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TPACK-BASED MENTORING PROGRAM: AN ALTERNATIVE TO IMPROVE THE ICT COMPETENCY OF MADRASAH IBTIDAIYAH TEACHERS

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis efektivitas program mentoring berbasis Pengetahuan Teknologi Pedagogi dan Konten (TPACK) dalam meningkatkan kompetensi teknologi informasi dan komunikasi serta kualitas media pembelajaran digital guru Madrasah Ibtidaiyah. Penelitian ini menggunakan desain pretest-posttest satu kelompok. Sampel penelitian ini adalah 30 guru Madrasah Ibtidaiyah di Kota Cirebon. Instrumen yang digunakan adalah kuesioner kompetensi TPACK dan rubrik penilaian media pembelajaran digital. Data dianalisis menggunakan uji t sampel berpasangan dan analisis deskriptif. Hasil penelitian menunjukkan bahwa sebelum mentoring, kompetensi teknologi guru berada pada kategori rendah (TK = 2,37; TPACK = 2,51), sedangkan penguasaan materi dan pedagogi berada pada kategori sedang hingga tinggi. Setelah pendampingan, semua aspek kompetensi TPACK mengalami peningkatan signifikan ($p < 0,001$) dengan ukuran efek yang sangat besar, terutama pada pengetahuan teknologi ($d = 2,89$) dan TPACK secara keseluruhan ($d = 2,76$). Kompetensi TPACK meningkat dari kategori rendah ke kategori tinggi ($M = 3,93$). Media pembelajaran digital yang dikembangkan oleh guru mencapai peringkat baik ($M = 3,28$), dengan aspek ketepatan materi menerima skor tertinggi ($M = 3,57$). Jenis media yang dikembangkan meliputi video pembelajaran interaktif (30%), presentasi multimedia interaktif (27%), dan permainan edukasi digital (23%). Studi ini membuktikan bahwa pendampingan berbasis TPACK efektif dalam memperkuat kemampuan guru untuk mengintegrasikan teknologi, pedagogi, dan konten dalam pembelajaran di MI.
Kata Kunci: TPACK; pendampingan guru; kompetensi TIK; media pembelajaran digital

ABSTRACT

This study aims to analyze the effectiveness of a mentoring program based on Technological Pedagogical and Content Knowledge (TPACK) in improving the information and communication technology competency and the quality of digital learning media of Madrasah Ibtidaiyah teachers. This study used a one-group

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pretest-posttest design. The sample of this study was 30 Madrasah Ibtidaiyah teachers in Cirebon City. The instruments used were a TPACK competency questionnaire and a digital learning media assessment rubric. Data were analyzed using paired sample t-test and descriptive analysis. The results showed that before mentoring, teachers' technological competency was in the low category (TK = 2.37; TPACK = 2.51), while mastery of material and pedagogy was in the medium to high category. After mentoring, all aspects of TPACK competency experienced a significant increase ($p < 0.001$) with a very large effect size, especially in technological knowledge ($d = 2.89$) and overall TPACK ($d = 2.76$). TPACK competency increased from the low category to the high category ($M = 3.93$). The digital learning media developed by teachers achieved a good rating ($M = 3.28$), with the aspect of material accuracy receiving the highest score ($M = 3.57$). The types of media developed included interactive learning videos (30%), interactive multimedia presentations (27%), and digital educational games (23%). This study proves that TPACK-based mentoring is effective in strengthening teachers' abilities to integrate technology, pedagogy, and content in learning at MI.
Keywords: TPACK; teacher mentoring; ICT competency; digital learning media

INTRODUCTION

The integration of technology into learning has become an urgent need in the digital era, especially following the Covid-19 pandemic, which accelerated the transformation of global education.[1] The use of information and communication technology is not merely an optional option but a necessity to prepare a generation capable of facing the complexities of the 21st century.[2] In Indonesia, the implementation of the Freedom to Learn policy encourages the creation of an innovative, technology-based learning ecosystem with a student-centered approach.[3] However, the success of this integration is largely determined by

[1] Shivangi Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis," *Journal of Educational Technology Systems*, 2020, https://doi.org/10.1177/0047239520934018; M A N Elmaadaway and Y A M Abouelenein, "In-Service Teachers' TPACK Development through an Adaptive e-Learning Environment (ALE)," *Education and Information Technologies* 28, no. 7 (2023): 8273–98, https://doi.org/10.1007/s10639-022-11477-8; P Griffin and E Care, "The ATC21S Method," in *Assessment and Teaching of 21st Century Skills*, 2015, https://doi.org/10.1007/978-94-017-9395-7_1.

[2] J M Voogt and N N Pareja Roblin, "Curriculum and 21st Century Skills," in *International Encyclopedia of Education*, 4th ed. (Elsevier, 2023), 49–55, https://doi.org/10.1016/B978-0-12-818630-5.03007-4.

[3] Aji Wahyudin et al., "Application of Style Leadership Transformational in Islamic Education Institutions," *Ar-Rosikhun: Jurnal Manajemen Pendidikan Islam* 3, no. 3 (July 15, 2024): 218–26, https://doi.org/10.18860/rosikhun.v3i3.27705.

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teachers' ability to combine three essential elements: technology, pedagogy, and mastery of learning materials.[4]

In Indonesia, Madrasah Ibtidaiyah, as an elementary Islamic educational institution, faces unique challenges in adopting learning technology. Studies show that the digital divide among madrasah teachers is greater than among general school teachers, encompassing limited access to devices and limited technology skills.[5] Weak digital literacy impacts the stagnation of learning innovation and the limited production of context-appropriate digital learning media.[6] This situation is further complicated by the lack of sustainable professional capacity-building programs tailored to the specific learning needs of madrasahs.

The Technological Pedagogical Content Knowledge framework formulated by Koehler et al is now a primary reference in the international literature for developing teacher competencies in integrating technology into learning.[7] TPACK emphasizes the importance of harmonizing three knowledge domains—technology, pedagogy, and content—as the basis for meaningful technology-based learning.[8] Empirical evidence shows that implementing the TPACK framework has been shown to improve teachers' technological pedagogical skills and positively impact learning quality.[9] However, the implementation of TPACK in developing countries,

[4] P Mishra and M J Koehler, "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge," *Teachers College Record: The Voice of Scholarship in Education* 108, no. 6 (2006): 1017–54, https://doi.org/10.1111/j.1467-9620.2006.00684.x; Teemu Valtonen et al., "TPACK Updated to Measure Pre-Service Teachers' Twenty-First Century Skills," *Australasian Journal of Educational Technology* 33, no. 3 (2017): 15–31, https://doi.org/10.14742/ajet.3518.

[5] H A B Malla et al., "Teachers' Digital Literacy Ability to Improve Islamic Religion Education Learning in Islamic Boarding School," *International Journal of Educational Reform*, 2023, https://doi.org/10.1177/10567879231211287.

[6] H Cartner and J Hallas, "Aligning Assessment, Technology, and Multi-Literacies," *E-Learning and Digital Media* 17, no. 2 (2020): 131–47, https://doi.org/10.1177/2042753019899732; U Hasanah, S Rahayu, and A I Anggraini, "Improving Prospective Basic Education Teachers' Capabilities on Digital Literacy: A Systematic Literature Review," *Al Ibtida: Jurnal Pendidikan Guru MI* 9, no. 2 (2022): 417, https://doi.org/10.24235/al.ibtida.snj.v9i2.10339.

[7] M J Koehler, P Mishra, and W Cain, "What Is Technological Pedagogical Content Knowledge (TPACK)?," *Journal of Education* 193, no. 3 (2013): 13–19, https://doi.org/10.1177/002205741319300303.

[8] D A Schmidt et al., "Technological Pedagogical Content Knowledge (TPACK)," *Journal of Research on Technology in Education* 42, no. 2 (2009): 123–49, https://doi.org/10.1080/15391523.2009.10782544; Jiahong Su and Weipeng Yang, "A Systematic Review of Integrating Computational Thinking in Early Childhood Education," *Computers and Education Open* 4 (December 2023): 100122, https://doi.org/10.1016/j.caeo.2023.100122.

[9] C S Chai, J H L Koh, and C C Tsai, "A Review of Technological Pedagogical Content Knowledge," *Journal of Educational Technology & Society* 16, no. 2 (2013): 31–51.

particularly in Islamic educational settings, requires further study due to differences in cultural contexts and infrastructure availability.[10]

Mentoring strategies in teacher professional development have been shown to be more effective than traditional training in building competencies and transforming learning practices.[11] Through mentoring, teachers have the opportunity to learn in real-world situations, receive direct feedback from mentors, and construct competencies through a continuous cycle of reflection and improvement.[12] A planned and structured TPACK-based mentoring model can strengthen teachers' confidence in integrating technology while encouraging more creative and innovative learning practices.[13]

Preliminary data collected from 45 Madrasah Ibtidaiyah teachers in Cirebon City in September 2023 revealed a concerning situation: 78% of teachers still used conventional teaching approaches, 75% faced serious obstacles when operating digital applications for learning, and only 25% had experience creating their own digital learning media. These findings underscore the urgent need for a systematic program that can improve elementary school teachers' information and communication technology competencies using approaches that have been proven effective.

The development of digital learning media was chosen as the primary focus of the mentoring program for three reasons. First, learning media is a concrete representation of the integration of TPACK (Teaching, Assessment, and Assessment), where teachers directly apply knowledge of technology, pedagogy, and content in creating learning resources.[14] Second, the process of developing digital learning media facilitates active and constructivist learning for teachers

[10] M H Baturay, Ş Gökçearslan, and F Ke, "The Relationship among Pre-Service Teachers' Computer Competence, Attitude towards Computer-Assisted Education, and Intention of Technology Acceptance," *International Journal of Technology Enhanced Learning* 9, no. 1 (2017): 1, https://doi.org/10.1504/IJTEL.2017.084084; Elmaadaway and Abouelenein, "In-Service Teachers' TPACK Development through an Adaptive e-Learning Environment (ALE)."

[11] M A Kraft et al., "The Effect of Teacher Coaching on Instruction and Achievement: A Meta-Analysis of the Causal Evidence," *Review of Educational Research* 88, no. 4 (2018): 547–88, https://doi.org/10.3102/0034654318759268.

[12] A Teemant, "A Mixed-Methods Investigation of Instructional Coaching for Teachers of Diverse Learners," *Urban Education* 49, no. 5 (2014): 574–604, https://doi.org/10.1177/0042085913481362.

[13] I M Gómez-Trigueros, M Ruiz-Bañuls, and D Ortega-Sánchez, "Digital Literacy of Teachers in Training: Moving from ICTs (Information and Communication Technologies) to LKTs (Learning and Knowledge Technologies)," *Education Sciences* 9, no. 4 (2019): 274, https://doi.org/10.3390/educsci9040274; J Tondeur et al., "Preparing Pre-Service Teachers to Integrate Technology in Education: A Synthesis of Qualitative Evidence," *Computers & Education* 59, no. 1 (2012): 134–44, https://doi.org/10.1016/j.compedu.2011.10.009.

[14] Mishra and Koehler, "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge."

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through hands-on experience designing, developing, and evaluating digital products.[15] Third, digital learning media developed by teachers can be directly implemented in teaching practices, thus having a direct impact on the quality of student learning.[16]

While there are several studies on developing teachers' TPACK competencies, research specifically exploring the implementation of TPACK-based mentoring for Madrasah Ibtidaiyah teachers in Indonesia is still very limited. Most previous research has focused on the context of general schools or secondary education,[17] while the unique characteristics of madrasahs that integrate education.

RESEARCH METHODS

This study used a quantitative approach with a one-group pretest-posttest design to analyze the effectiveness of TPACK-based mentoring in improving the ICT competency of madrasah ibtidaiyah teachers.[18] The study was conducted for 30 days, from October 1 to 30, 2023. Participants consisted of 30 madrasah ibtidaiyah teachers in Cirebon City, West Java, including 19 female teachers and 11 male teachers. The sample was chosen using purposive sampling based on the following criteria: (1) teachers with a minimum of 5 years of teaching experience; (2) possession of a teaching certificate; (3) readiness to engage in an intensive mentoring program; and (4) basic computer literacy.

The study was conducted in four systematic stages. The preparation stage (Week 1) included institutional permitting, informed consent, a TPACK competency pretest, and a needs analysis interview. The implementation phase of the mentoring program (Weeks 2 and 3) consisted of structured TPACK-based mentoring sessions through a combination of workshops, hands-on practice, collaborative design activities, and individual mentoring. Each participant received a total of 16 face-to-face hours, including 8 hours of group workshops on TPACK principles and digital media development tools and 8 hours of individual mentoring sessions on personal media development projects. The implementation and

[15] Cartner and Hallas, "Aligning Assessment, Technology, and Multi-Literacies"; D Novaliendry et al., "Smart Learning Media Based on Android Technology," *International Journal of Innovation, Creativity and Change* 12, no. 11 (2020): 715–35.

[16] R Kimmons, R E West, and C R Graham, "The PICRAT Model for Technology Integration in Teacher Preparation," *Contemporary Issues in Technology and Teacher Education* 20 (2020): 176–98, https://citejournal.org/volume-20/issue-1-20/general/the-picrat-model-for-technology-integration-in-teacher-preparation/.

[17] S Pamuk et al., "Exploring Relationships among TPACK Components and Development of the TPACK Instrument," *Education and Information Technologies* 20, no. 2 (2015): 241–63, https://doi.org/10.1007/s10639-013-9278-4.

[18] J Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (Sage Publications Inc, 2014).

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reflection phase (Week 4) required participants to apply the developed digital media in actual learning and engage in reflective practice sessions. The evaluation phase included a posttest, focus group discussions, and the collection of digital media products for quality assessment.

This research instrument used the TPACK survey adapted from Schmidt et al to measure seven TPACK domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK).[19] The instrument consisted of 42 items with a 5-point Likert scale (1 = strongly disagree to 5 = agree) and a Cronbach's alpha reliability of 0.89. Furthermore, the Digital Media Quality Assessment Rubric, developed based on the criteria of Kimmons et al, evaluated digital media products on five dimensions: pedagogical appropriateness, content accuracy, technological functionality, design aesthetics, and usability, using a 4-point scale.[20]

Analysis of the TPACK survey was performed using SPSS version 29. Descriptive statistics (mean, standard deviation, and percentage) were calculated to map participants' TPACK competency profiles. Paired-samples t-tests were conducted to test for significant differences between pretest and posttest scores across all TPACK domains, with Cohen's d used to determine effect size.[21] The significance level was set at $\alpha = 0.05$. Digital media products were independently assessed by three raters using the quality assessment rubric, with inter-rater reliability using the Fleiss' kappa coefficient.

RESULTS AND DISCUSSION

Results

The Effectiveness of Mentoring on Improving TPACK Competencies

The comparison of TPACK competencies before and after the implementation of the mentoring program was analyzed using a paired-samples t-test. Detailed results are presented in Table 1.

[19] Schmidt et al., "Technological Pedagogical Content Knowledge (TPACK)."
[20] Kimmons, West, and Graham, "The PICRAT Model for Technology Integration in Teacher Preparation."
[21] L Cohen, L Manion, and K Morrison, *Research Methods in Education*, 8th ed. (Routledge, 2021).

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Table 1. Comparison of TPACK Competencies Before and After Mentoring (N = 30)

TPACK's Domain	Pretest	Posttest	t	df	p	Cohen's d
TK	2.37	3.85	-11.78	29	< .001	2.89
PK	3.48	4.09	-6.23	29	< .001	1.39
CK	3.81	4.21	-4.87	29	< .001	1.03
TPK	2.59	3.91	-10.45	29	< .001	2.45
TCK	2.45	3.78	-10.12	29	< .001	2.33
PCK	3.55	4.15	-5.89	29	< .001	1.42
TPACK	2.51	3.93	-12.34	29	< .001	2.76

The results of the paired-samples t-test showed that the TPACK-based mentoring program had a significant impact on improving all TPACK competency domains ($p < .001$). The largest increase occurred in the Technological Knowledge (TK) domain with a very large effect size (Cohen's $d = 2.89$), followed by TPACK ($d = 2.76$), Technological Pedagogical Knowledge (TPK; $d = 2.45$), and Technological Content Knowledge (TCK; $d = 2.33$). Although the Pedagogical Knowledge (PK), Content Knowledge (CK), and Pedagogical Content Knowledge (PCK) domains already had relatively high initial scores, all three still experienced significant increases with a large effect size ($d > 1.0$). These findings indicate that mentoring not only improves technological competency but also strengthens the integration of pedagogy and content in the context of technology-based learning.

The Quality and Characteristics of Digital Learning Media Developed by Teachers

During the mentoring program, all participants successfully developed digital learning media products. The results of the media quality assessment are presented in Table 2.

Table 2. Assessment of the Quality of Digital Learning Media for MI Teachers

Dimension of assessment	Mean	SD	Category
Pedagogical Suitability	3.32	0.56	Good
Content Accuracy	3.57	0.52	Very good
Technological Functionality	3.21	0.64	Good
Design Aesthetics	2.98	0.61	Good
Usability	3.29	0.58	Good
Total Score	**3.28**	**0.51**	**Good**

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The assessment of the digital learning media products developed by teachers showed a total average score of 3.28 (SD = 0.51), which is in the good category. The content accuracy dimension obtained the highest score (M = 3.57), indicating the suitability of the material with the MI curriculum and learning objectives. The pedagogical suitability and usability dimensions were also in the good category, while the design aesthetics dimension obtained the lowest score (M = 2.98), although still in the good category. The Fleiss' kappa value of 0.81 indicates a strong level of inter-rater reliability.

The Variation of Digital Learning Media Products Resulting from the Mentoring

Analysis of the resulting media products shows that teachers developed a variety of digital learning media according to the characteristics of the subjects they taught. The distribution of these media types is presented in Table 3.

Table 3. Distribution of Types of Digital Learning Media Developed by MI Teachers

Media Type	Frequency	Percentage
Interactive learning videos	9	30%
Interactive Multimedia Presentations	8	27%
Digital Educational Games	7	23%
EInteractive E-Modules	4	13%
Interactive Digital Quizzes	2	7%
Total	**30**	**100%**

The media products produced by teachers show considerable variation. The most commonly developed type of media is interactive learning videos (30%), followed by interactive multimedia presentations (27%) and digital educational games (23%). Meanwhile, interactive e-modules (13%) and interactive digital quizzes (7%) are developed in smaller proportions. This distribution indicates a tendency for teachers to choose visual, interactive, and contextual media to support learning in Madrasah Ibtidaiyah.

Discussion

This research makes an important contribution to the study of TPACK-based teacher professional development, particularly in the context of Islamic education in Indonesia. Significant improvements across all TPACK domains, with very large effect sizes, support Mishra & Koehler's argument that the use of technology in learning requires a holistic approach that integrates technology, pedagogy, and

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content.[22] The TPACK framework creates interactions that generate new forms of knowledge unique to teaching with technology.[23]

Significant improvements in technological knowledge are crucial given teachers' low baseline skills. The evidence suggests that the digital skills gap can be addressed through structured and intensive mentoring programs.[24] These findings align with Chai et al's findings that TPACK-based programs with intensive mentoring can fundamentally change teachers' technological perceptions and skills.[25] Improved technological skills coincide with a stronger understanding of pedagogy and content, as evidenced by significant increases in TPK and TCK.

Improvements in the domains of pedagogy, content, and PCK, despite already high initial scores, are an interesting finding. Many studies have shown that an excessive focus on technology can distract from pedagogy and content.[26] However, this study demonstrates that an integrated TPACK approach actually strengthens understanding of pedagogy and content. Schmidt et al explain that the use of technology forces teachers to rethink their teaching methods and explore new ways to deliver material, resulting in transformative learning.[27]

Combining group workshops and individual coaching has been shown to be effective in meeting diverse learning needs. Kraft et al comprehensive review of 60 studies showed that programs with individual support yielded an effect size of 0.49 standard deviations greater.[28] Group workshops provide opportunities for collaborative learning and peer support to build a community of practice[29], while individual coaching allows for contextualized problem-solving.[30]

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[22] Mishra and Koehler, "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge."

[23] Koehler, Mishra, and Cain, "What Is Technological Pedagogical Content Knowledge (TPACK)?"

[24] Malla et al., "Teachers' Digital Literacy Ability to Improve Islamic Religion Education Learning in Islamic Boarding School."

[25] Chai, Koh, and Tsai, "A Review of Technological Pedagogical Content Knowledge."

[26] M E Ottogalli and G M A Bermudez, "A PCK-Mapping Approach to Show the Integration among Components of the Pedagogical Content Knowledge of Elementary Education Teacher Educators about Biodiversity," *Teaching and Teacher Education* 151 (2024): 104746, https://doi.org/10.1016/j.tate.2024.104746; Tondeur et al., "Preparing Pre-Service Teachers to Integrate Technology in Education: A Synthesis of Qualitative Evidence."

[27] Schmidt et al., "Technological Pedagogical Content Knowledge (TPACK)."

[28] Matthew A. Kraft and John P. Papay, "Can Professional Environments in Schools Promote Teacher Development? Explaining Heterogeneity in Returns to Teaching Experience," *Educational Evaluation and Policy Analysis*, 2014, https://doi.org/10.3102/0162373713519496.

[29] Teemant, "A Mixed-Methods Investigation of Instructional Coaching for Teachers of Diverse Learners."

[30] Gómez-Trigueros, Ruiz-Bañuls, and Ortega-Sánchez, "Digital Literacy of Teachers in Training: Moving from ICTs (Information and Communication Technologies) to LKTs (Learning and Knowledge Technologies)."

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The learning-through-design approach applies the constructionist principle that learning occurs most effectively when participants are actively involved in creating meaningful products.[31] Teachers not only learn about technology but also actively design their own learning media. This process facilitates deep engagement with content, critical reflection on pedagogy, and technology experimentation.[32] Cartner & Hallas emphasized that this design experience creates a strong sense of ownership and enhances classroom implementation. [33]

The quality of the developed digital learning media reflects the successful application of TPACK skills to real-world practice. Excellence in content accuracy indicates that teachers have successfully maintained academic quality in digitalized learning.[34] However, lower scores on aesthetics indicate that visual and graphic design skills require additional attention. Pamuk et al found a similar pattern in Turkey, where teachers were strong in content accuracy and pedagogical appropriateness but struggled to create visually appealing digital products.[35] The limitations of the aesthetic aspect can be understood from the perspective of cognitive load theory. Developing quality media requires the simultaneous processing of multiple skills, which can lead to cognitive overload. Within 30 days, teachers prioritized fundamental aspects before refining aesthetics, which is a natural developmental stage and can be enhanced through ongoing professional learning.[36]

The variety of media types reflects an understanding of technological possibilities.[37] The abundance of interactive learning videos demonstrates teachers' recognition of the power of video in conveying complex information visually, in keeping with the characteristics of elementary school students who are at the

[31] Kimmons, West, and Graham, "The PICRAT Model for Technology Integration in Teacher Preparation."
[32] Novaliendry et al., "Smart Learning Media Based on Android Technology."
[33] Cartner and Hallas, "Aligning Assessment, Technology, and Multi-Literacies."
[34] Valtonen et al., "TPACK Updated to Measure Pre-Service Teachers' Twenty-First Century Skills."
[35] Pamuk et al., "Exploring Relationships among TPACK Components and Development of the TPACK Instrument."
[36] Tondeur et al., "Preparing Pre-Service Teachers to Integrate Technology in Education: A Synthesis of Qualitative Evidence."
[37] Y Su, "Delving into EFL Teachers' Digital Literacy and Professional Identity in the Pandemic Era: Technological Pedagogical Content Knowledge (TPACK) Framework," *Heliyon* 9, no. 6 (2023): e16361, https://doi.org/10.1016/j.heliyon.2023.e16361.

concrete thinking stage.[38] Learning videos designed with multimedia principles can reduce cognitive load and enhance information retention through dual processing.[39]

The abundance of educational games demonstrates teachers' adoption of gamification, a significant shift from one-way instruction to engaging learning experiences.[40] Gamification uses game elements to increase student motivation and engagement.[41] However, developing effective educational games requires a balance between entertainment value and learning objectives.[42]

The choice of visual and interactive media over text-based media reflects teachers' perspectives on Islamic elementary school students' learning[43]. This aligns with dual coding theory[44], which suggests that information encoded verbally and visually is more likely to be retained. This choice also reflects adaptation to the digital generation, but it is important not to discount the value of reading-based learning pedagogy.[45]

The success of this program has several important theoretical implications. First, the findings challenge the notion that the TPACK framework cannot be effectively implemented in Islamic educational settings with different cultures and infrastructures. This research provides concrete evidence that, with appropriate adaptations, the TPACK framework remains robust and applicable.[46] Second, this research reinforces the notion that effective professional development must be embedded in the workplace and practice-based, rather than detached from context

[38] J P Byrnes, "Piaget's Cognitive-Developmental Theory," in *Encyclopedia of Infant and Early Childhood Development* (Elsevier, 2020), 532–39, https://doi.org/10.1016/B978-0-12-809324-5.23519-0.

[39] R C Clark and R E Mayer, *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning* (John Wiley & Sons, 2023); Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis."

[40] Malla et al., "Teachers' Digital Literacy Ability to Improve Islamic Religion Education Learning in Islamic Boarding School."

[41] S Deterding et al., "From Game Design Elements to Gamefulness," in *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 2011, 9–15, https://doi.org/10.1145/2181037.2181040.

[42] Kimmons, West, and Graham, "The PICRAT Model for Technology Integration in Teacher Preparation."

[43] Sutjiatmo, Bayu Prabowo. "Empowering internet of things (IoT) through big data." International Journal of Engineering and Advanced Technology (IJEAT) (2019).

[44] A Paivio, *Mental Representations: A Dual Coding Approach* (Oxford University Press, 1990).

[45] Griffin and Care, "The ATC21S Method."

[46] Baturay, Gökçearslan, and Ke, "The Relationship among Pre-Service Teachers' Computer Competence, Attitude towards Computer-Assisted Education, and Intention of Technology Acceptance"; Elmaadaway and Abouelenein, "In-Service Teachers' TPACK Development through an Adaptive e-Learning Environment (ALE)."

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and overly theoretical.[47] Teachers learn best when they can directly apply new kno[48]wledge and see immediate impact. This aligns with situated learning theory, which argues that learning is inseparable from the context and activities in which it occurs.[49] Third, this research provides concrete support for an iterative design model in professional learning. Teachers undergo multiple design-test-refine cycles, facilitating incremental refinement of practice.[50] This model reflects the principles of design thinking, emphasizing continuous improvement through rapid prototyping and feedback.[51]

CONCLUSION

This study demonstrates that TPACK-based mentoring is an effective strategy for transforming the information and communication technology competencies of elementary school teachers. The mentoring program successfully bridged a significant digital divide through an approach that holistically integrates three pillars of knowledge. Significant improvements in the technology domain without compromising pedagogical quality and content mastery demonstrate that the TPACK framework provides an appropriate structure for teacher professional development in the digital era. The program's success underscores the importance of a mentoring model that combines collective learning with context-specific individual support. The applied learning-by-design approach enables teachers to become creators of meaningful and contextual learning media rather than mere consumers of technology. The quality of the resulting digital products validates that with structured support, elementary school teachers are able to produce learning innovations that meet pedagogical and technological standards. The practical implications of this study emphasize the need to reorient madrasah teacher professional development policies from conventional training models to sustainable mentoring programs that empower teachers as agents of change. For Islamic educational institutions, this study offers a concrete model that can be adapted to accelerate digital transformation without losing the distinctive pedagogical identity

[47] Kraft et al., "The Effect of Teacher Coaching on Instruction and Achievement: A Meta-Analysis of the Causal Evidence."

[48] Gómez-Trigueros, Ruiz-Bañuls, and Ortega-Sánchez, "Digital Literacy of Teachers in Training: Moving from ICTs (Information and Communication Technologies) to LKTs (Learning and Knowledge Technologies)."

[49] B Morgan, "Situated Cognition and the Study of Culture: An Introduction," *Poetics Today* 38, no. 2 (2017): 213–33, https://doi.org/10.1215/03335372-3868421.

[50] Teemant, "A Mixed-Methods Investigation of Instructional Coaching for Teachers of Diverse Learners."

[51] Gómez-Trigueros, Ruiz-Bañuls, and Ortega-Sánchez, "Digital Literacy of Teachers in Training: Moving from ICTs (Information and Communication Technologies) to LKTs (Learning and Knowledge Technologies)."

of madrasahs. Further research is needed to explore the long-term sustainability of the program's impact and the effectiveness of this model in madrasah contexts with different geographic and infrastructure characteristics.

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