DEVELOPMENT OF SURVEY OF TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK)

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ABSTRACT
The purpose of this study is to develop a survey of technological pedagogical and content knowledge (TPACK). The survey consists of seven subscales forming the TPACK model: 1) technology knowledge (TK), 2) pedagogy knowledge (PK), 3) content knowledge (CK), 4) technological pedagogical knowledge (TPK), 5) technological content knowledge (TCK), 6) pedagogical content knowledge (PCK), and 7) TPACK. This study is conducted in five phases: 1) item pool, 2) validity and reliability, 3) discriminant validity, 4) test-retest reliability, and 5) translation of the TPACK survey. To examine language equivalence, both Turkish and English versions of the TPACK survey are administered to preservice teachers studying English language education. It is determined the questionnaire meets the language equivalence. Results demonstrate the TPACK survey is a valid and reliable measure.
Keywords: Survey development; Technology; Pedagogy; Content; TPACK; Preservice teachers.

INTRODUCTION

For teachers to be successful in their career, they need to develop themselves in pedagogy, technology, and their content areas. By using information and communication technologies, teachers can follow developments in their areas, transfer the contemporary approaches and applications regarding teaching methods into their instruction, and keep themselves up-to-date. For these reasons, technology plays a critical role for teacher knowledge improvement.

In recent years, computer and instructional technologies have become an important part of our lives by affecting our learning and communication. Uses of these technologies in our daily lives become widespread since these technologies provide individuals with many benefits and opportunities. For example, the digital video composing feature of computers "can provide rich opportunities for students to learn curricular concepts deeply as they draw on tacit knowledge of media, connect curriculum to their lives through embodied experience, learn multimodal design, and create new identities as designers and active learners" (Miller, 2008, p. 21). Computer and instructional technologies also bring significant novelties to teachers and their classroom instruction.

When teachers integrate technology into instruction, their students become more interested in the subject (Schrum et al., 2007; Sweeder & Bednar, 2001). In the literature, it is stated that teachers with more experience in educational computer use maintain higher expectations for student learning (Hicks, 2006). In addition, use of computers and educational technologies may help increase student performance (Margerum-Leys & Marx, 2002). Hence, teachers should have knowledge in

- identifying subjects to be learned with educational technology in ways that show the added value of educational technology applications,
- determining representations for conveying the context into a comprehensible manner which is hard to teach with the traditional methods,
- establishing teaching strategies which meet learners' needs,
- choosing appropriate educational technology tools which support information transformation and teaching strategies, and
- integrating educational technology activities into the classroom (Angeli & Valanides, 2005).

The literature (Lambert & Sanchez, 2007; Margerum-Leys & Marx, 2002) suggests that teachers' use of educational technology requires comprehensive and multi-faceted knowledge. The goal of a contemporary educational system is to raise individuals, who search for ways to obtain information, know where and how to use it, and have critical thinking skills (Yılmaz, 2007). This goal can be met with teachers who renew themselves with the ever-developing science and technology. Hence, teachers should have the necessary abilities and responsibilities to integrate new technologies into their areas (Hicks, 2006). For instance, rapid diffusion of the Internet and distance education technologies require educators to discuss some issues, such as publishing content online, and interaction between students and educational materials (Peruski & Mishra, 2004).

Increasing quality in teacher education is described as one of the most critical issues (Dexter, Doering, & Riedel, 2006; Strawhecker, 2005). Although the availability of hardware, software, and Internet connections continues to increase in schools and colleges (Miller, 2008), many beginning teachers and preservice teachers do not have the necessary knowledge or experience to incorporate this technology into their classrooms (Buckenmeyer & Freitas, 2005; Niess, 2005). The major reason for their insufficient skills in educational technology is their lack of undergraduate preservice teacher training (Angeli & Valanides, 2005; Koehler, Mishra, & Yahya, 2007). Seeing technology, pedagogy, and content as being independent from each other is a very common problem in preservice and in-service teachers' professional development. Hence, a shift toward training teachers in the use of computers and educational technologies within their academic subject areas has begun (Niess, 2005). Overall, teacher professional development requires a consideration of multiple knowledge domains. So, the need for successful connections between technology, pedagogy, and content in teacher education programs is inevitable.

Examining teachers or teacher candidates' perceptions of their knowledge in technology, pedagogy, content, and their intersections is an essential need to determine the level of their knowledge in each domain. In the literature, it is easy to find surveys developed to assess technology, pedagogy, and content knowledge separately. However, there is a need for an instrument to measure knowledge in not only technology, pedagogy, and content areas, but also their intersections. Although the importance and necessity of technological pedagogical and content knowledge (TPACK) are emphasized, there is currently no comprehensive survey to evaluate TPACK. In fact, it is a common critique for educational technology studies that there is a lack of theoretical framework. Therefore, they ignore the complex and dynamic interaction between technology, pedagogy, and content (Harris, Mishra, & Koehler, 2007). In the current study, the TPACK model is used as the theoretical framework in the process of instrument development, data collection, and interpretation of the results (see Appendix A for the TPACK survey).

Theoretical Framework: Technological Pedagogical and Content Knowledge (TPACK)

Technology changes and develops rapidly. This situation requires determination of its effect on education and teacher beliefs (Margerum-Leys & Marx, 2002). In their conceptual framework for teacher knowledge, Mishra and Koehler (2006) extend Shulman's (1986) "pedagogical content knowledge" model by adding technology knowledge. As seen in Figure 1, the final framework includes three areas of knowledge (technology, pedagogy, and content) and their intersections.

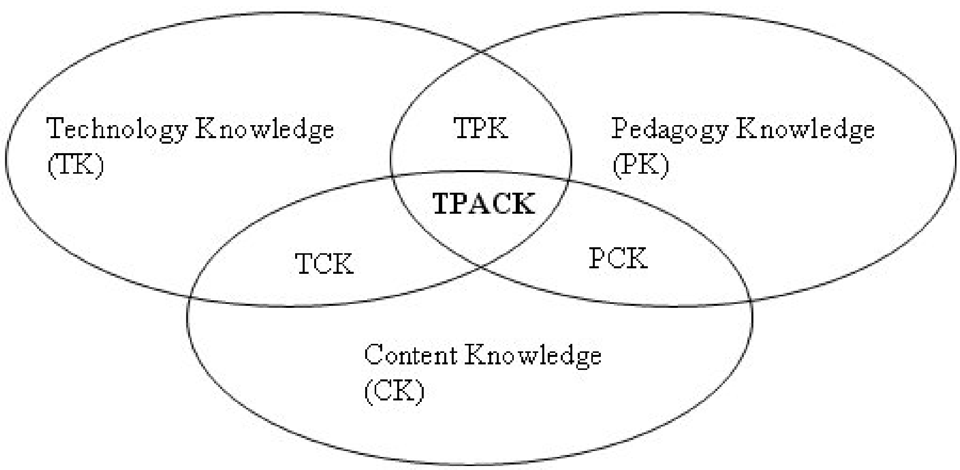

Figure 1: Relationships among Technology, Pedagogy, and Content Knowledge

In the model, the three unitary types of knowledge are technology knowledge (TK), pedagogy knowledge (PK), and content knowledge (CK). The three knowledge constructs are explained below.

Technology Knowledge (TK): This knowledge includes all instructional materials from blackboard to advanced technologies (Koehler et al., 2007). In general, it refers to a variety of technologies used in learning environments (Margerum-Leys & Marx, 2002).

Pedagogy Knowledge (PK): This knowledge includes teaching strategies for addressing individuals' learning needs and methods of presenting the subject matter (Kanuka, 2006). In other words, it refers to practice, procedure, or methods necessary for teaching and learning (Koehler et al., 2007). For instance, this knowledge consists of general classroom management strategies, course planning, and student assessment.

Content Knowledge (CK): This type of knowledge is about the subject area a teacher instructs (Koehler et al., 2007). In other words, it answers the question of "what will be taught?" (Margerum-Leys & Marx, 2002). It includes terms, theories, ideas, constructs, and applications specific to a content area (Shulman, 1986), such as math, biology, and history. An individual without this knowledge may have misconceptions or misleading facts regarding the area (Koehler & Mishra, 2009).

In addition, the model has the three dyadic components of knowledge: technological pedagogical knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK). These types of knowledge are explained next.

Technological Pedagogical Knowledge (TPK): TPK requires an understanding of general pedagogical strategies applied to the use of technology (Margerum-Leys & Marx, 2002). It requires an understanding of how teaching and learning will change with use of certain technologies. It consists of the integration of technological tools and equipment with appropriate instructional designs and strategies by realizing their strengths and limitations. The majority of popular computer software are not designed for educational purposes (Koehler & Mishra, 2009). Instead, they are produced for business, entertainment, communications, and social-interaction purposes. Thus, teachers need to go beyond the general uses of these technologies and integrate them into instruction.

Technological Content Knowledge (TCK): TCK helps teachers visualize instances where technology can be effectively integrated into their teaching (Margerum-Leys & Marx, 2002). For example, significant developments can be realized by computer simulations in physics and math areas (Koehler & Mishra, 2009). This knowledge type shows that technology and content affect and support each other. Hence, teachers must have an idea about their content areas, as well as the use of certain technologies that improve student learning.

Pedagogical Content Knowledge (PCK): PCK refers to teaching knowledge applicable to a certain subject area (Harris et al., 2007). It is necessary to turn content into instruction, like presenting a subject in different ways or adapting instructional materials, based on student needs and alternative ideas. This supports the links between curriculum, assessment, and pedagogy.

However, as the core of the model, TPACK is the intersection of the three knowledge bases.

Technological Pedagogical and Content Knowledge (TPACK): In this model, it is clear that content-based educational technologies must be pedagogically sound (Ferdig, 2006). Mishra and Koehler (2006) especially emphasize the interactions between the three elements. Successful teaching with technology is a multi-dimensional process that:

> . . . requires understanding the representation and formulation of concepts using technologies; pedagogical techniques that utilize technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help address these issues; knowledge of students' prior knowledge and theories of epistemology; and an understanding of how technologies can be utilized to build on existing knowledge and to develop new or strengthen old epistemologies (Koehler et al., 2007, p. 743).

TPACK is suggested as effective teaching with technology. In the literature, TPACK is defined as a critical knowledge base needed to be developed by preservice teachers (Angeli & Valanides, 2005). Developing and implementing successful teaching requires an understanding of how technology is related to pedagogy and content (Koehler et al., 2007). "Unless a teacher views technology use as an integral part of the learning process, it will remain a peripheral ancillary to his or her teaching. True integration can only be understood as the intersection of multiple types of teacher knowledge" (Pierson, 2001, p. 427). Although the importance of the TPACK is clear, extensive research on this type of knowledge has not been conducted yet (Strawhecker, 2005). In the present study, a survey is developed to determine preservice teachers' perceptions of their TPACK.

DEVELOPMENT PHASES OF TPACK SURVEY

As mentioned above, the survey developed in the present study consists of seven subscales forming the TPACK model: 1) TK, 2) PK, 3) CK, 4) TPK, 5) TCK, 6) PCK, and 7) TPACK. This research study is conducted in five phases: 1) item pool, 2) validity and reliability, 3) discriminant validity, 4) test-retest reliability, and 5) translation of the TPACK survey. These phases are explained next.

Phase 1: Item Pool

To develop the survey, the theoretical framework and related literature are used. An item pool, including 60 items, is formed. The items for seven subscales of the TPACK model (TK, PK, CK, TPK, TCK, PCK, and

TPACK) are evaluated with the options of "totally measuring," "somewhat measuring," or "not measuring" by 10 faculty members from the programs of Computer and Instructional Technology, Curriculum Development, and Psychological Counseling. Next, the 47 items, labeled "totally measuring" by at least seven faculty members, were selected. In Table 1, minimum and maximum points for each subscale are presented.

Table 1: Minimum and Maximum Points for Each Subscale

Subscale	No of Items	Min. Point	Max. Point
TK	15	15	75
PK	6	6	30
CK	6	6	30
TPK	4	4	20
TCK	4	4	20
PCK	7	7	35
TPACK	5	5	25

Higher scores for each subscale indicate higher perceived acquaintance with the applications of the knowledge base. The survey items are answered by means of a Likert-type scale with five response choices, including "1=not at all," "2=little," "3=moderate," "4=quite," and "5=complete."

Phase 2: Survey Validity and Reliability

Participants: Validity and reliability studies of the survey are conducted with 348 (44.5% female; 55.5% male) preservice teachers.

Procedures: Phase 2 involves testing the construct validity of the TPACK survey. The factor validity of the seven subscales is examined using exploratory factor analysis (EFA). EFA is used to verify whether the survey items for each subscale successfully measure each variable. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity (BTS) are applied to the data prior to factor extraction to ensure the characteristics of the data set are suitable for EFA. Since the KMO and BTS results indicate the data satisfy the psychometric criteria for factor analysis, the EFA is performed. Furthermore, item-total correlations and Cronbach's alpha internal consistency coefficient are calculated.

Results: Before conducting factor extraction, the KMO and BTS are applied to ensure that characteristics of the data set are suitable for factor analysis. Factor loadings along with the KMO and BTS results are provided in Table 2.

Table 2: Factor Loadings for Each Subscale

Item	TK	PK	CK	TPK	TCK	PCK	TPACK
1	0.773	0.800	0.599	0.831	0.823	0.824	0.872
2	0.751	0.833	0.752	0.903	0.892	0.811	0.891
3	0.816	0.872	0.855	0.895	0.877	0.848	0.884
4	0.706	0.849	0.792	0.819	0.865	0.847	0.832
5	0.774	0.856	0.826			0.859	0.882
6	0.650	0.773	0.772			0.858	
7	0.633					0.764	
8	0.732						
9	0.779						
10	0.736						
11	0.614						
12	0.798						
13	0.653						
14	0.639						
15	0.708						
KMO	0.940	0.896	0.817	0.796	0.789	0.903	0.878
BTS	3186.27	1316.39	998.56	817.54	830.98	1737.51	1279.14
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Overall, KMO analysis yields higher indexes with statistically significant BTS scores. The KMO and BTS results indicate the data satisfy the psychometric criteria for performing a factor analysis. As seen in Table 2, the factor loads related to the 47 items on the subscales range from 0.60 to 0.90. From this point, it is determined these items are qualified sufficiently to be included in the scale. Except for the TK subscale, one factor with eigenvalues greater than one emerges for each subscale of the TPACK survey (see Table 3). For the TK subscale, the scree plot for the survey items shows a sudden drop following the first factor. This result suggests the presence of only one factor; in fact, the first factor alone explains more than half of the total variance. Hence, the factor analysis for these items results in a single factor.

Table 3: Eigen Value and Percentage of Variance for Each Factor

Factor	Eigen Value	Percentage of Variance (%)
TK	7.782	51.877%
PK	4.146	69.098%
CK	3.562	59.368%
TPK	2.979	74.485%
TCK	2.991	74.776%
PCK	4.832	69.025%
TPACK	3.805	76.107%

Also, the correlations among the factors are given in Table 4. Statistically significant correlations exist among the subscales of the TPACK survey. These results show knowledge in technology, pedagogy, content, and their intersections are related.

Table 4: Pearson Correlation Coefficients between Subscales

Subscale	1	2	3	4	5	6	7
1. TK	-						
2. PK	0.28**	-					
3. CK	0.36**	0.61**	-				
4. TPK	0.46**	0.67**	0.53**	-			
5. TCK	0.53**	0.60**	0.59**	0.79**	-		
6. PCK	0.29**	0.80**	0.63**	0.73**	0.69**	-	
7. TPACK	0.41**	0.66**	0.56**	0.72**	0.79**	0.72**	-

*: $p<0.05$; **: $p<0.01$

For the reliability of the scale, Cronbach's alpha coefficient is used. The internal consistency scores for each subscale calculated are determined as 0.93 for TK, 0.90 for PK, 0.86 for CK, 0.88 for TPK, 0.88 for TCK, 0.92 for PCK, and 0.92 for TPACK. As presented in Table 5, item-total correlations range from 0.62 to 0.90 for the survey items. When the correlations between the factor scores are examined, highly positive and strong relationships are seen among all of the subscales.

Table 5: Item-total Correlation Scores between Subscales

Item	TK	PK	CK	TPK	TCK	PCK	TPACK
1	0.722	0.802	0.618	0.834	0.829	0.822	0.866
2	0.723	0.830	0.754	0.899	0.892	0.809	0.886
3	0.796	0.867	0.841	0.891	0.872	0.848	0.880
4	0.693	0.850	0.788	0.822	0.862	0.846	0.842
5	0.768	0.850	0.823			0.856	0.885
6	0.644	0.781	0.773			0.856	
7	0.638					0.771	
8	0.735						
9	0.784						
10	0.738						
11	0.627						
12	0.805						
13	0.671						
14	0.656						
15	0.726						

Phase 3: Discriminant Validity

Participants: The discriminant validity study of the TPACK survey is conducted with 205 (46.4% female; 53.6% male) preservice teachers.

Procedures: In this phase, a research study is carried out for the criterion-related validity. The participants' grades in technology, pedagogy, and area-specific classes are obtained from the administration office of the college and matched with the survey data. Next, the correlations between the scores from each subscale and the corresponding grades are determined.

Results: Evidence of discriminant validity is provided by correlating scores on the TPACK subscales with the related grades. As seen in Table 6, each of the TPACK subscale scores is statistically and significantly related to its corresponding grade.

Table 6: Correlations between Subscale Scores and Grades

Subscales	Average Grade of Computer Classes	Average Grade of Pedagogy Classes	Average Grade of Area Classes	Average Grade of Computer & Pedagogy Classes	Average Grade of Computer & Area Classes	Average Grade of Pedagogy & Area Classes	GPA
TK	0.27**						
PK		0.17**					
CK			0.16**				
TPK				0.30**			
TCK					0.30**		
PCK						0.26**	
TPACK							0.34**

*: $p<0.05$; **: $p<0.01$

All positive correlations between the subscale scores and the grade points are statistically significant. Especially, it is important to highlight the highest correlation exists between the TPACK subscale and the GPA scores. Results from this analysis show the discriminant validity of the survey developed.

Phase 4: Test-retest Reliability

Participants: Test-retest reliability analysis is conducted with 76 (44.8% female; 55.2% male) preservice teachers.

Procedures: In Phase 4, the test-retest reliability of the TPACK survey is checked. The questionnaire is administered twice with an interval of three weeks between the two stages of administration.

Results: After the survey is administered twice as described above, a reliability coefficient is determined as 0.80 ($p < 0.01$) for the TK subscale, 0.82 ($p < 0.01$) for the PK subscale, 0.79 ($p < 0.01$) for the CK subscale, 0.77 ($p < 0.01$) for the TPK subscale, 0.79 ($p < 0.01$) for the TCK subscale, 0.84 ($p < 0.01$) for the PCK subscale, and 0.86 ($p < 0.01$) for the TPACK subscale. Overall, these results confirm the test-retest reliability of the survey.

Phase 5: Survey Translation

Participants: The participants of the last phase of the current study are students studying English language education. The original form of the TPACK survey and its English version are administered to 84 students to check the language equivalence of the survey. Since the students may remember their answers on the first administration, a two-week interval is used between the two administration stages.

Procedures: Phase 5 involves translation of the survey into English. Following the procedure suggested in the literature (Kevrekidis et al., 2008), the validation of the translation is made by translation and counter-translation. The survey is translated from Turkish to English independently by the authors and professional translators, three faculty members who work in the Department of English Language Education. Also, the English version is back-translated into Turkish by a bilingual person for crosschecking. Then, the two translated forms are compared and modifications are made accordingly. The changes are mainly related to different alternatives of synonymous words. The structure or the meaning of the scale items is not changed.

Results: A significant positive relationship is found between the scores from the Turkish and English forms of the TPACK survey administered over a two-week period ($r = 0.95$, $p < 0.001$). Therefore, the translated version is accepted as equivalent to the original.

CONCLUSIONS

When the studies regarding the scale development are examined, it is seen that a systematic and step-by-step approach is followed for the validity and reliability of the scale. In this study, a similar process is completed. The validity and reliability of the TPACK survey are checked with preservice teachers. First, a pool of 60 items is formed and reduced to 47 items after expert evaluation. Then, EFA is conducted to examine the construct validity and the factor structure of the survey. Based on the EFA, the results show the survey items for each subscale successfully measure each variable. KMO and BTS measures also indicate the data satisfy the psychometric criteria for the EFA.

Furthermore, item-total correlations and Cronbach's alpha internal consistency coefficient are calculated. For scales used in research, the level of an acceptable Cronbach's alpha coefficient is suggested as 0.70 (Anastasi, 1982; Tavsancil, 2002). In the present study, findings suggest that Cronbach's alpha coefficients of the subscales show the internal consistency of the scale, and the item-total correlations of the scale items are quite high. Each of the subscales is statistically and significantly related to its corresponding course grade, so the survey also meets the discriminant validity along with the test-retest reliability. Since TPACK is an emerging theme in the literature and the primary contribution of this research is in furthering our understanding of TPACK, the survey should be open to an international audience. Thus, the original scale, composed of 47 items, is translated into English. A significantly positive correlation is determined between the scores obtained from the English form and the Turkish form of the scale. This shows the language equivalence is obtained. In summary, the findings from the present research study demonstrate the TPACK survey is a valid and reliable measure.

In the present study, correlation scores show that significant interactions between technology, pedagogy, and content knowledge bases are evident. Findings from the current study and literature suggest the three knowledge domains should be treated in an integrated manner, not as separate constructs (Koehler et al., 2007; Niess, 2006). From this point of view, the present study supports the intertwined relationship between the three knowledge bases. In fact, if preservice teachers see the value of integration of appropriate educational technologies and pedagogies into their content area, they will more likely use these technologies and pedagogies to support student learning when they become real teachers. It is apparent that much research in this line of inquiry should be conducted. Also, future research could conduct the TPACK survey with different research designs and contexts. In future research, other variables might be included to analyze their impact on preservice teachers' TPACK domains.

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APPENDIX A. ITEMS OF TPACK SURVEY

Subscale	Items (I have knowledge in …)
Technology Knowledge (TK)	Solving a technical problem with the computer
	Knowing about basic computer hardware (ex., CD-Rom, mother-board, RAM) and their functions
	Knowing about basic computer software (ex., Windows, Media Player) and their functions
	Following recent computer technologies
	Using a word-processor program (ex., MS Word)
	Using an electronic spreadsheet program (ex., MS Excel)
	Communicating through Internet tools (ex., e-mail, MSN Messenger)
	Using a picture editing program (ex., Paint)
	Using a presentation program (ex., MS Powerpoint)
	Saving data into a digital medium (ex., Flash Card, CD, DVD)
	Using area-specific software
	Using printer
	Using projector
	Using scanner
	Using digital camera
Pedagogy Knowledge (PK)	Assessing student performance
	Eliminating individual differences
	Using different evaluation methods and techniques
	Applying different learning theories and approaches (ex, Constructivist Learning, Multiple Intelligence Theory, Project-based Teaching)
	Being aware of possible student learning difficulties and misconceptions
	Managing class
Content Knowledge (CK)	Knowing about key subjects in my area
	Developing class activities and projects
	Following recent developments and applications in my content area
	Recognizing leaders in my content area
	Following up-to-date resources (ex, books, journals) in my content area
	Following conferences and activities in my content area
Technological Pedagogical Knowledge (TPK)	Choosing technologies appropriate for my teaching/learning approaches and strategies
	Using computer applications supporting student learning
	Being able to select technologies useful for my teaching career
	Evaluating appropriateness of a new technology for teaching and learning
Pedagogical Content Knowledge (PCK)	Selecting appropriate and effective teaching strategies for my content area
	Developing evaluation tests and surveys in my content area
	Preparing a lesson plan including class/school-wide activities
	Meeting objectives described in my lesson plan
	Making connections among related subjects in my content area
	Making connections between my content area and other related courses
	Supporting subjects in my content area with outside (out-of-school) activities
Technological Content Knowledge (TCK)	Using area-specific computer applications
	Using technologies helping to reach course objectives easily in my lesson plan
	Preparing a lesson plan requiring use of instructional technologies
	Developing class activities and projects involving use of instructional technologies
Technological Pedagogical and Content Knowledge (TPACK)	Integrating appropriate instructional methods and technologies into my content area
	Selecting contemporary strategies and technologies helping to teach my content effective
	Teaching successfully by combining my content, pedagogy, and technology knowledge
	Taking a leadership role among my colleagues in the integration of content, pedagogy, and technology knowledge
	Teaching a subject with different instructional strategies and computer applications