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A Path Analysis of Pre-service Physical Education Teachers' Teaching Growth from the Perspective of Technology Empowerment: The Mechanism of Self efficacy

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Abstract

Drawing on ICAP theory and self-efficacy theory, this study examines how technology use influences the teaching growth of pre-service physical education (PE) teachers and explores the mediating role of self-efficacy. Using survey data from 360 pre-service PE teachers in five universities in Anhui Province, structural equation modeling was employed to test the proposed relationships.

Results indicate that technology use significantly and positively predicts teaching growth. Technology use also strongly enhances teachers' self-efficacy, which in turn contributes to teaching growth. Mediation analysis confirms that self-efficacy partially mediates the relationship between technology use and teaching growth, forming a "technology–self-efficacy–teaching growth" pathway.

These findings highlight that technology empowerment promotes professional development not only directly, but also indirectly through psychological mechanisms. The study extends the application of ICAP theory to teacher education and underscores the importance of cultivating both technological competence and self-efficacy in pre-service PE teacher training programs.

Keywords: technology empowerment; pre-service physical education teachers; teaching growth; self efficacy.

1. Introduction

Low efficiency in the teaching growth of pre-service physical education (PE) teachers and poor practice quality can lead to a decline in the value of undergraduates majoring in PE and increase their employment pressure (Wang Xianmao, Lingchen, Dong Guoyong, Gao Hongyun, 2021). These problems also directly reduce the effectiveness of PE instruction in primary and secondary schools (Zhang Bo, 2021). They seriously hinder the current school curriculum reform, and affect teachers' career development and the improvement of China's education quality in the future (Meng Han, 2022). Some studies have shown that the

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ability to use technology is one of the core competencies of high quality teachers in the new era (Hong Beibei, 2023). The widespread use of technology in education can bring profound changes to pedagogical knowledge and practice (Zhou Ling, 2022).

For pre-service PE teachers, mastering and applying modern educational technology is essential. Some research indicates that introducing technology into PE teaching can vividly and concretely present and explain sports knowledge, deepen students' understanding of basic PE knowledge, and support practical instruction (Zhou Ling, 2022). Secondly, integrating technology into teacher education courses can significantly enhance teachers' professional knowledge (ML Wilson et al., 2020), and according to occupational socialization theory, using a four stage method can effectively help pre-service PE teachers develop their technological pedagogical content knowledge (DP Gawrisch et al., 2020).

However, for teachers to successfully integrate digital tools, they also need certain capabilities. For example, Thurm, D & Barzel, B (2020) mentioned that teachers not only need specialized knowledge for technical implementation but that beliefs also play a crucial role. Because beliefs influence, guide, and filter context, actions, and intentions (Fives & Buehl, 2012). In research by Gomez Jr et al. (2022), it was also pointed out that self efficacy can effectively influence teachers' use of technology and thus affect their teaching competence improvement. Meanwhile, current PE teaching still faces practical problems such as lack of remote teaching capacity (Y Liu et al., 2022), poor fit of technology applications, single modality of technology representation (Xiao Peng, 2022), limitations in integrating technology and teaching, and general effectiveness of implementation (Yu Ting, 2024). Therefore, how technology influences pre-service PE teachers' teaching growth, and whether self efficacy mediates between technology use and teaching growth, remain gaps that require further exploration and in depth research.

2. Literature Review

2.1 ICAP Theory and Self-Efficacy Theory

ICAP theory explains from the perspective of cognitive activation how students' depth of cognitive engagement differs across learning activities, and is one of the core theories for analyzing learning quality and effectiveness (Weinhandl R et al., 2025). The ICAP model distinguishes four modes of cognitive engagement: Passive, Active, Constructive, and Interactive. The theory argues that teaching activities should move from shallow tasks like "watching, memorizing" toward deep tasks involving "reasoning, creating, collaborating" to promote higher level cognitive processing (Chi et al., 2018). In classroom technology applications, whether technology truly facilitates interactive or constructive learning is an important indicator of quality technology integration (Fütterer et al., 2022). Based on ICAP theory, Antonietti et al. (2023) developed the ICAP Technology Integration Scale (ICAP-TS) to assess how frequently teachers use technology under different cognitive engagement modes thereby measuring how much technology promotes deep learning. This scale maps technology integration quality directly to levels of cognitive engagement, providing a theoretical and instrumental foundation for studying technology empowered teaching (Maričić M et al., 2024).

The origin of self efficacy stems from the development of social cognitive theory. That theory posits that self efficacy beliefs influence our choices of activities, the effort we invest, and the persistence we maintain especially in the face of challenge (Waddington, J 2023). In education, self efficacy beliefs are frequently used to study their influence on teacher or student motivation, learning, and achievement (Al-Abyadh M & Abdel Azeem H, 2022; Alemayehu L & Chen HL, 2023). Some studies suggest that higher self efficacy can promote the development of student skills, capacity building, and resilience especially when facing difficulties (Vermeiren et al., 2022). For pre-service PE teachers, self efficacy is widely regarded as one of the most important psychological predictors of teaching performance (Alhumaid M et al., 2020).

ICAP theory emphasizes that technology must promote deep cognitive engagement; self efficacy decides whether teachers can effectively implement technology supported teaching. Together, they provide the theoretical basis for this study's logical path of "Technology - Psychological mechanism - Teaching Growth."

2.2 Technology Empowerment and Teaching Growth

With the rapid spread of technology in education, exploring how it influences PE teachers' pedagogical knowledge and practice has become especially important (Gawrisch et al., 2020). Technology application not only redefines the way educational content is delivered, but also greatly influences teachers' instructional strategies and students' learning modes (JM Krause et al., 2020). In PE teaching contexts, integrating technology brings both opportunities for innovative teaching and new demands for professional competencies (AP Phelps et al., 2021). Therefore, understanding the mechanism of technology's role in PE teaching is especially significant.

Existing research supports technology's important role in PE from multiple perspectives. For example, Gawrisch et al. (2020), based on occupational socialization theory, proposed a four phase pedagogical method to promote the development of pre-service PE teachers' technological content knowledge. Yang et al. (2020) proposed four strategies for technology supported learning: authentic learning, online inquiry, immersive and interactive technologies, and a "student as creator" model which can effectively enhance students' problem solving ability in interdisciplinary learning. A study by Taghizadeh et al. (2020) found that teachers generally hold a positive attitude toward integrating technology into teaching. At the same time, Liu et al. (2022) confirmed that AR technology can significantly improve students' athletic performance and learning ability in PE classes.

In summary, the value of technology in PE teaching has been confirmed from multiple dimensions, but pre-service PE teachers still face challenges in technology use competence, pedagogical content knowledge involving technology, and teaching integration (T Kopcha et al., 2023). Therefore, this study aims to explore how technology empowerment affects pre-service PE teachers' teaching growth, providing theoretical and practical foundations for cultivating future PE teachers who are capable of integrating technology in order to better meet the needs of educational modernization and social development.

2.3 Self-Efficacy in Technology and Teaching Growth

Teachers' self-efficacy is widely viewed as the most critical psychological mechanism in technology integration. Its core lies in teachers' confidence in completing ICT integration tasks in teaching practice (Šabić et al., 2022). If teachers lack confidence in using technology, or cannot effectively combine technology with teaching content, even a good technical environment may fail to

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realize the potential value of technology empowerment (Mikusa, 2025). The impact of technology often does not act directly on teaching behavior; rather, it influences teachers' willingness to use technology through psychological factors such as self efficacy and attitude (Mikusa, 2025). Therefore, self efficacy is regarded as a crucial support for teacher professional development and ongoing growth; it is not only closely related to professional capacity and learning motivation, but also a core factor in promoting teachers' technology integration behavior (Şen & Yildiz Durak, 2022).

However, in the context of technology integration, teachers often face "technostress," one root of which is lack of self efficacy and technological pedagogical knowledge (Dong et al., 2020). For pre-service teachers, the formation of technological self efficacy depends more on the learning environment, attitude cultivation, course culture, resource support, and institutional arrangements provided during teacher education training (Williams et al., 2023). Improving self efficacy is the prerequisite for future technology supported teaching (Williams et al., 2023). Moreover, experience in using technology itself can positively shape teachers' self efficacy, enhance teaching confidence, teaching quality, and technology application levels (Hampton et al., 2020). Further research also indicates that self efficacy can significantly influence teachers' or learners' behavior and performance in technological contexts (Getenet et al., 2024).

To summarize, self efficacy is not only a core factor promoting technology integration, but also a key mechanism affecting teachers' knowledge construction, teaching competence improvement, and professional growth. For pre-service PE teachers, whether self efficacy mediates between technology empowerment and teaching growth is a question worthy of further research.

2.4 Research Framework Model and Hypotheses

Based on the above literature review, the following conceptual framework model and hypotheses are proposed to analyze the influence and pathways of technological empowerment and self efficacy on the teaching growth of pre-service physical education teachers.

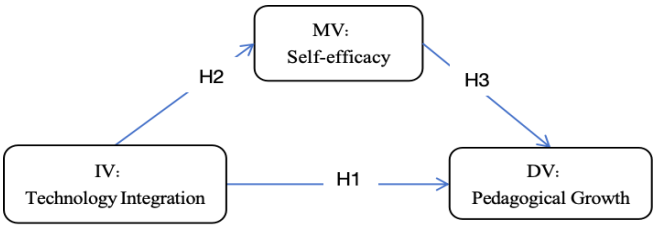

Figure 1: Conceptual Framework Model

H1: Technology use has a positive effect on the teaching growth of pre-service physical education teachers.
H2: Technology use positively affects the self efficacy of pre-service physical education teachers.
H3: Self efficacy positively affects the teaching growth of pre-service physical education teachers.
H4: Self efficacy mediates the relationship between technology use and teaching growth of pre-service physical education teachers.

3. Research Methods

3.1 Research Design

This study adopts a quantitative research method, collecting data through a questionnaire survey in order to explore the pathways of teaching growth under a technology empowerment perspective and the mechanism of self efficacy. In the research design, technology use is set as the independent variable, teaching growth as the dependent variable, and self efficacy as the mediator variable (see Figure 1). Data come from five general undergraduate universities in China offering PE education majors; the sample distribution is sufficiently diverse and representative. The study aims to construct a path model of pre-service PE teachers' teaching growth under technology empowerment, revealing the relationships among technology use, self efficacy, and teaching growth, and to provide theoretical basis and practical reference for improving PE teacher education quality and technology integration training.

3.2 Research Sample

This study mainly uses random sampling to select five general undergraduate colleges in Anhui Province. Based on the sample size calculation formula by Krejcie and Morgan (Renthlei Z & Lallawmkima C, 2025), and using the Raosoft online tool to estimate sample size, under an error margin of 5% and confidence level of 95%, the minimum sample size calculated was 346. To prevent bias due to invalid questionnaires or missing data, the study added a 4.1% redundancy, distributing a total of 360 questionnaires. All 360 questionnaires were returned valid, making the final sample size 360. This sample size meets the requirements for statistical analysis and has sufficient test power to comprehensively reflect the overall situation of pre-service PE teachers in Anhui Province universities.

3.3 Instruments

In selecting instruments, this study referred to several mature questionnaires developed by scholars. The technology use instrument is based on the ICAP-TS scale developed by Antonietti et al. (2023), with moderate contextual revision but without changing the original structure or dimension settings of the scale. As the independent variable, technology use includes four dimensions: interactive, constructive, active, and passive, with a total of 12 items. Teaching growth, as the dependent variable, includes four dimensions: teaching knowledge, teaching ability, teaching beliefs, and teaching reflection, with a total of 15 items. Self efficacy, as the mediator variable, comprises 10 items. All questionnaires use a five point Likert scale, where 1 indicates "strongly disagree," 5 indicates "strongly agree," and 2-4 represent ascending levels in between. Higher scores represent greater levels of technology use, teaching growth, and self efficacy.

3.4 Data Analysis Methods

All collected data were first coded and digitized, then entered into SPSS. After data entry, data cleaning was performed, including processing missing data and identifying and dealing with outliers. In addition, reliability analysis (e.g. Cronbach's alpha) and validity analysis (e.g. KMO value and Bartlett's test of sphericity) were conducted to verify the suitability of the instruments. Then descriptive statistics were carried out, followed by constructing a structural equation model to examine basic paths between technology use and teaching growth, and finally a Bootstrap method was used to test the mediation effect.

3.5 Research Ethics

This study strictly followed ethical norms for educational research. Before data collection, researchers explained the purpose and content of the study to all participants and obtained their informed consent under the principle of voluntary participation. Throughout data collection and processing, anonymity was maintained to ensure individual privacy and information security. All research procedures were approved by the ethics review process of the

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respective institutions, ensuring the legality and scientific integrity of the study.

4. Results

4.1 Reliability and Validity Tests

To ensure the scientific validity and stability of the measurement instruments, this study conducted reliability analyses on the technology use questionnaire, the self efficacy questionnaire, and the teaching growth questionnaire. Results shown in Table 1 indicate that the Cronbach's α coefficient for the technology use questionnaire is 0.939, for the self efficacy questionnaire is 0.974, for the teaching growth questionnaire is 0.960; the overall scale α coefficient reaches 0.973 .all far above 0.9 . indicating that each scale has very high internal consistency.

Validity analysis results show that the KMO sampling adequacy values are 0.771 for technology use, 0.795 for self efficacy, and 0.763 for teaching growth; the total coefficient is 0.871. Bartlett's test of sphericity is significant (χ^2 = 11,112.439, df = 136, p < 0.001), indicating that the data are suitable for factor analysis and that the questionnaire structure has good construct validity.

Table 1: Reliability Analysis Results

Variable	Cronbach's α	KMO	P
Technology Use	0.939	0.771	< 0.001
Self-Efficacy	0.974	0.795	< 0.001
Teaching Growth	0.96	0.763	< 0.001
Overall Scale	0.973	0.871	< 0.001

4.2 Description of Sample

This study selected 360 pre-service physical education teachers from five general undergraduate universities in China as the sample. The data cover gender and grade distribution. Gender distribution: 214 male (59.4%),146 female (40.6%). Grade distribution: first-year students 99 (27.5%), second-year 83 (23.1%), third-year 57 (15.8%), fourth year 121 (33.6%).

4.3 Descriptive Statistics

Table 2: Descriptive Statistics Results

Variable	N	Min	Max	M	SD
Interactive	360	1	5	4.14	0.73
Constructive	360	3	5	4.17	0.64
Active	360	2	5	4.16	0.74
Passive	360	2	5	4.13	0.75
Teaching Knowledge	360	3	5	4.15	0.62
Teaching Ability	360	3	5	4.13	0.64
Teaching Beliefs	360	3	5	4.19	0.64
Teaching Reflection	360	3	5	4.23	0.65
Self-Efficacy	360	2	5	4.16	0.66

Descriptive statistics show that the mean scores of all major variables are at a relatively high level (M > 4.0). Among the four dimensions of technology use, interactive technology use has M = 4.14 (SD = 0.73); constructive technology use scores highest (M = 4.17, SD = 0.64); active technology use M = 4.16 (SD = 0.74); passive technology use M = 4.13 (SD = 0.75). Overall, all four dimensions are at "high" to "very high" levels, indicating that respondents generally use technology extensively in PE teaching, especially favoring constructive and active forms of technology integration.

For the four dimensions of teaching growth, teaching knowledge scores M = 4.15 (SD = 0.62), teaching ability M = 4.13 (SD = 0.64), teaching beliefs slightly higher at M = 4.19 (SD = 0.64), and teaching reflection highest at M = 4.23 (SD = 0.65). This indicates that pre-service PE teachers overall show positive performance in teaching growth especially in teaching reflection and teaching beliefs demonstrating strong awareness of reflecting on teaching, adjusting strategies, and establishing positive teaching beliefs.

In addition, self efficacy scores M = 4.16 (SD = 0.66), also at a high level, indicating that pre-service PE teachers generally have strong confidence in their ability to handle teaching tasks and solve problems.

In sum, all variable means exceed 4.0, standard deviations range from 0.62 to 0.75, showing that the sample overall holds positive attitudes and distributions are relatively concentrated. The sample exhibits high and stable levels in technology use, teaching growth, and self efficacy providing a solid data basis for subsequent structural equation modeling and mediation effect analysis.

4.4 Path Coefficients and Significance

Table 3: Path Coefficient Results

Hypothesis	Coefficient	p-value	Significance
H1: Technology use → Teaching growth	0.609	< 0.001	Significant
H2: Technology use → Self-efficacy	0.858	< 0.001	Significant
H3: Self-efficacy → Teaching growth	0.331	< 0.001	Significant

According to the path analysis results of the structural equation model (see Table 3), the three hypotheses proposed in the study are all supported. First, technology use has a significant positive effect on teaching growth (β = 0.609, p < 0.001), indicating that the more frequently pre-service PE teachers use technology in teaching, the higher their teaching growth level supporting hypothesis H1. Second, technology use significantly and positively predicts self efficacy (β = 0.858, p < 0.001), showing that teachers with higher levels of technology integration feel more confident and capable in facing teaching tasks supporting H2. In addition, self efficacy significantly and positively influences teaching growth (β = 0.331, p < 0.001), indicating that teachers with higher self efficacy are more likely to achieve growth in teaching ability, beliefs, and reflection supporting H3.

Overall, technology use not only directly promotes teaching growth, but also indirectly fosters teaching growth by enhancing self efficacy; this is consistent with the subsequent mediation effect findings. All three paths are significant, indicating that the

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theoretical model built in this study has good explanatory power and robustness.

4.5 Mediation Effect Test

Table 4: Mediation Effect Results

Effect	B	β	LLCI	ULCI
Total Effect	0.85	0.892	0.805	0.894
Direct Effect	0.579	0.609	0.499	0.66
Indirect Effect	0.27	0.283	0.169	0.372

To further test the mediating role of self efficacy between technology use and teaching growth, this study used the Bootstrap method proposed by Hayes along with SPSS's PROCESS macro (Model 4), setting 5,000 resamples and a 95% confidence interval. Controlling for gender and grade, we used technology use as the independent variable, self efficacy as the mediator, and teaching growth as the dependent variable.

The results in Table 4 show that the total effect of technology use on teaching growth is significant (B=0.850, β= 0.892, 95% CI [0.805, 0.894]). After adding self-efficacy, the direct effect of technology use on teaching growth remains significant (B=0.579, β=0.609, 95% CI [0.499, 0.660]), and the indirect effect via self efficacy is also significant (B=0.270, β=0.283, Bootstrapped 95% CI [0.169, 0.372]). Since the confidence interval does not contain zero, the mediation effect is significant. Thus, self efficacy plays a partial mediating role between technology use and teaching growth, supporting hypothesis H4.

5. Discussion

5.1 Main Findings

This study carried out an empirical analysis of the influence pathways of pre-service physical education (PE) teachers' teaching growth under a technology empowerment background, yielding three main findings. First, the level of technology use has a significant positive effect on teaching growth indicating that as technology becomes more deeply integrated into PE courses, pre-service PE teachers are able to more effectively conduct diversified teaching activities, improving their abilities in classroom organization, student engagement, and teaching reflection.

Second, technology use can significantly raise pre-service PE teachers' self efficacy. As a learning resource, teaching tool, and practical support, technology can enhance teachers' confidence when facing teaching tasks, prompting them to develop stronger problem solving abilities and a greater sense of control in technological teaching contexts. Third, self efficacy plays a partial mediating role between technology use and teaching growth, suggesting that technology use not only directly promotes teaching growth, but also further drives professional development by increasing teachers' self efficacy. This result verifies that teachers' psychological factors play a key role during technology integration, and also reveals the deeper mechanism by which technology empowerment promotes teaching growth providing empirical support for a "technology-psychology-teaching growth" effect model.

5.2 Theoretical Significance

Starting from ICAP theory and self efficacy theory, this study built a model of the effects among technology use, self efficacy, and teaching growth. This provides a new perspective for theoretical research in PE teacher education. By differentiating among interactive, constructive, active, and passive forms of technology use, it reveals how technology integration through different levels of cognitive engagement promotes teaching development among pre-service PE teachers.

Moreover, the study further enriches the explanatory power of self efficacy theory in the domain of teacher technology integration: it validates that self efficacy plays a partial mediating role between technology use and teaching growth, demonstrating that teachers' psychological perceptions are a key mechanism for effective achievement of technology empowerment. Meanwhile, the "technology use - self efficacy - teaching growth" model established in this study offers a new theoretical path for explaining teacher professional growth, emphasizing that teaching growth depends not only on technological resources but also on teachers' own beliefs, cognition, and motivation for practice. This finding provides an integrated framework for understanding teacher professional development mechanisms and significantly advances the theoretical development of PE teacher education.

5.3 Practical Significance

The main findings of this study jointly reveal the important practical value of technology empowerment for pre-service PE teacher development. The fact that technology use can significantly promote teaching growth indicates that technology has become an important driver for improving the effectiveness of PE teaching, helping to solve traditional teaching difficulties such as action demonstration, classroom organization, and inadequate feedback. Technology use can also enhance pre-service PE teachers' self efficacy, reflecting that technology not only improves teaching tools but also improves teachers' self-perception of their own capabilities promoting the formation of more stable professional confidence through practice.

In addition, the mediating role of self efficacy between technology use and teaching growth suggests that the real value of technology depends on its ability to elicit positive psychological states in teachers, rather than on the technical function itself. Overall, these findings emphasize that PE teacher growth is the result of a joint effect of technical ability and psychological mechanism, offering a new practical perspective for understanding how technology can promote teacher development at the practice level.

5.4 Limitations and Future Research Directions

Although this study has achieved certain results, there are still several limitations. First, it uses cross sectional data, which makes it difficult to reveal the dynamic evolution of the relationships among technology use, self efficacy, and teaching growth. Future research could adopt longitudinal or experimental designs to further verify the causal mechanisms. In addition, the sample in this study is concentrated in five universities in Anhui Province; the geographic and subject background is relatively limited. In the future, the sample scope could be expanded to different regions and different types of universities to enhance the generalizability of the findings.

Moreover, this study only focuses on three variables: technology use, self efficacy, and teaching growth; it does not take into account potential influencing factors such as teacher emotions, learning motivation, or learning environment support. Future research may explore multi path mechanisms of technology empowered teacher growth under a more complex theoretical framework, to further deepen the understanding of professional development for PE teachers.

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6. Conclusion

6.1 Main Conclusion

Based on analysis of data from 360 pre-service PE teachers in five universities in Anhui Province, this study constructed and validated the relational framework among technology use, self efficacy, and teaching growth. Results show that pre-service PE teachers generally possess high levels of technology use, self efficacy, and teaching growth reflecting that the professional competence of current PE major students is being elevated in line with the demands of educational modernization. The structural model further confirms that the relationships among technology use, self efficacy, and teaching growth are clear and stable, and the proposed conceptual model has strong explanatory power. This study provides a reliable empirical basis for understanding the characteristics of professional development of PE teacher candidates.

6.2 Theoretical Contributions

Using ICAP theory as the classification framework for technology and self efficacy theory as the psychological mechanism foundation, this study is the first to integrate them into research on teaching growth of PE teacher candidates forming a theoretical model with educational technology characteristics. On a theoretical level, this study not only supplements the applicability of ICAP theory in teacher education, but also deepens the explanatory range of self efficacy theory in technological contexts. More importantly, this study provides a new structural cognition framework for professional growth of PE teachers, transforming technology use and teacher psychological factors from parallel variables into a theoretically connected system thus extending the boundary of teacher growth theory in the field of PE education.

6.3 Practical Significance

The results of this study can serve as reference for universities to optimize the course structure of PE education majors, suggesting that universities and administrative departments should strengthen the systematization and practicability of technology related courses; at the same time, provide evidence for schools to carry out technology integration training, emphasizing the need to create real and operable technology application scenarios for teacher training students; in addition, provide evidence for the construction of teacher development support systems, reminding that pre-service training should balance training in technical ability and shaping of teacher beliefs. The findings of this study have direct practical value for improving the quality of pre-service PE teacher training and promoting modernization of PE education personnel.

6.4 Future Research Directions

Despite important findings, there remains room for further depth. First, as this study used a cross sectional design, future work could adopt longitudinal or experimental research to further verify causal relationships. Second, as the sample comes from five universities in Anhui Province, future studies should expand to different regions and school types to enhance representativeness. Third, as this research mainly uses self reported questionnaires, subsequent studies could combine classroom observation, interviews, or multi source data to improve result accuracy. Moreover, future research could include variables such as teacher emotion or learning motivation, constructing more complex structural models to further uncover multi path mechanisms of technology empowered teacher growth.

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