogru, M., & Gencosman, T. (2015). *Investigation of the self-efficacy levels of teachers in using educational technology.* Paper presented at Proceedings of the Multidisciplinary Academic Conference, Prague, Czech Republic.

Dong, Y., Chai, C. S., Sang, Y., Koh, H. L., & Tsai, C.-C. (2015). Exploring the profiles and interplays of preservice teachers and in-service teachers' technological pedagogical content knowledge (TPACK) in China. *Educational Technology & Society, 18*(1), 158–169.

Gentry, J. E., Baker, C., Thomas, B. D., Whitfield, C., & Garcia, L. (2014). Transforming technology integration: An instrument to measure educator's self-efficacy for modeling 21st-century skills. *National Teacher Education Journal, 7*(3), 31–38

Giles, R. M., & Kent, A. M. (2016). An investigation of preservice teachers' self-efficacy for teaching with technology. *Asian Education Studies, 1*(1), 2424–8487.

Gomez, F. C., Trespalacios, J., Hsu, Y. C., & Yang, D. (2022). Exploring teachers' technology integration self-efficacy through the 2017 ISTE Standards. *TechTrends, 66*(2), 159–171.

Handler, L. K., Petty, T. M., Good, A. J. (2021). Supporting teacher learning during the professional development experience: The case of national board certification. *Current Issues in Education, 22*(3). https://doi.org/10.14507/cie.vol22iss3.1976

Harlow Shinas, V., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J. J. (2013). Examining domains of technological pedagogical content knowledge using factor analysis. *Journal of Research on Technology in Education, 45*(4), 339–360.

Hines, L. (2013). *National Board for Professional Teaching Standards certification and teacher self-efficacy* (Paper No. 46) [Doctoral dissertation, Western Kentucky University].

Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in Education, 45*(1), 83–106

Ismaeel, D. A., & Al Mulhim, E. N. (2022). E-teaching internships and TPACK during the Covid-19 crisis: The case of Saudi pre-service teachers. *International Journal of Instruction, 15*(4).

Jordan, K., & Dinh, H. (2012). TPACK: Trends in current research. *Proceedings of the Australian Council for Computers in Education Conference, Australia, 1-15.*

Kazu, I. Y., & Erten, P. (2014). Teachers' technological pedagogical content knowledge self-efficacies. *Journal of Education and Training Studies, 2*(2), 126–144.

Keser, H., Yilmaz, F. G., & Yilmaz, R. (2015). TPACK competencies and technology integration self-efficacy perceptions of preservice teachers. *Elementary Education Online, 14*(4), 1193–1207.

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education, 29,* 76–85.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Evaluation, 9*(1), 60–70.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? Journal of Education, 193(3), 14–19.

Kurt, G., Mishra, P., & Kocoglu, Z. (2013). Technology pedagogical content knowledge development of Turkish preservice teachers of English. *24th Society for Information and Teacher Education (SITE) International Conference, New Orleans, USA.*

Ledermann, T., & Kenny, D. A. (2017). Analyzing dyadic data with multilevel modeling versus structural equation modeling: A tale of two methods. *Journal of Family Psychology, 31*(4), 442.

Lehiste, P. (2015). The impact of a professional development program on in-service teachers' TPACK: A study from Estonia. *Problems of Education in the 21st Century,66,* 18–28.

Liu, Q., Zhang, S., & Wang, Q. (2015). Surveying Chinese in-service K12 teachers' technology, pedagogy, and content knowledge. *Journal of Educational Computing, 53*(1), 1–20. https://doi.org/10.1177/0735633115585929

Masuda, A. M., Ebersole, M. M., & Barrett, D. (2012). A qualitative inquiry: Teachers' attitudes and willingness to engage in professional development experiences at different career stages. *Delta Kappa Gamma Bulletin, 79*(2), 6–14.

McPeake, J., Bateson, M., & O'Neill, A. (2014). Electronic surveys: How to maximize success. *Nurse Researcher, 21*(3), 24–26.

McWilliam, E. (2017). Today's children, tomorrow's creatives: Living, learning and earning in the conceptual age. In *Educating for the 21st Century* (pp. 7–23). Springer Singapore.

Mezirow, J. (1991). *Transformative dimensions of adult learning.* Jossey-Bass

Mezirow, J. (2000). *Learning as transformation: Critical perspectives on a theory in progress*. Jossey-Bass.

Millen, R., & Gable, R. (2016). New era of teaching, learning and technology: Teachers' perceived technological pedagogical content knowledge and self-efficacy towards differentiated instruction. *Paper presented at the annual meeting of the New England Educational Research Organization, Portsmouth, New Hampshire, USA*. https://core.ac.uk/download/pdf/303926307.pdf

Minshew, L., & Anderson, J. (2015). Teacher self-efficacy in 1:1 iPad integration in middle school science and math classrooms. *Contemporary issues in Technology and Teacher Education, 15*(3), 334–367.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. ***Teachers College Record, 108***(6), 1017–1054.

Mishra, P., Koehler, M., & Henricksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st Century learning. *Educational Technology, 51*(2), 22–28.

Mulder, D. J. (2014). Technology-infused teacher preparation: Connecting technology and pedagogy, 1–17. Dordt University.

https://digitalcollections.dordt.edu/cgi/viewcontent.cgi?article=1045&context=faculty_work

National Board Certification. (2022, September 22). *Get certified and take your teaching career to the next level.* Dordt University.

National Board for Professional Teaching Standards (2014). *Guide to national board certification (1.5)*. http://boardcertifiedteachers.org/sites/default/files/Guide_to_NB_Certification.pdf

National Board for Professional Teaching Standards (2015). *Middle childhood generalist standards.* http://www.nbpts.org/wp-content/uploads/2017/07/MC_Gen_Component1.pdf

National Board for Professional Teaching Standards (2022). *What teachers should know and be able to do*. https://www.accomplished teacher.org/_files/ugd/0ac8c7_25be1413beb24c14

ab8f6e78a20aa98f.pdf

Neville, H. A., Poteat, V. P., Lewis, J. A., & Spanierman, L. B. (2014). Changes in White college students' color-blind racial ideology over 4 years: Do diversity experiences make a difference? *Journal of Counseling Psychology, 61*(2), 179.

Nordin, H., Davis, N., & Ariffin, T. F. T. (2013). A case study of secondary preservice teachers' technological pedagogical and content knowledge mastery level. *Procedia-Social and Behavioral Sciences, 103*, 1–9.

Osborne, J. W., & Overbay, A. (2004). The power of outliers (and why researchers should always check for them). *Practical Assessment, Research & Evaluation, 9*(6), 1–12.

Pollet, T. V., & van der Meij, L. (2017). To remove or not to remove: The impact of outlier handling on significance testing in testosterone data. *Adaptive Human Behavior and Physiology, 3*(1), 43–60.

Paciga, K. A., Fowler, A., & Quest, M. (2018). Constructing preservice teachers' knowledge of technology integration. In *Encyclopedia of Information Science and Technology, Fourth Edition* (pp. 7623–7634). IGI Global.

Sasseen, J., Olmstead, K., & Mitchell, A. (2013). Digital: As mobile grows rapidly, the pressures on news intensify. *The state of the news media 2013—An annual report on American journalism.* Washington, DC: Pew Research Center's Project for Excellence in Journalism.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123–149.

Shulman, L. S. (1986). Those who understand knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of new reform. ***Harvard Educational Review***, 57(1), 1–21.

Su, X., Huang, X., Zhou, C., & Chang, M. (2017). A Technological Pedagogical Content Knowledge (TPACK) scale for geography teachers in senior high school. *Education and Science, 41*(190), 135–341.

Sykes, J. (2022). The impact of national board certification, advanced degree, and teaching experience on reading achievement of second and third grade students. *International Journal of Education and Social Science Research, 5*(1), 42–63. http://dx.doi.org/10.37500/IJESSR.2022.5105

Tavokal, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2,* 53–55.

Torres, R., Goyal, D., Burke-Aaronson, A. C., Gay, C. L., & Lee, K. A. (2017). Patterns of symptoms of perinatal depression and stress in late adolescent and young adult mothers. *Journal of Obstetric, Gynecologic & Neonatal Nursing, 46*(6), 814–823.

Trihastuti, E. (2022). The relationship of Technological Pedagogical and Content Knowledge capabilities with mastery of biological concepts of prospective biology teachers. *Journal of Biology Education, 11*(2), 193–201.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001a). Teacher efficacy: Capturing an elusive construct. [Measurement Instrument]. *Teaching and Teacher Education, 17,* 783–805.

Tweed, S. R. (2013). Technology implementation: Teacher age, experience, self-efficacy, and professional development as related to classroom technology integration (UMI no. 3570301) [Doctoral dissertation, East Tennessee State University]. ProQuest Dissertations & Theses.

Utomo, E. (2022). The synthesis of qualitative evidence-based learning by design model to improve TPACK of prospective mathematics teacher. *Journal of Physics: Conference Series, 2157*(1), 1–6. https://doi.org/10.1088/1742-6596/2157/1/012044

Yi, J., Choi, J., & Lee, Y. (2015). A survey on the perception of South Korea elementary school teachers' competency about technology, pedagogy, and content knowledge (TPACK). *E-Learn,* 45–50.

Young, J. R., Young, J. L., & Hamilton, C. (2014). The use of confidence intervals as a meta-analytic lens to summarize the effects of teacher education technology courses on preservice teacher TPACK. *Journal of Research on Technology Education, 46*(2), 149–172. https://doi.org/10.1080/15391523.2013.10782617