

Revisiting E-Learning in China: Analysis of TPACK Development in China and Other Countries

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Abstract

The development of TPACK for teachers is crucial for the effective use of technology in teaching and the promotion of teacher professional development. TPACK development has become a hot topic in the field of teacher education and educational technology. In order to gain a deeper understanding of the overall situation of current research on teachers' TPACK development and predict the future trend of research, this study used "TPACK" as the theme word to search for relevant literature from the core journals of CNKI database (SCI/EI/Peking University Core/CSSCI/CSCD/AMI) and English journals of Scopus database. 306 and 1095 relevant literature were selected respectively. High-frequency keyword and co-word analysis methods were conducted on the obtained literature. The results showed that the current research hot spots in the TPACK field are current situation investigation and analysis, ability improvement, influencing factors. It is predicted that the future research on TPACK development will tend to focus on interdisciplinary and specialized research, applied practice research, and teacher TPACK ability improvement training research. By comparing the commonalities and differences of TPACK research in China and other countries. it is proposed to shift from universal research to specialized research, and carry out action and experimental research on teacher TPACK ability improvement training courses. And it is necessary to closely follow the digital process of education and carry out research on the framework development of I-TPACK and AI-TPACK to enhance teachers' ability of teaching with technology.

Keywords: *teachers, TPACK, literature, teaching with technology, improvement*

INTRODUCTION

With the rapid development of global informatization, improving teaching efficiency through information technology has become a current trend in education development. Traditional classroom education is shifting towards e-learning. At present, blended teaching combining e-learning and offline learning is becoming one of the main teaching methods in major universities around the world.

To step up with e-learning process, the teachers need to develop their ability of teaching with technology. Although China has already carried out large-scale information-based teaching reforms and provided a large number of hardware facilities and training for teachers, there are still some problems. For example, some teachers are accustomed to traditional teaching methods and have a weak awareness of actively applying teaching with technology. Some teachers have no effective ways to access online resources or lack the ability to analyze and extract data resources, so they cannot use information technology to solve practical problems in teaching and improve teaching effectiveness.

In addition, many teachers lack sufficient participation in training and self-learning, resulting in a lack of initiative when facing new technologies, environments, equipment, and methods.

In 2005, Mishra and Koehler(2005) proposed the theoretical framework of TPACK (Technical Pedagogical and Content Knowledge), emphasizing the need for teachers to master a personal knowledge system of "technology internalization" under the demand of informatization, and achieve the integration of information technology (TK), teaching methods (PK), and subject content (CK). This provides a necessary theoretical basis for teachers to effectively apply technology in teaching.

Technical Pedagogical Content Knowledge (TPACK): Refers to how teachers use information and communication technology (ICT) to develop specific teaching strategies on different issues to promote learning knowledge. Therefore, it is a form of knowledge that transcends these three components (content, teaching methods, and technology). One of the fundamental components of the TPACK knowledge framework is TK, highlighting the importance of technical knowledge. The TPACK knowledge framework requires subject teachers to use teaching methods to package and disseminate subject knowledge with the support of technology. The TPACK knowledge framework emphasizes the application of information technology in teaching, and emphasizes the support and improvement of information technology in teaching. This theory can help teachers better understand the relationship between technology and teacher knowledge.

Currently, many studies in the TPACK field focus on the theoretical framework structure, measurement methods, and empirical research of TPACK. Based on these viewpoints, the author analyzed the research on TPACK published in China's largest journal databases CNKI and Scopus database, and conducted literature analysis about the papers. By analyzing and exploring the hot topics and future development directions in the field of TPACK research, this study aims to provide some suggestions for future research on teaching with technology, and also widen the theoretical basis for better implementation of e-learning.

LITERATURE REVIEW

When discussing the research and development trajectory of teachers' Technological Pedagogical Content Knowledge (TPACK), it can be further divided into the following stages:

Stage 1: Initial Stage (Mid-2000s)

The TPACK concept was initially introduced by Mishra and Koehler (2005), emphasizing that teachers need to integrate technology, pedagogical, and content knowledge effectively to teach courses. This stage primarily focused on concept clarification, exploring how teachers need to span multiple domains to successfully incorporate technology into classroom teaching. Scholar Li and Li (2008) first introduced TPACK framework into China and considered that this design learning model will combine learning technology, learning design with learning knots and improve teachers' ability of teaching with technology.

Stage 2: Concept Clarification and Development of Measurement Tools (Late-2000s)

After the introduction of the TPACK concept, researchers began clarifying the implications of its different components: technological knowledge, pedagogical knowledge, and content knowledge, and their interrelationships(Angeli & Valanides, 2009). With the concept being clarified, measurement tools gradually developed to assess teachers' TPACK levels, such as through questionnaire surveys or interviews. The measurement tool that was widely cited was the "Pre-service Teacher Teaching and Technical Knowledge Survey Scale" designed by Schmidt et al. (2009).

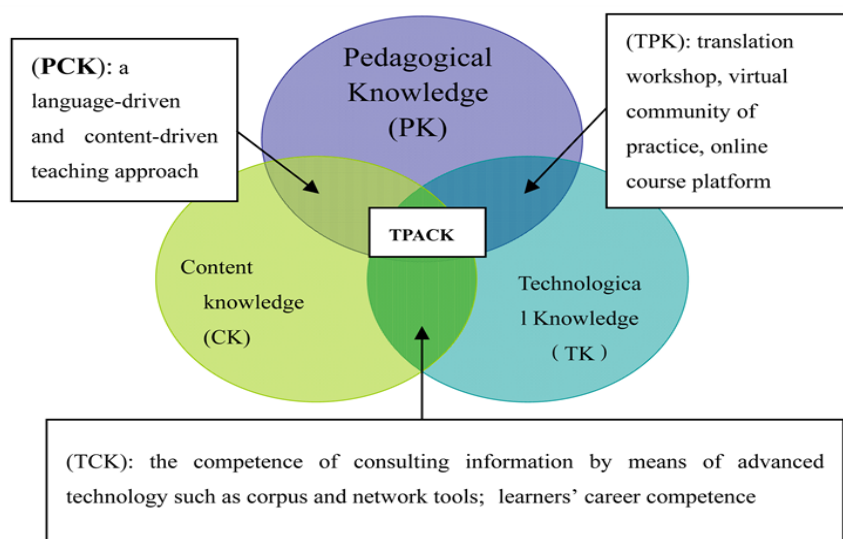


Figure 1: TPACK framework

Stage 3: Empirical Research and Case Studies (2010s)

During this stage, researchers started conducting empirical studies to explore how teachers' TPACK is applied in actual classrooms. Huang (2013) focused on how teachers integrate technology tools into teaching and the impact of such integration on student learning outcomes, engagement, and instructional effectiveness. Ertmer (2010) demonstrates four variables of teacher change and discusses the implications of them in pre-employment teacher education and in-service teacher TPACK development.

Stage 4: Professional Development and Education Policy (Late 2010s to Present)

With the proliferation of educational technology, more educational institutions and policies started paying attention to the development of teachers' TPACK. Saubern (2020) pointed that many teacher training and professional development courses began emphasizing the cultivation of teachers' TPACK abilities to adapt to the rapidly changing educational technology landscape. Ali (2020) stressed the necessity in making online courses for remote learning in higher education institutions to comply with the teachers' professional development.

Stage 5: Interdisciplinary Research and Expansion (2020s)

Recent research increasingly focuses on the development of teachers' TPACK in different subject areas, age groups, and cultural backgrounds (Tondeur et al., 2020). Additionally, researchers are starting to integrate TPACK with new technologies to delve deeper into teaching with technology. Celik (2023) insisted that having more knowledge about AI-based tools would enhance teachers' comprehension of the pedagogical benefits of AI.

In summary, the research and development trajectory of teachers' TPACK has evolved from the initial conceptualization to empirical research and professional development. This process not only contributes to a better understanding of teachers' teaching abilities with technology but also offers guidance to educational institutions to better support the integration of TPACK among teachers. However, systematic reviews on the research of TPACK development in China and foreign countries is still minimal. This research intends to make a review of the researches done on TPACK to find out the research trends and give some suggestions on future research direction.

METHOD AND SAMPLING

Literature selection

The author uses the advanced search function in CNKI database, takes "TPACK" as the main title, and limits the literature source category to SCI/EI/ Peking University Core /CSSCI/CSCD/AMI journals. A total of 306 papers were retrieved from 2013 to 2023. Using the retrieval function of Scopus database, the author conducted a search with the title "TPACK" and limited the publication year from 2013 to 2023, a total of 1095 English Journal papers were selected.

Research methods

This study used co-word analysis and word frequency analysis to analyze data extracted from CNKI and Scopus databases. The co-word analysis method is to analyze the phenomenon of keywords that can represent a certain research topic appearing simultaneously in the same literature, and then determine the relationship and research structure between the topics in the research field (Zhang et al., 2007). High-frequency keywords are a collection of keywords from all research literature in a certain field over a period of time, which can reflect the hot topics of the research field and help researchers determine its development frontiers and trends(Hou et al., 2009).

Research tools

This study mainly utilizes the built-in statistical analysis function of the database and the literature statistical analysis tool to conduct statistical analysis on the TPACK-related sample literature through a combination of charts.

FINDINGS

Statistical analysis of the numbers of "TPACK" relevant literature publications from CNKI and Scopus.

As is shown in Figure 2, the research trend on the topic "TPACK" in China and other countries is basically similar from 2013 to 2023, and it has shown an upward trend in recent years. Koehler and Mishra (2005) first specifically elaborated on the TPCK knowledge framework theory. Since then, the theoretical and practical research related to TPACK has become increasingly rich. In contrast, TPACK research in China started relatively late with scholars Li and Li (2008) first introduced it to China in 2008. It also showed a research peak in 2015 according to the figure. Although followed by a decline, the overall research still maintained an upward trend. Through data comparison, the author found that the number of TPACK research literature from 2019 to 2021 is relatively high both in China and other countries, this was mainly due to the impact of COVID-19. Most of the universities around the world have successively launched online teaching, so there was a high demand for research on information technology teaching and learning. The number of TPACK related studies has plummeted in 2022, which may indicate that TPACK research has temporarily entered a stage of adjustment and reflection.

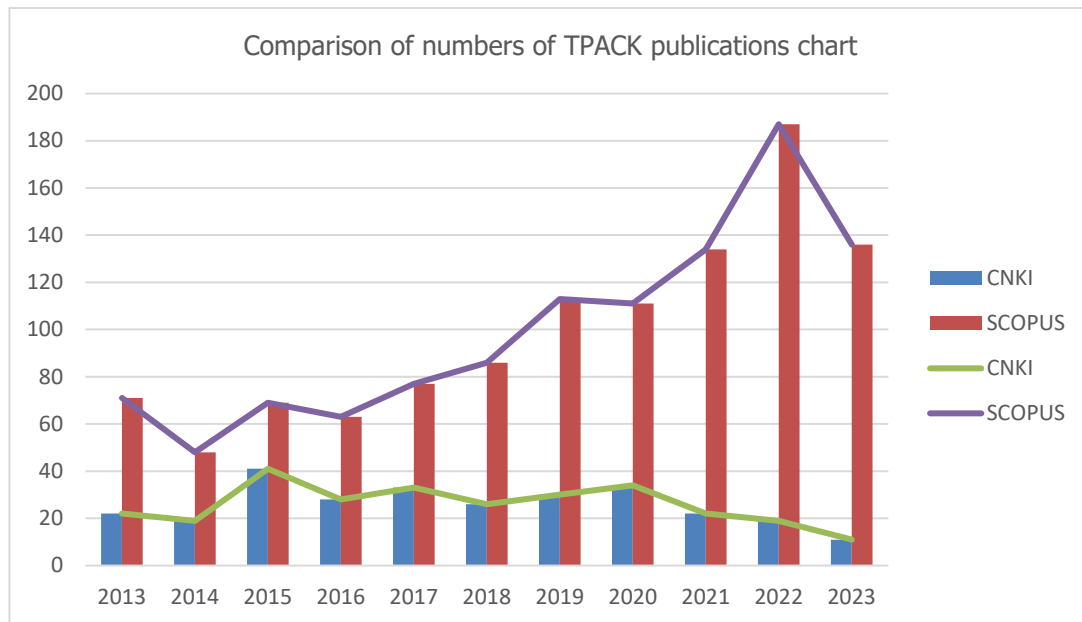


Figure 2: Comparison of numbers of TPACK publications from 2013 to 2023

Word frequency analysis

306 core journals retrieved from CNKI were used to extract field information using "keywords", and words with the same meaning were artificially synthesized, such as "TPACK", "TPCK", "Integrated Technology Teaching Methodology Knowledge", etc. The same operation was performed on the 1095 journal articles from the Scopus database. We have obtained a list of high-frequency keywords and frequencies for TPACK research from the two databases. Due to space limitations, only the top 18 are listed (as shown in Table 1). The higher the frequency of statistical results, the greater the correlation between the keyword and the topic, and the more research results based on this direction.

Table 1: List of high-frequency keywords in CNKI and Scopus TPACK literature

NO.	CNKI high-frequency words	frequency	Scopus high-frequency words	frequency
1	TPACK	187	TPACK	711
2	Normal students	20	Technology integration	131
3	Teacher's Informatization Teaching Ability	19	Pre-service teachers	125
4	Pre-service teachers	12	Teacher education	104
5	University teacher	10	Teacher professional development	91
6	Information technology	10	Technology	58
7	TPACK improvement model	9	Engineering Education	57
8	Empirical Study	8	ICT	49
9	Teacher professional development	8	educational technology	46
10	Subject knowledge	7	teachers	39
11	Math teachers	5	Higher education	39
12	influence factor	5	Mathematics education	35
13	Technology integration	5	Teacher training	34

14	Primary school teachers	4	Pedagogy	34
15	Vocational Teachers	4	E-learning	33
16	Cultivation Path	4	Content knowledge	32
17	TPACK development	4	Curricula	30
18	educational technology	4	Students	27

Co-word matrix

After extracting high-frequency keywords from TPACK-related literature obtained from CNKI and Scopus, the co-word matrix is generated. When two keywords appear in the same literature, it indicates that there is a relationship between them. The more often the two appear together, the greater the correlation between the group of words. The value on the diagonal in the matrix is the word frequency of the keyword. The local co-word matrices of the two groups of TPACK high-frequency words obtained are shown in Table 2 and Table 3.

Table 2: Common Word Matrix of CNKI TPACK High Frequency Keywords (Local)

	TPACK	Normal students	Pre-service teachers	Teacher's Informatization on Teaching Ability	University teacher	Information technology	TPACK improvement model	Empirical Study
TPACK	187	14	9	3	7	4	0	5
Normal students	14	20	1	0	0	0	0	2
Pre-service teachers	9	0	12	0	0	2	0	0
Teacher's Informatization Teaching Ability	7	0	0	0	0	0	0	0
University teacher	6	0	0	1	10	0	0	0
Information technology	14	0	0	0	3	0	0	0
TPACK improvement model	11	0	0	0	0	0	0	0
Empirical Study	4	0	0	0	0	0	0	0

Table 3 : Common Word Matrix of Scopus TPACK High Frequency Keywords (Local)

	TPACK	Technology integration	Pre-service teachers	teacher education	Teacher professional development	Technology	Engineering Education	ICT
TPACK	711	24	15	14	23	13	5	7
Technology integration	24	131	9	7	5	3	5	4
Pre-service teachers	15	9	125	5	5	2	0	0
teacher education	14	7	5	104	8	2	2	2

Teacher professional development	23	5	5	8	91	5	1	1
Technology	13	3	2	2	5	58	2	3
Engineering Education	5	5	0	2	1	2	57	2
ICT	7	4	0	2	1	3	2	49

From word frequency analysis and co word matrix, it can be intuitively seen that some high-frequency words are closely related to other words and have been valued by many researchers. Therefore, co-word matrix and high-frequency words are currently a research hot spot in the field of TPACK. Some other keywords are at the edge of the co word matrix, but this does not mean that these words are irrelevant. Since most of the related research on these words has appeared in recent years, it can be explained that these keywords represent the forefront and trend of research in the field of TPACK. According to the high-frequency keyword table and co-word matrix, the author combined with the representative literature to comprehensively analyze the research hot spots and future research trends in the field of TPACK.

DISCUSSION

The latest research commonalities of TPACK in China and other countries

The top five high-frequency words in CNKI research are "TPACK", "normal students", "teacher information teaching ability", "pre-service teachers", and "university teachers"; The top five Scopus research keywords are "TPACK", "pre-service teachers", "Technology integration", "teacher education", and "teacher professional development". By comparing high-frequency keywords in China and other countries, it can be found that scholars have given a lot of attention to teachers' information technology teaching ability and the development of TPACK for pre-service teachers.

Research on Improving Teachers' Informatization Teaching Ability

Through specific literature review, it can be concluded that research focusing on teachers' information technology teaching ability mainly focuses on investigating the current situation of ability, quantifying information technology teaching ability, and empirical research on ability improvement strategies. Wang (2023) conducted a comprehensive survey and research on the current situation of information technology teaching ability of English teachers in Chinese universities. They pointed out that school policies, training conditions, teacher attitudes, and self-efficacy have a significant impact on the TPACK level of English teachers in universities, with self-efficacy having the greatest impact. Therefore, they proposed to strengthen professional training and skill empowerment teaching. Driss(2023) conducted a questionnaire survey on 82 prospective nursing educators in Morocco, and the results showed that participants had a higher level of self-awareness towards TPACK, scored higher in subject teaching knowledge and subject content knowledge, and scored lower in technology content knowledge. This study suggests conducting more teacher training to help nursing educators integrate technology, teaching methods, and content in teaching practice. Zhang(2017) and Zhang(2021) conducted research on the measurement of teachers' information based teaching ability and improved the scale and evaluation system. Sofwan(2023) developed tools for measuring TPACK and integrating technology in educational internships based on previous research, and proposed using Partial Least Squares Structural Equation Modeling (PLS-SEM) for data analysis, supplemented by Importance Performance Map Analysis (IPMA). Based on the TPACK theory and starting from the group of university teachers, Qi(2017) and Cong(2021) pointed out that improving teachers' information-based teaching ability requires the construction of training systems and courses. Luo

(2023) proposed a research-practice collaborative relationship approach to support the integration of CT and teacher information technology skills through case studies on the information technology teaching abilities of three American primary school teachers.

Research on TPACK Development for Pre-service Teachers

In recent years, research on the development of TPACK for pre-service teachers has focused on measuring the TPACK level of pre-service teachers, training methods and strategies, as well as empirical research. Eliana (2023) investigated the differences in self-reported subject teaching knowledge (TPACK) and technical beliefs of three groups of pre-service teachers through surveys. Sofwan (2023) studied the role of TPACK in pre-service teacher education internships and improved the TPACK level measurement scale accordingly. Nguyen(2022) found through their research on the design discourse of pre-service teachers that TPACK elements can collaborate with their technical enhancement courses. In China, Dai(2022) took Arizona State University in the United States as a reference, have optimized the training path of information technology teaching ability for pre-service teachers by promoting conceptual changes in the cultivation of information technology teaching ability for pre-service teachers and constructing a "curriculum group" for the cultivation of information technology teaching ability for pre-service teachers. Bai(2020) conducted a study on the correlation between PKM and TPACK levels of pre-service teachers based on a combination of quantitative and qualitative analysis, providing new ideas for the development of TPACK in pre-service teachers. Wang(2018) proposed an improvement path for the TPACK level of pre-service teachers through a questionnaire.

In addition, through a comparative study of the relevant literature content corresponding to high-frequency words in CNKI and Scopus database, it was found that the research section on pre-service teachers in China has conducted a separate study on the development of TPACK among normal student.

Differences in TPACK research both in China and other countries

By comparing high-frequency words in CNKI and Scopus research, the author found that CNKI research on TPACK in universities focuses on the investigation and development of university teachers, while Scopus research in this area focuses on higher education, while also focusing on both teachers' teaching and students' learning.

Wang(2022) improved the measurement scale based on the TPACK theoretical framework and the blended teaching competency model of university teachers, providing tool support for measuring the level of blended teaching competency of university teachers. Wei(2021) proposed a suggestion to form a TPACK system thinking to promote development mechanism based on the MOOC context. Xu(2018) and Song(2020) conducted surveys on the TPACK levels of university teachers nationwide and in western regions, and proposed development suggestions. Okan (2022) examines teacher experience and student perception by integrating technology into the teaching context of engineering colleges. Chansanam (2021) developed the Humanities and Social Sciences Online Student Platform (HUSO-OPS) using a user centric, TPACK, and V-model design. Aslam (2021) used a quantitative method of survey research design to explore the relationship between teacher technical education content knowledge (TPACK) and their technical proficiency. Marcelo (2019) and Ronny (2020) explored strategies for enhancing TPACK abilities of university teachers from the perspective of teacher preparation.

Future Trends in TPACK Research in China and other countries

Through the study of co-words and knowledge graphs, it has been found that future research on TPACK development will tend to focus on interdisciplinary and specialized research, applied practice research, and teacher TPACK ability improvement training research.

TPACK development in different disciplines

TPACK research should delve into specific disciplines. From the perspective of marginal keywords such as "mathematics teachers" and "English subjects", China has gradually realized the importance of subject specific TPACK research. However, currently there are only a few studies in China that have focused on the development of specific disciplines such as TPACK. And the scope and depth of existing research are still limited. Therefore, revealing the structural characteristics and development pathways of teacher TPACK from a disciplinary perspective will be a new trend in CNKI TPACK research.

Research on TPACK Ability Enhancement Training for Teachers

From the edge keywords "cultivation path" and "TPACK development", it can be seen that research on improving teacher TPACK ability training has attracted the attention of some CNKI scholars. At present, open learning situations such as flipped classrooms and MOOCs in China are in a popular development stage, and higher education teaching reform is urgent. These have put forward higher requirements for improving teachers' TPACK abilities. The development of information technology is also changing rapidly, so the improvement of teachers' TPACK ability depends on continuous self-learning and improvement training. Therefore, the research on teacher TPACK ability improvement training is an urgent problem to be solved in the current and future TPACK field.

IMPLICATION & CONCLUSION

As can be seen from the above, there are both similarities and differences in the research hot spots of TPACK in China and other countries. Most of the researches paid attention to the issue of improving teachers' TPACK abilities, and a focus has been placed on exploring the group of pre-service teachers. In terms of research trends, both CNKI and Scopus's TPACK research tends to focus on the development of teacher TPACK at specific educational levels and disciplines. However, compared to the already emerging TPACK research on pre-service teachers and mathematics education in Scopus, China is still relatively weak in terms of research breadth and depth. Thus TPACK research in China needs to be further deepened and expanded. Another noteworthy trend is the research on teacher TPACK ability improvement training. Based on the foundation laid by a large amount of quantitative research in the early stage, scholars have gradually shifted their research direction towards teacher ability improvement strategies and systematic training research in recent years. Based on the current research status in China and other countries, this study proposes the following suggestions for future TPACK research.

Firstly, TPACK research on specific application environments should be added, shifting from universal research to specialized research. Only by conducting TPACK localization research in a specific teaching environment or cultural background can it truly and effectively guide practice. Researchers need to change their thinking and pay more attention to specific situational factors such as subject, region, and stage, especially by delving deeper into specific disciplines to examine the structural characteristics and development mechanisms of TPACK among teachers in different disciplines. Shift from universal TPACK research to specialized TPACK research based on specific subject content, specific technical tools, or specific teacher groups.

Secondly, action and experimental research on TPACK teacher education courses should be carried out. At present, Chinese scholars have proposed several training models, development paths, and strategies for the development of TPACK, but few studies have been able to reflect on the problems and solutions of teacher information training courses in China from the perspective of designing teacher training. Therefore, China should keep up with the international forefront, make cultivating awareness and ability of technological design thinking the key to teacher curriculum, actively carry out action research and experimental research, and continuously optimize the design of teacher education curriculum. We should not only focus on whether teachers' skills meet the standards, but also pay attention to the changes in teachers' concepts, thinking, decision-making and

other processes, so that teachers become independent actors in technological learning and designers of technological innovation applications.

Finally, it is important to closely follow the digital process of education and conduct research on the framework development of I-TPACK and AI-TPACK. The TPACK framework research itself is already very mature and is constantly being improved through in-depth research. However, with the rapid changes in technology, the development of TPACK's framework is also a dynamic process. At present, with the development of information technology and the emergence of the metaverse, the reform of digital education is imperative. Therefore, conducting research on the framework development of I-TPACK and AI-TPACK is also an important direction for TPACK current development.

The literature data in this article is selected based on the theme as the search term, which has certain limitations and cannot cover all literature related to TPACK. This may lead to incomplete data analysis, which is the deficiency of this study. TPACK is hailed by the academic community as one of the most important developments in the field of information technology and curriculum integration in the past 25 years. As a research hot spot in the field of educational technology, it is a promising research field that deserves further in-depth research.

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