Hindawi
Mobile Information Systems
Volume 2022, Article ID 1594554, 9 pages
https://doi.org/10.1155/2022/1594554

Research Article

Application of Digital Technology-Based TPACK in English Translation

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Received 6 January 2022; Revised 24 January 2022; Accepted 1 February 2022; Published 16 March 2022

Academic Editor: Hasan Ali Khattak

Internet teaching encourages the societal improvement of teaching and learning systems. In this paper, we examine big data and interactive teaching modes and the design process of interactive teaching modes. We propose an interactive teaching model that uses big data in learning analytics and content analysis to optimize the whole teaching practice application process. We also show how to use current technology, build a great teaching management platform, and raise the teaching management level. In this paper, we also examine and develop an English translation teaching model based on TPACK and propose the use of TPACK in technical English translation based on big data platforms, with the purpose of "cultivating students to improve translation abilities". The model is effective and promotes the improvement of translation teaching levels.

1. Introduction

Network information technology has advanced fast over the globe since the beginning of the twenty-first century. Education and teaching reform in Chinese universities have been aided by the close collaboration of education and current network information technology [1–3]. In the twenty-first century, college English translation instructors' capacity to educate intelligently has become one of the most important abilities for college English translation teachers. It is also a must for schools and institutions to foster top-tier talent. Creating smart teaching classrooms in colleges and universities, improving college English translation teachers' smart teaching skills, and focusing on teachers' professional technical skills promote the professional development of college English translation teachers [4, 5]. However, it can also ensure that the new century has an innovative, high-quality English translation team.

The objective of global education growth and the path of contemporary university reform has always been intelligent education. People better comprehend intelligent instruction now that the "Internet Plus" age has arrived. Smarter teaching has taken on a new meaning that includes more than merely transmitting theoretical information to pupils; it also improves their abilities and fosters intellectual growth [6]. The intelligent environment of artificial intelligence and big data has altered the educational landscape. Smart teaching entails developing a smart teaching environment, applying smart teaching techniques, and encouraging students to study smartly [3, 7, 8]. A contemporary approach to changing English translation instruction in colleges and universities is wisdom teaching, backed by constructivist learning theory and wisdom formation theory. Undergraduate English instructors' abilities have become critical in translating knowledge into college English. Improving college English instructors' smart teaching abilities helps them become mentors of teaching knowledge, contributes to inventive talents in the information age, and improves their professional quality [9, 10].

People's jobs and lifestyles have been fundamentally developed using sophisticated technologies such as the Internet, Big Data, Cloud Computing, etc. At the same time, the reform emphasizes the bounds of schools as educational institutions. China's education plan was unveiled in October 2020, and it includes new standards for the professionalization of information technology instructors. The TPACK knowledge framework is based on American scientist Shulman's PCK framework (Pedagogy and Content

Knowledge) [11–13]. A novel notion has been developed by academics Koehler and Mishra [14]. The TPACK knowledge framework is a hotspot in educational research and is crucial to teacher development. The three come together to form the four TPACK composite parts, as shown in Figure 1. The seven main aspects of the TPACK knowledge architecture do not exist in isolation and are inextricably linked. Complexity, interaction, and dynamic balancing are inherent elements of the TPACK knowledge architecture. There has been much study done on instructors' TPACK levels. As a result, several TPACK measuring studies for elementary and secondary school instructors have been conducted, spanning a wide range of disciplines such as mathematics, physics, and computer science. Faculty in the sciences are more interested in TPACK levels than those in the humanities.

However, research on TPACK levels in humanities topics such as English instructors is still in its early stages, and research on TPACK levels in college professors, particularly adjunct English teachers, is limited and inconsistent, necessitating additional information and deep study. Several studies have been undertaken to assess undergraduate English instructors' TPACK levels, including a qualitative assessment of the TPACK level and features of English instructors on the job in colleges and universities is another example. Four TPACKs were examined via interviews with six college English professors and their correspondents. Each component was tested, evaluated, and made into a proposal [15]. University teachers' TPACK levels were tested and studied, offering rationalizing suggestions. Because most TPACK studies are vast and general, they are distinguished by their broad scope, including more than [16]five university professors and a large and representative research sample [17, 18]. We aim to assess individual college English translation teachers' TPACK levels in their local environment and provide focused and suitable TPACK development techniques for college English instructors to help them advance their careers.

2. Related Work

2.1. English Translation Based on TPACK. Traditional English translation instruction is teacher-centred, with a teaching paradigm that emphasizes translation theory and skills. This teaching method prioritizes information transmission above skill development, which does not enhance students' translation abilities. As a result, it must be changed into an interactive teaching model to build effective language abilities, such as translation and categorization. After finishing their courses, English language graduates must evaluate their English proficiency. The five characteristics of translation ability to consider are language ability, textability, topic ability, cultural ability, and language conversion ability. Translation competence is defined as a skill comprised of the translator's translation knowledge, aptitude, and methods [19], and it is built on the translator's language and pragmatic competence.

Cultural judgment, language analysis and pragmatic ability, language execution and mutual expression, esthetic judgment and expression ability, and the capacity to evaluate and rectify logic are all important parts of translation abilities. Translation competence is a multidimensional notion comprised of a collection of interconnected skill variables that may be applied to a broad range of languages. The capacity to listen, talk, read, write, and translate refers to the translator's ability to master and apply necessary language knowledge, cultural understanding, and other applicable information. The impact of interactive education on students' translating abilities Teachers and students and students engage throughout the interactive teaching process.

Each other may be reached via unique educational knowledge and emotional interactions. This pleasant teacher-student contact helps children grasp what they have learned, allows practice, and develops language abilities. Interactive teaching [20] helps improve the emotional communication between teachers and students and creates a more active classroom environment. Students communicate and cooperate with other students who have better translation skills and strong translation skills [21], which helps to learn translation skills and immigrant integration. Interactive teaching stresses that instructors encourage students' initiative and excitement for learning. Conduct emotional interactions and conversations with pupils to absorb information and learn directly from instructors. This kind of teaching encourages students to actively engage in class discussions and build on what they have learned. Teachers and students working together to investigate English Chinese communication skills and laws may help students develop their brains, translation knowledge, and translation abilities. It becomes simpler to develop autonomous translating skills. Constructivist philosophy is met through student-centered interactive English translation education. Compared to the standard teaching model that stresses information and overlooks skills, the interactive teaching model fosters students' cognitive and creative talents and their learning passion and initiative. This will allow students to acquire and practice translation abilities. We have drawn the basic elements of TRACK education as shown in Table 1, which can be found to contain 7 main elements and related descriptions.

TPACK redefines teacher knowledge, structure, and role orientation. First, instructors' knowledge structures must shift from PCK to TPCK. These talents include decision-making and planning skills, as well as PK knowledge. Teaching knowledge is based on solid professional knowledge. Combining the two provides PCK knowledge, which is the cornerstone of instructors' knowledge and fundamental classroom needs.

Tech knowledge is an understanding of how to think about and utilize technology. TCK combines technical and content knowledge [22, 23]. Electronic textbooks and audio-visual archives combine technology and topic information to enhance conventional textbooks. Using technology to comprehend language and language-cultural knowledge expresses a language teacher's TCK. TPK knowledge is connected to instructional principles such as online collaborative learning, flipped classrooms, and topical inquiry. Blended learning reduces the teacher's function as a knowledge mediator while increasing the role of technology

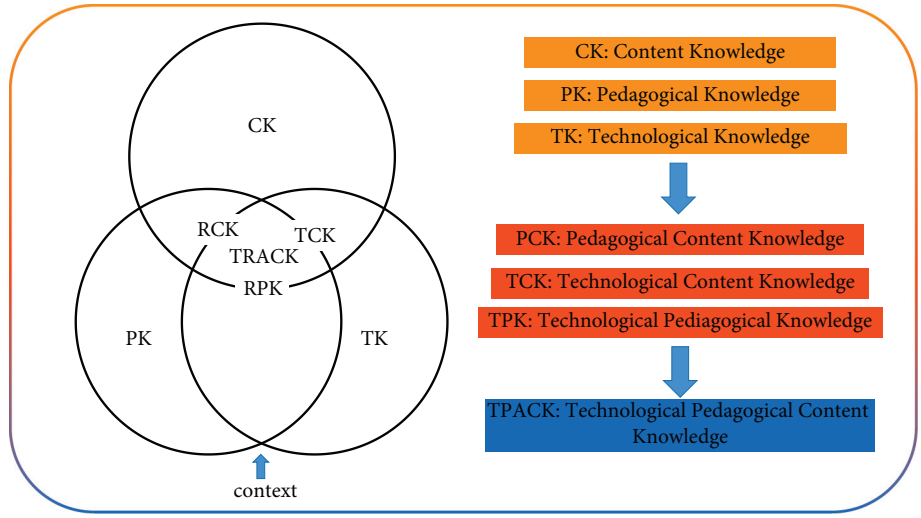

Figure 1: TRACK theory diagram.

Table 1: Basic elements table.

Basic elements	Connotation
TK (technology knowledge)	Mainly describe the ability of teachers to use various information technology knowledge and related resources
PK (pedagogical knowledge)	PK understands the goals, values, and objectives of education and can also be applied in more specific areas, including understanding how students learn, classroom management skills, lesson planning, and assessment
CK (content knowledge)	Primarily refers to teachers' mastery of the subject matter they teach
TPK (technology pedagogical knowledge)	Primarily refers to how teachers integrate information technology or internet-specific teaching technologies and teaching practices, processes, and methods that enable information technology-enhanced education to be applied to curriculum development
PCK (subject pedagogical knowledge)	It mainly concerns how teacher education integrates pedagogy with the content of the subjects taught. The most important thing about English is to provide an environment for students to practice English. Teachers use appropriate teaching strategies and pedagogical knowledge to teach a subject
TCK (technology content knowledge)	It primarily describes the teacher's understanding of how technology can help present content knowledge. This includes how different educational content complements different technology offerings
TPACK (technological pedagogical content knowledge)	TPACK is the end result of the intersection of multiple dimensions. A course is designed to consist of three basic components: Content knowledge, pedagogical knowledge, and technical knowledge, and their intersections are combined into a complete course

integration [24]. Teachers are main curriculum creators, developers, and experimenters in the classroom and learning resource suppliers, facilitators, and evaluators after school. The essential shift in the role of teachers in the TPACK idea is that they must become designers of complete technology.

2.2. Digital Teaching Platform. The need for big data in educational assessment is growing. Evaluating China's educational system is straightforward with restricted aims, outmoded techniques, and single topics. It is vital to develop educational assessment techniques, analyze outcomes properly, and give feedback to students and instructors. Developmental assessment has become an essential approach for reforming the classroom evaluation process. However, using developmental assessment in the classroom has various challenges: First, developmental assessment is complex. Developmental assessments must be undertaken to evaluate, monitor, and identify difficulties throughout the educational process. However, owing to the lecturers' tremendous research pressure, homework is seldom done in university instruction, and final examinations are more important [25].

Second, collecting statistics on development is complicated. The quantity of process data needed grows with time. The data collection area is vast in space. Third, feedback on developmental evaluations is challenging [26]. Effective development evaluation requires quick feedback on the assessment topic, but this is impossible under normal technical settings. All of the issues listed above may be addressed by promoting and using development evaluation. To address the issues raised above, this study recommends building a big data education platform with automated data collection, assessment, and positive feedback to fulfill

development evaluation data and process evaluation demands [27]. Teaching monitoring is mainly to monitor teaching-related elements, including student portraits, teacher portraits, classroom portraits, and course portraits, as shown in Figure 2.

(1) Encourage the use of teaching evolution evaluation. The digital big data teaching platform underpins evaluation data processing. The big data processing platform processes all types of educational data, and then all types of data are sorted into requirements, giving an analytical platform for education. (2) E-learning aids in better classroom management. The educational big data platform allows for quicker technical monitoring. Monitoring the teaching process has always been difficult and time-consuming. Big data can automatically gather teaching process data to monitor instruction. (3) Improves classroom feedback efficiency. There are many ways to model and extract data from huge datasets. The basic goal of data analysis and modeling is to find anomalous information. Compared to monitored items, the overall proportion of abnormal data is minimal. Thus, the only relevant information is provided, minimizing the feedback load on instructors and enhancing feedback efficiency [28].

3. Method

3.1. System Structure Diagram. The English translation teaching platform is separated into three sections: the big data teaching platform, the monitoring system, and the early warning system. The teaching big data platform's primary role is to gather data on students' online learning behaviors and share different teaching business data. The teaching monitoring system comprises further processing data from the big data platform, merging and extracting data based on business and monitoring needs, and graphically showing the outcomes. Monitoring data is used to power the teaching early warning system. According to the early warning model, further data mining and analysis are performed, anomalous data is monitored, and timely warnings are stressed. Figure 3 depicts the specifics.

The educational big data platform gathers structured, semistructured, and unstructured data, extracts and processes it, and stores and analyses the processing outcomes. Student portraits, instructor portraits, classroom portraits, and course portraits are the primary presenting techniques of the course monitoring system. Student portrait, also known as student annotation, is a methodology for abstract annotation of students based on their learning process's fundamental traits and characteristics. The student picture label mostly includes basic information, academic standing, and learning style. Teacher picture labels primarily comprise instructors' basic information, research status, teaching status, and teaching [29] style. The course portrait creates educational data linked to course teaching, such as course participants, course resources, coursework, teacher-student interaction behavior, course evaluation data, etc. Basic classroom information, student attendance, online classroom interactions, and student academic success are all included in classroom pictures.

Early warning is mostly taught via the analysis of monitoring indicators and the presentation of early warning information based on thresholds. The teaching warning is primarily intended to address aberrant events involving instructors and students throughout the teaching process, and particular manifestations include student curriculum warning, student classroom warning, teacher classroom warning, and teacher classroom warning. The early warning procedure is divided into three stages: First, aberrant data must be identified. Unusual data may be discovered using an early warning model. Second, abnormal data is shown in the form of warning lights. Signal lights may be changed to one of three colors: red, yellow, or green. A red light represents a serious warning, a yellow light represents a general warning, and a green light represents normal. The hue of the signal lights may also be changed to suit the needs. Teachers and administrators are worried about red lights because they are warning indicators. The third step is to deal with unusual information and comments. Conspicuous information should be delivered on time and transmitted to administrators and instructors through text messages, emails, and other means, so that they may get anomalous information in advance and take countermeasures.

3.2. Data Analysis. Data analysis is a data processing model used to provide educational information, in which the data analysis model is given in broad strokes, and anticipated values are stated as weighted sums of variables:

$$y = \sum_{i=1}^{n} a_i x_i, \tag{1}$$

where y is the calculated predicted value, x_i is the i-th variable, and a_i is the coefficient or weight of the variable x_i. This data analysis model is available in the model library and stores the coefficients (or weights) and variable values. Furthermore, the model includes two model generation techniques in specialized applications: multiple linear regression and built-in index weighting. (1) The multiple linear regression approach is mostly used to predict outcomes. The multiple linear regression approach is mostly employed in this system for early warning of students' courses. Student Course Alert retrieves all prior courses for English translation classes (in general, you may pick all relevant courses from the previous semester or school year), then determines their dependencies, and removes all extremely relevant past courses. The regression coefficient is then obtained using the multiple linear regression techniques, and equation (1) is transformed into the early warning model below.

$$P_c = \sum_{i=1}^{n} P_{ci} R_{ci}, \tag{2}$$

where P_c is the expected grade of English translation in class C, P_{ci} is the English translation score before Ci class, and R_{ci} is the regression coefficient of English translation before Ci class. (2) Method of global index weighting. The global index weight approach works on the following principles: On the one hand, the English translation early warning index value is acquired, and if it is evaluation data, it is immediately

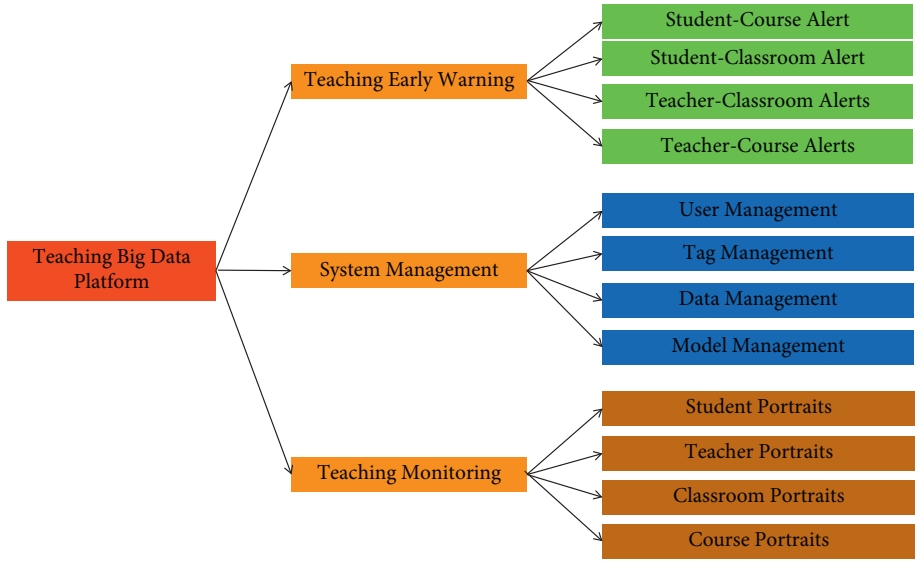

Figure 2: Neural network structure diagram.

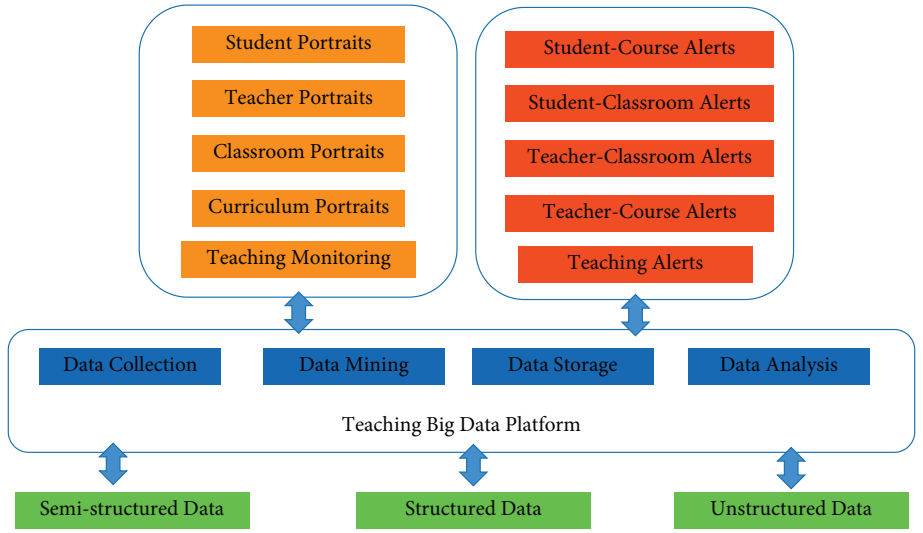

Figure 3: Architecture diagram of English translation teaching big data platform.

called. The error data is normalized using the extreme value approach and then multiplied by 100, yielding a score in the range [0, 100], as determined below.

$$P_{ci} = \frac{V_{ci}}{\mathrm{MAX}(V_i)} \times 100, \tag{3}$$

where $\mathrm{MAX}(V_i)$ is the maximum value of the ith index, V_{ci} is the specific value of the ith index of the warning object, and P_{ci} is the score of the index element that does not reach the alarm. It is an early object, that is, the variable in (1), x_i. Here the variable a_i is replaced by the weight W_{ci}, so (1) can be expressed by the following equation:

$$P_c = \sum_{i=1}^{n} P_{ci} W_{ci}, \tag{4}$$

where P_c is the predicted value of the object, P_{ci} is the value of each indicator item, and W_{ci} is the weight of each indicator item. There are two methods for determining the weights: one is based on experience or asking experts to assess them, and the other is based on automated learning of past data. Method 2's unique approach begins by providing the starting weight vector $W_0 = (w_{10}, w_{20}, \ldots, w_{n0})$, then calculates the projected value, and determines the actual value's mean absolute MAE error. MAE denotes the difference between the expected and actual

value. The smaller the discrepancy, the more precise the forecast. The optimal weight is determined using a new weight vector if the EAW is less than the previous EAW. Repeat this procedure until all feasible weight assignments based on the rules have been explored and the optimal weight vector located.

3.3. TPACK Framework. In the combined dimensions of technical, pedagogical, and disciplinary content, the interactions between components within TPACK are unique. It may be summed up as three implicit characteristics: (1) Complicatedness: Three single components and four composite elements are connected yet independent of one another, and they exhibit free aggregation and complicated variability. (2) Participation: The seven components are linked and interdependent and modifying one will impact the operation and status of the others. (3) Dynamic equilibrium: The seven aspects of TPACK's knowledge structure theory are constantly in a state of flux. Breaking the balance of one element will result in the restoration of changes in other components, resulting in the creation of a new equilibrium.

(1) Justifications for adopting the TPACK theory: This study is a project for teaching optimization based on information technology and curricular integration concepts. If a teacher's TPACK awareness and level and the level of structured instruction are insufficient, they will be unable to handle the enormous obligation of teaching and research. As a result, to optimize teaching practice from the standpoint of information technology and curricular integration, English instructors in colleges and universities must assess and analyze their TPACK level and informatization teaching capacity. This is a requirement for this degree and a prerequisite. (2) TPACK theory has four dimensions: (1) instructors' technical conceptions, (2) teaching material design and presentation tactics, (3) multimedia resource selection and design, and (4) teachers' measurement and assessment. In this paper, the key assumptions and premise include the TPACK level, information-based teaching abilities, students' perspectives, and practical teaching challenges.

4. Experimentation and Evaluation

4.1. Dataset. We chose 38 research samples as study subjects based on precise data on the number of instructors in English translation courses acquired from informational university websites and field visits in 2020. College English instructors and master English teachers are among them. The surveys were filled on paper and electronically, and 35 valid questionnaires were retrieved for a 92.1% recovery rate.

(1) Basic personal information is included in the relevant material of the questionnaire framework. This covers instructors' gender, age, and educational background. (2) Create measurement questions for each TPACK element. Use a five-point Likert scale with the following choices: strongly disagree, disagree, average, agree, and highly agree. The scale incorporates 7 TPACK knowledge framework components for a total of 33 items.

4.2. Analysis of Subjective Results. First, statistical and descriptive analyses were done for each item of the college English translation instructors' TPACK levels, and the data for each item of their TPACK levels were ordered from highest to lowest, as shown in Table 2. Second, do a descriptive statistical analysis. The mean TPACK ratings for English professors at S colleges were sorted from top to lowest as follows: TCK > TPACK > TPK > TK > PCK > CK > PK > TCK > TPACK > TPK > TK The maximum value of PCK among them suggested that the image of instructors' knowledge was excellent in terms of pedagogy and didactic content integration. The CK and PK scores followed, indicating that the instructors' knowledge framework was strong subject knowledge and pedagogical knowledge, showing their great pedagogical understanding and robust pedagogical skills. Following that, there are three composite elements, TCK, TPK, and TPACK, which are somewhat higher than the median TPACK level (2.5), although the values of these three composite elements are generally bad. This implies that English professors at colleges and universities S use technology to combine pedagogy and subject knowledge to a limited extent and that this component has to be developed and expanded. Finally, the value of TC is near to and below average in terms of awareness and actual implementation of technical instruments. To some degree, this suggests that understanding and use of technology are fundamental inadequacies and failings of English university professors. There is an urgent need to increase technical knowledge and employ technological tools to combine instruction and practice. In conclusion, the overall TPACK level of English translation instructors in colleges and universities is fairly bad and unsatisfactory. Even though the PK, PCK, and CK scores are above average and better, the scores in the technological dimension are low. This has a significant influence on the total TPACK level of instructors.

4.3. Analysis of Objective Results. The correlation between the TPACK components was established using correlation analysis of the seven elements of the TPACK college English teacher's knowledge framework, as shown in Table 3. A substantial positive association was found between TK and TPK, TPK and CK, and PCK and TPACK. Other components have a very low correlation. Finally, it can be inferred from the correlation analysis of the TPACK items in college English instructors S that the TPACK level of college English teachers is unequal, and the TPACK knowledge structure is weak.

4.4. Visualization Results. The TPACK Mixed Modal Reform was created for translation theory and practice courses for undergraduate English translation students. The technique's success is evaluated after six months of classroom reform and practice for the acceptable application of translation and initiative and the impact of learning. Figure 4 depicts students' evaluations of different translation capacities after utilizing TPACK's digital optimization. The students' translation ability has significantly increased, as seen by every detail, particularly

Table 2: TPACK level statistics.

	N	Minimum value	Maximum value	Average
TK	35	2.11	2.68	2.3334
PK	35	2.56	3.59	3.0097
CK	35	2.56	3.68	3.3000
TPK	35	2.26	3.59	2.9754
TCK	35	2.36	3.44	2.9866
PCK	35	3.16	3.74	2.7917
TPACK	35	2.15	3.69	3.3472
Effective N	35			

Table 3: TPACK correlation of elements.

	TK	PK	CK	TPK	TCK	PCK	TPACK
TK	1	−0.13	−0.003	−0.418	−0.186	−0.248	−0.320
PK	−0.13	1	−0.047	0.169	−0.1	0.146	−0.210
CK	−0.003	−0.047	1	−0.402	0.077	0.124	−0.231
TPK	−0.418	0.169	−0.402	1	0.049	0.277	−0.215
TCK	−0.186	−0.1	0.077	0.049	1	0.005	0.104
PCK	−0.248	0.146	0.124	0.277	0.005	1	−0.413
TPACK	−0.320	−0.210	−0.231	−0.215	0.104	−0.413	1

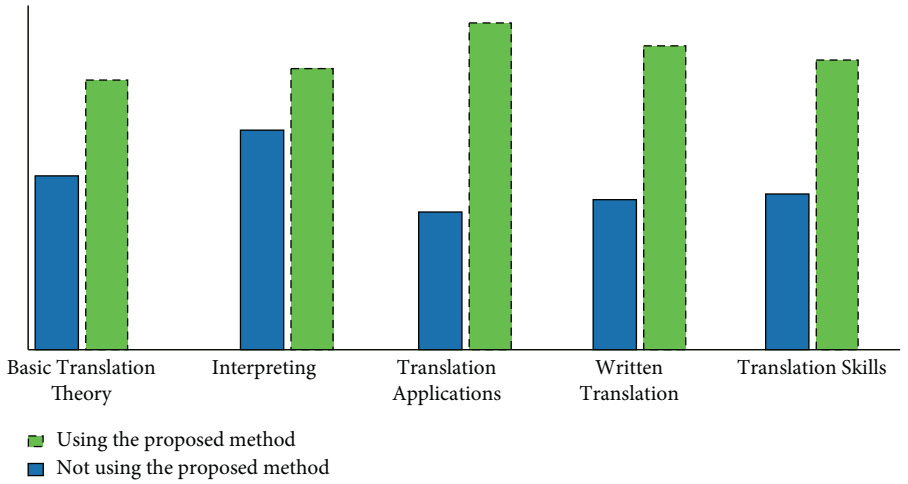

Figure 4: Comparison of the effects of the proposed method.

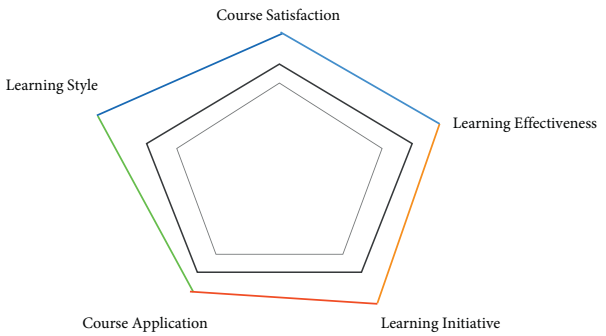

Figure 5: Learning initiative and effectiveness evaluation.

the students' translation ability and translation abilities. Figure 5 depicts the learning initiative and impact assessment. It can be noticed that the kids' learning initiative has substantially improved, as has the learning impact, which instructors and students have universally acknowledged.

Figure 5 illustrates that the TPACK area of study has a strong scientific foundation. To put it another way, the scientific community focuses its study on topics that are linked. The amount of keyword coincidence between eras, on the other hand, is above 35%. Furthermore, between the first and second periods, there is a larger degree of awareness than between the second and third periods. This might suggest a shift in the scientific community's research priorities.

5. Conclusion

The teaching model of English translation courses in digital TPACK described in this paper emphasizes the integration of digital technology, educational material, and teaching techniques to achieve instructional diversity—diversification of material, learning techniques, and media to support personalized learning strategies. The college English translation course has produced excellent outcomes via context, debate, engagement, and teamwork. Trainers should actively engage teachers in "Educational Technology." The use of digital technology tools is not sufficient, and the real teaching difficulties of separation and fragmentation are emphasized. Teachers should improve awareness of the use of information tools and carry out teaching activities. Participation in teacher training courses on computers, networks, lesson planning, and similar topics enhances teachers' TK, TPK, and TCK levels. Incorporating technology ideas and tools into teaching practice increases effectiveness and professionalism and encourages professional growth. Building a teacher learning community enables English instructors to utilize collective knowledge and methodologies such as technical tools and teaching design to tackle actual classroom difficulties.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

References

[1] P. Mishra, "Considering contextual knowledge: the TPACK diagram gets an upgrade," *Journal of Digital Learning in Teacher Education*, vol. 35, no. 2, pp. 76–78, 2019.

[2] J. Pei, K. Zhong, J. Li, J. Xu, and X. Wangn, "ECNN: evaluating a cluster-neural network model for city innovation capability," *Neural Computing & Applications*, 2021.

[3] Y. J. Joo, S. Park, and E. Lim, "Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model," *Journal of Educational Technology & Society*, vol. 21, no. 3, pp. 48–59, 2018.

[4] J. Li, "Decentralized on-demand energy supply for blockchain in internet of things: a microgrids approach," *IEEE Transactions on Computational Social Systems*, vol. 6, no. 6, pp. 1395–1406, 2019.

[5] S. T. U. Shah, F. Badshah, F. Dad, N. Amin, and M. A. Jan, "Cloud-assisted IoT-based smart respiratory monitoring system for asthma patients," *Applications of Intelligent Technologies in Healthcare*, Springer, Berlin, Germany, pp. 77–86, 2019.

[6] S. T. U. Shah, J. Li, Z. Guo, G. Li, and Q. Zhou, "DDFL: a deep dual function learning-based model for recommender systems," *International Conference on Database Systems for Advanced Applications*, Springer, Berlin, Germany, 2020.

[7] M. Schmid, E. Brianza, and D. Petko, "Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK.xs) and comparing the factor structure of an integrative and a transformative model," *Computers & Education*, vol. 157, Article ID 103967, 2020.

[8] M. Schmid, E. Brianza, and D. Petko, "Self-reported technological pedagogical content knowledge (TPACK) of preservice teachers in relation to digital technology use in lesson plans," *Computers in Human Behavior*, vol. 115, Article ID 106586, 2021.

[9] S. T. U. Shah, H. Yar, I. Khan, M. Ikram, and H. Khan, "Internet of things-based healthcare: recent advances and challenges," *Applications of Intelligent Technologies in Healthcare*, Springer, Berlin, Germany, pp. 153–162, 2019.

[10] F. Dad, N. Amin, F. Badshah, and Z. U. Rahman, "Optimal path selection using dijkstra's algorithm in cluster-based LEACH protocol," *Journal of Applied Environmental and Biological Sciences*, vol. 7, no. 2, pp. 194–198, 2017.

[11] E. Baran, S. Canbazoglu Bilici, A. Albayrak Sari, and J. Tondeur, "Investigating the impact of teacher education strategies on preservice teachers' TPACK," *British Journal of Educational Technology*, vol. 50, no. 1, pp. 357–370, 2019.

[12] D. Akyuz, "Measuring technological pedagogical content knowledge (TPACK) through performance assessment," *Computers & Education*, vol. 125, pp. 212–225, 2018.

[13] J. Tondeur, R. Scherer, F. Siddiq, and E. Baran, "Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): a mixed-method study," *Educational Technology Research & Development*, vol. 68, no. 1, pp. 319–343, 2020.

[14] J. H. L. Koh, "TPACK design scaffolds for supporting teacher pedagogical change," *Educational Technology Research & Development*, vol. 67, no. 3, pp. 577–595, 2019.

[15] A. Habibi, F. D. Yusop, and R. A. Razak, "The role of TPACK in affecting pre-service language teachers' ICT integration during teaching practices: Indonesian context," *Education and Information Technologies*, vol. 25, no. 3, pp. 1929–1949, 2020.

[16] S.-L. Cheng and K. Xie, "The relations among teacher value beliefs, personal characteristics, and TPACK in intervention and non-intervention settings," *Teaching and Teacher Education*, vol. 74, pp. 98–113, 2018.

[17] A. Tanak, "Designing TPACK-based course for preparing student teachers to teach science with technological pedagogical content knowledge," *Kasetsart Journal of Social Sciences*, vol. 41, no. 1, pp. 53–59, 2020.

[18] J.-J. Tseng, Y.-S. Cheng, and H.-N. Yeh, "How pre-service English teachers enact TPACK in the context of web-

conferencing teaching: a design thinking approach," *Computers & Education*, vol. 128, pp. 171–182, 2019.

[19] W. Wang, D. Schmidt-Crawford, and Y. Jin, "Preservice teachers' TPACK development: a review of literature," *Journal of Digital Learning in Teacher Education*, vol. 34, no. 4, pp. 234–258, 2018.

[20] M. Muhaimin, A. Habibi, A. Mukminin et al., "A sequential explanatory investigation of TPACK: Indonesian science teachers' survey and perspective," *Journal of Technology and Science Education*, vol. 9, no. 3, pp. 269–281, 2019.

[21] H. Özgür, "Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: a structural equation modeling," *Computers in Human Behavior*, vol. 112, Article ID 106468, 2020.

[22] D. Roussinos and A. Jimoyiannis, "Examining primary education teachers' perceptions of TPACK and the related educational context factors," *Journal of Research on Technology in Education*, vol. 51, no. 4, pp. 377–397, 2019.

[23] A. Juanda, A. S. Shidiq, and D. Nasrudin, "Teacher learning management: investigating biology Teachersâ€ TPACK to conduct learning during the covid-19 outbreak," *Jurnal Pendidikan IPA Indonesia*, vol. 10, no. 1, pp. 48–59, 2021.

[24] A. O. Akturk and H. S. Ozturk, "Teachers' TPACK levels and students' self-efficacy as predictors of students' academic achievement," *International Journal of Research in Education and Science*, vol. 5, no. 1, pp. 283–294, 2019.

[25] Y. Dong, C. Xu, C. S. Chai, and X. Zhai, "Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support," *The Asia-Pacific Education Researcher*, vol. 29, no. 2, pp. 147–157, 2020.

[26] I. Kabakci Yurdakul, "Modeling the relationship between preservice teachers' TPACK and digital nativity," *Educational Technology Research & Development*, vol. 66, no. 2, pp. 267–281, 2018.

[27] D. Petko, "Quo vadis TPACK? Scouting the road ahead," in *Proceedings of the Association for the Advancement of Computing in Education (AACE)*, pp. 1277–1286, Switzerland, June 2020.

[28] T. Valtonen, U. Leppänen, M. Hyypiä, E. Sointu, A. Smits, and J. Tondeur, "Fresh perspectives on TPACK: pre-service teachers' own appraisal of their challenging and confident TPACK areas," *Education and Information Technologies*, vol. 25, no. 4, pp. 2823–2842, 2020.

[29] F. Badshah, S. T. U, Shah, S. R. Jan, and I. U. Rahman, "Communication between multiple processes on same device using TCP/IP suite," in *Proceedings of the 2017 International Conference on Communication, Computing and Digital Systems (C-CODE)*, IEEE, March 2017.