Promoting Teachers' Digital Literacy through Innovative E-Learning Media Creation

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ABSTRACT

This research aimed to develop teachers' digital technology knowledge and skills in creating electronic learning media, and to enable teachers to create effective e-learning materials. The study employed a mixed-methods approach with 50 participating teachers. Data collection involved knowledge assessment tests and satisfaction questionnaires, with content validity verified by experts. The research implemented practical training in innovative electronic learning media creation based on the TPACK framework and adult learning principles. Results showed significant improvement in teachers' knowledge and understanding of electronic media development, with post-participation scores (M=8.92, SD=0.78) significantly higher than pre-participation scores (M=4.66, SD=1.32) at p<.05. Participating teachers successfully created at least two pieces of electronic learning media, including interactive content for mathematics instruction. Teacher satisfaction with the training program was highest overall (M=4.80, SD=0.38), particularly regarding opportunities for questions and discussions. The theoretical integration of digital literacy concepts with teacher professional development frameworks provided a robust foundation for the intervention design. The study demonstrates the effectiveness of situated, practice-oriented professional development in enhancing teachers' digital literacy and their capacity to create innovative e-learning media for digital age learning management, suggesting implications for sustainable technology integration in educational settings.

Key words: Digital Literacy, E-learning Media, Teacher Professional Development, Educational Technology, Digital Age Teaching

INTRODUCTION

In the 21st century, dynamic global changes and digital technology advancement affect human learning, as well as the development of new integrated and cross-cultural sciences. The thinking process and learning of new generations shift toward using technology that can access information easily, conveniently, quickly, and at all times. This includes economic expansion entering the industrial technology era, making the demand for personnel who form the foundation of production and technological capability very important. To increase competitive efficiency or add value in various aspects must start with developing new generations to have universal potential, principles, concepts, and ethics that will be an important foundation of society to elevate the country to international standards (Klangburum, 2023). Education 4.0 extends learning to build knowledge by emphasizing innovation, intelligence, technology, and creativity. Learning builds upon existing knowledge, creates new knowledge, thinks and applies knowledge appropriately for oneself and society according to situations. Educational direction under Education 4.0 concept prepares and adjusts educational management and teaching-learning processes to align with Thailand 4.0 model, promotes innovation creation and

intelligence through technology use and creativity, encourages teachers and learners to become innovative thinkers. Access to knowledge content in today's world with open characteristics (Open Education Resource) is easily accessible through smartphones and various tools. This mobile education format allows access to information more conveniently. Knowledge seeking becomes faster. For new-generation children and youth, traditional classroom teaching that requires memorizing content according to curriculum framework lesson plans or doing conventional exercises and tests is no longer suitable for this modern era that emphasizes self-directed learning exploration and creative new thinking in challenging ways. From the report on implementation of national education reform, teaching and learning management to respond to 21st century changes still lacks readiness of educational institutions and quality of educational personnel who must adjust their attitudes and adapt to keep pace with the current world. The Digital Revolution, leap-forward advancement in digital technology, and entry into the Internet of Things era affect learning behavior changes and human ways of life through complete disruption. This creates new globalization challenges that every country in the world must prepare to handle and can create benefits from

vast digital and information technology for economic advantage under free and borderless competition. From this information, teaching and learning skills in the 21st century align with Education 4.0 concept where learners can integrate existing knowledge creatively to develop innovations that respond to social needs. Learning activities focus on learners to use smart technology for learning through global networks and practice initiative to create innovations with support from teachers and innovative sources, including social networks as online innovation learning sources. Education 4.0 has educational management processes to design changes in learning formats and physical environments from traditional classrooms by using convenient, quick and diverse technology appropriate for learning management objectives, pursuit of skill development, knowledge creation and creative initiative to create new innovative alternatives.

Therefore, teachers' learning management should align with national educational goals, can integrate knowledge into practice, and arrange learning activities that encourage students to learn and develop according to their potential. With the advancement of computer technology and internet networks that play a role in teachers' instruction at all levels, to use in teaching alongside classroom learning, teachers can develop their own teaching processes to keep pace with technological changes and today's world. Teachers must have computer skills and various technologies for teaching management, especially the integration of technological knowledge to design electronic media for learning management in digital age classrooms.

Learning media is important for student-centered learning management. It is generally accepted that electronic learning media affects interest stimulation and learning activity participation, allows students to learn outside class time, and enables students to learn to their full potential without time constraints. However, the integration of technological knowledge with content knowledge and teaching methods to design and create learning media remains difficult and new for teachers. This results in teachers' lack of knowledge, skills, and expertise in program usage and learning media design skills, causing teachers to be unable to create and design electronic media, including inability to effectively use it as media for student-centered learning activities. Therefore, to prepare classrooms for the digital era, it is necessary to accelerate knowledge and skill development in computer program use for electronic learning media design. The design of electronic learning media for digital age learning management should be diverse and colorful, create excitement to stimulate students' interest in learning, enable continuous learning development, and result in effective subject content learning. This is because the combination of various media types including sound, still images, and animation makes lessons interesting and can enhance learners' understanding effectively.

Learning media is an important component that helps promote valuable, interesting, thought-provoking, easy to understand, and quick learning. It also encourages learners to know methods of knowledge seeking, results in extensive, deep, and continuous learning. This makes students interested in learning, receive extensive knowledge, understand lessons better, and saves time. It helps systematically transfer knowledge from abstract to concrete concepts. Electronic lessons that align with learning objectives and content, with diversity and color, create excitement to stimulate students' interest in learning, enable continuous learning development, and result in effective subject content learning. This is because the combination of various media types including sound, still images, and animation makes lessons interesting and can enhance learners' understanding effectively. This makes learners enjoy learning more and maintain focus on the teaching media. Teachers are important persons both directly and indirectly to transfer knowledge. When teachers' understanding and use of digital technology through innovative electronic learning media creation is promoted, it enhances skills in using technology to support teachers' teaching potential. This will make the learning process of school-age children more successful.

Digital Literacy and Teacher Professional Development are closely interconnected concepts in the digital age. Gilster (1997) defined digital literacy as the ability to understand and use information from various computer sources, which when applied to educational contexts, involves teachers' ability to evaluate, access, use, and create digital media for instruction. In terms of teacher professional development, Darling-Hammond et al. (2017) proposed key principles of effective professional development, including content-specific focus, active learning, and sustained support. When integrated with digital skills development, training must focus on providing teachers with practical experience in creating electronic learning media relevant to their subject areas.

The TPACK (Technological Pedagogical Content Knowledge) framework by Mishra and Koehler (2006) further emphasizes the importance of integrating technological, content, and pedagogical knowledge. Professional development in digital literacy for teachers is therefore not merely about teaching technical skills but promoting an understanding of how to effectively blend technology with content and teaching methods.

The design of teacher professional development in this research applied Knowles' (1984) adult learning theory, considering the principle that adults need to see connections between what they learn and real-world applications, and desire involvement in the learning process. The development process thus focused on having teachers create electronic learning media that could be immediately implemented in their classrooms. Additionally, the concept of Situated Learning by Lave and Wenger (1991) was incorporated to establish learning contexts similar to actual work situations. Teachers therefore learned to create electronic learning media in the context of their teaching content, aligning with Desimone's (2009) research finding that effective teacher professional development should be coherent with teachers' knowledge and beliefs, as well as school reform initiatives and policies.

Tour's (2015) study demonstrated that teachers need continuous support in developing digital skills, not just short-term training, but learning that occurs in work contexts with

ongoing reflection. This aligns with Falloon (2020), who found that effective technology professional development for teachers must connect with real teaching contexts and provide both technical and educational support. Furthermore, Foulger et al. (2017) developed the Teacher Educator Technology Competencies (TETCs), identifying necessary technology competencies for teacher educators. This research highlights the importance of teachers being able to design learning that integrates technology and evaluate the use of technology in teaching. This corresponds with Amhag et al. (2019), who studied digital competence development among teachers in Sweden and found that involvement in creating digital resources enhances teachers' confidence and skills in using technology in the classroom. Boholano (2017) examined technology use in education among Filipino teachers and found that digital literacy is a crucial skill enabling teachers to effectively integrate technology into 21st-century teaching. This aligns with Starkey's (2020) recent research suggesting that teacher professional development should focus on promoting teachers as producers of digital content, not merely consumers.

Another important aspect in integrating the theoretical framework was the application of the Digital Competence Framework for Educators (DigCompEdu) by Redecker and Punie (2017). This framework identifies essential digital competencies for teachers, including creating and developing digital resources, managing and utilizing digital resources, and fostering learners' digital competencies. The design of professional development activities in this research thus comprehensively covered these competencies.

Objectives

This study aimed:
1. To develop teachers' digital technology knowledge, understanding and usage in electronic learning media creation.

RESEARCH METHODOLOGY

Population and Sample Group

Population: The target population consisted of primary and secondary school teachers in Roi Et Province, Thailand, who are currently teaching various subjects and have basic computer literacy skills.

Participants: Fifty teachers participated in this research project. The participants comprised 14 male teachers (28%) and 36 female teachers (72%) from public schools in Roi Et Province. Participants had varying levels of teaching experience, ranging from 2 to 25 years, and taught across different subject areas including mathematics, science, Thai language, English, and social studies. All participants had basic computer skills and access to computers or tablets for instructional purposes.

Sampling Method: A stratified random sampling method was employed to select participants. Schools in Roi Et Province were first categorized by educational levels (primary and secondary) and geographic location (urban and rural areas). Teachers were then randomly selected from each stratum to ensure representation across different school types and locations. Inclusion criteria included: (1) current employment as a full-time teacher in Roi Et Province, (2) basic computer literacy skills, (3) willingness to participate in the training program, and (4) commitment to implement learned skills in their teaching practice.

Selection Process: Initial recruitment was conducted through the Roi Et Provincial Education Office, which distributed information about the research project to all schools in the province. Interested teachers submitted applications, and final selection was made through random sampling within each stratum to achieve the target sample size of 50 participants.

Data Collection

Step 1: Study information, documents, concepts, theories, and related research for digital age teaching and learning management and electronic learning media creation

Step 2: Practical training in innovative electronic learning media creation. The data collection tools were knowledge assessment tests about electronic learning media development and creation process, and teacher satisfaction questionnaires. These tools were developed through studying and reviewing related concepts, theories, and research, then applied as data collection instruments as follows:

Tool 1: Knowledge assessment test on digital technology use in electronic learning media creation for teachers who participated in the research project, consisting of 10 items. For content validity, the researcher presented the created tool to 3 experts in educational measurement and evaluation, and curriculum and instruction to verify content accuracy and validity, then made improvements accordingly. The IOC values ranged from 0.67 to 1.00. The reliability analysis of the test from trying out with a population group most similar to the research sample, then calculating reliability using Kuder-Richardson KR-20 formula, yielded a value of 0.890.

Tool 2: Satisfaction questionnaire with 5-level rating scale characteristics, with the following criteria for opinion levels:

Score level 5 means highest satisfaction level
Score level 4 means high satisfaction level
Score level 3 means medium satisfaction level
Score level 2 means low satisfaction level
Score level 1 means lowest satisfaction level

The researcher calculated means with the following interpretations (Fruchter et al., 1989):

Mean 4.50 - 5.00 indicates highest satisfaction level
Mean 3.50 - 4.49 indicates high satisfaction level
Mean 2.50 - 3.49 indicates medium satisfaction level
Mean 1.50 - 2.49 indicates low satisfaction level
Mean 1.00 - 1.49 indicates lowest satisfaction level

The analysis of the Index of Item-Objective Congruence found that all questionnaire items aligned with learning objectives with IOC values between 0.67 and 1.00.

Data Analysis

In this research, content analysis follows these steps:

Step 1: Analyze concepts, theories, and related research data for digital age teaching and learning management and electronic learning media creation

Step 2: Analyze knowledge and understanding results of digital technology use in electronic learning media creation from teachers who participated in the research project

Step 3: Analyze satisfaction results from teachers who participated in the research project

Ethics Approval and Consent to Participate

The research has been reviewed by the Roi Et Rajabhat University. Written informed consent was obtained from all participants involved in the study and adheres to research ethics principles on consent, confidentiality, and participants' right to withdraw.

RESULTS

This study aimed to develop teachers' digital technology knowledge, understanding and usage in electronic learning media creation. The results are presented according to the three dimensions of development:

Development of Teachers' Digital Technology Knowledge

Framework of Electronic Learning Media Components: Electronic media consists of three main components that work together to create effective digital learning environments.

1. Electronic lessons are content presented in electronic format. They have multimedia characteristics which can be transmitted through text, animation, and sound as main elements. Their key advantages are time and cost savings. Additionally, teachers can produce content by themselves or use simple interactive multimedia lessons to supplement their teaching materials, which teachers can conveniently produce and update content independently.

2. Learning management system is a program that serves as a center for learning management and support, with both online and offline formats to create interaction between teachers and students, students and students, and students and information sources. This helps students and teachers access content conveniently and easily through the internet, applications, smartphones, or computers.

3. Learning assessment in blended learning for some subjects requires pre-learning knowledge level measurement to help students select the most appropriate lessons or courses for maximum learning efficiency. When entering lessons in each course, there will be chapter quizzes and tests before course completion. These tests can be in formats available through the learning management system such as multiple choice, fill-in-the-blank, and matching, with immediate assessment results available both online and offline.

Instructional Design Process Learned by Teachers: Teachers mastered the systematic instructional design process, learning to address four fundamental questions:

1. Who is this teaching design and development for? Who are the learners or target group? Designers should understand and know the characteristics of the target e-learning student group.

2. What should learners learn? What knowledge, understanding, and/or abilities should they gain? Teachers must clearly define the teaching objectives.

3. How will learners best learn that subject content? What learning methods and activities should be used to help learners learn? What factors need consideration?

4. When do learners enter the learning process? How will we know if learning occurs and succeeds? What methods will be used to assess learner outcomes?

Therefore, there should be planning to consider who the learners are, what their basic characteristics are, how to set teaching objectives, what teaching methods and learning activities to use, and what assessment methods to employ to achieve teaching goals - so that after learning, students can know, understand, remember, apply, perform, and create new things. Thus, considerations in instructional design include learners, teaching methods and learning activities, objectives, and assessment. Electronic learning media can be created in various types as follows:

1. Computer-Assisted Instruction (CAI) is a form of computer-based teaching media that uses computer capabilities to present multimedia, including text, still images, graphics, charts, graphs, video, animation, and sound.

2. Web-based Instruction (WBI) refers to lessons created for learning through the internet network by applying the strengths of WWW service delivery methods. WBI is therefore an online CAI lesson, meaning learners study at a computer screen connected through a network to a server containing the lessons.

3. Electronic learning or e-Learning is education through computer networks and internet for self-learning. Learners can study according to their abilities and interests through lesson content that includes text, images, sound, video, and other multimedia.

4. E-book, abbreviated from electronic book, refers to books created with computer programs in electronic document format. These files typically can be read on computer screens both offline and online.

5. E-Training is an electronic media training process for skill development and knowledge enhancement that emphasizes self-learning. Trainees have freedom to study according to their preferred time and opportunity. The knowledge content is designed for easy learning in multimedia format, which consists of text, images, or may include animation.

6. Learning Object organizes learning content into independent units that require short learning periods of approximately 2 to 15 minutes. Although it is modular learning, Learning Objects are self-contained. Each content includes title, description, keywords, learning objectives, learning activities, and assessment. One key feature is that learners can study independently.

Kamaruddin (2021) developed a mathematics learning prototype using e-learning. Electronic lessons greatly support learning implementation due to independent teaching media that can be accessed anytime. Electronic lessons can improve student learning in terms of active student participation and data capability and quality that would be difficult with ordinary devices. Well-designed electronic lessons can increase learning interaction levels. All students can ask questions or express opinions in discussions, which differs from conventional learning due to limited opportunities. From these hypotheses, it was necessary to study development strategies for electronic lesson prototypes. Specifically, this research aimed to develop an electronic learning device prototype using Moodle. This research was research and development with a four-dimensional development model. The results were in the form of a mathematics learning device prototype with electronic lessons that could be developed into complete mathematics learning media. Kamaruddin (2021) designed electronic lessons on Moodle based on high school students' mathematical problem-solving and to determine the feasibility and effectiveness levels of electronic lessons on Moodle based on high school students' problem-solving. This research included research and development with the following steps: potential and problems, design data collection, design verification, design improvement, experimentation, revision, trial use. The data collection technique used in this research was in the form of literature studies. The study results from literature studies found that the average score of media experts was 88.67 at a good level, the average score of material experts was 80.67 at a sufficient level, while the average score of mathematics learning outcomes was 8 at a good level, with group t-test results in single group design of 11.51. From data analysis, it can be concluded that the use of electronic lessons on Moodle was based on appropriate problem-solving and effectively implemented in high schools. Evangeline Dap-og and Orongan (2022) studied the effects of Computer-Assisted Instruction (CAI) on student academic achievement and science engagement. This study determined student academic achievement and science engagement using quasi-experimental research design. The results found that students exposed to CAI achieved "fairly satisfactory" results in post-tests, while those without CAI were found to "need improvement" in both pre and post-tests. Additionally, for student science engagement, the CAI group had high engagement levels for emotional, cognitive, and behavioral domains. In contrast, the non-CAI group had moderate engagement before and after intervention. Science learning outcomes of students exposed to CAI were significantly higher than those without CAI. There were also significant differences in student engagement levels for cognitive domains to support CAI.

Electronic learning media in digital age teaching and learning plays an important role in instruction. Most research results indicate that various forms of electronic learning media serve as teaching aids. Students who learn through electronic learning media achieve higher academic achievement than other forms of instruction. This shows that electronic learning media effectively responds to individual learning needs. For this reason, the researcher implements the enhancement of electronic learning media design skills for learning management in the digital age. The use in learning management becomes another method that encourages students to learn independently and effectively stimulates student interest, resulting in better academic achievement.

Development of Teachers' Understanding in Electronic Learning Media Creation

The comparison results of teachers' knowledge and understanding about the development process and creation of electronic learning media before and after participation in the research project show that before participation (Table 1), the average knowledge and understanding score equals 4.66 points from a total of 10 points (SD= 1.32), and after participation, the average knowledge and understanding score equals 8.92 points from a total of 10 points (SD=0.78). The test results of the difference in mean knowledge and understanding about the development process and creation of electronic learning media of teachers before and after participation in the research project indicate that teachers who participate in the project have significantly higher knowledge and understanding about the development process and creation of electronic learning media at the statistical significance level of 0.05.

The innovative creation of electronic learning media products: Among 50 participating teachers, 14 male teachers account for 28 percent, and 36 female teachers account for 72 percent. These teachers can design learning media through software packages to create electronic learning media for digital age learning management with at least 2 pieces of work.

Development of Teachers' Usage - Practical Implementation

The teachers' digital technology implementation through innovative electronic learning media involves creating interactive content that allows students to learn about prisms and cylinders (Figure 1) through:
1. Text explanations of key mathematical concepts, formulas, and properties of prisms and cylinders
2. Visual elements like:
   - 2D and 3D diagrams of different types of prisms and cylinders
   - Animated visualizations showing rotations and cross-sections

Table 1. A comparison of teachers' knowledge and understanding about the development process and creation of electronic learning media before and after participation in the research project

Events	N	Mean	SD	t	p-value
Before the event	50	4.66	1.32	17.85	0.000*
After the event	50	8.92	0.78		

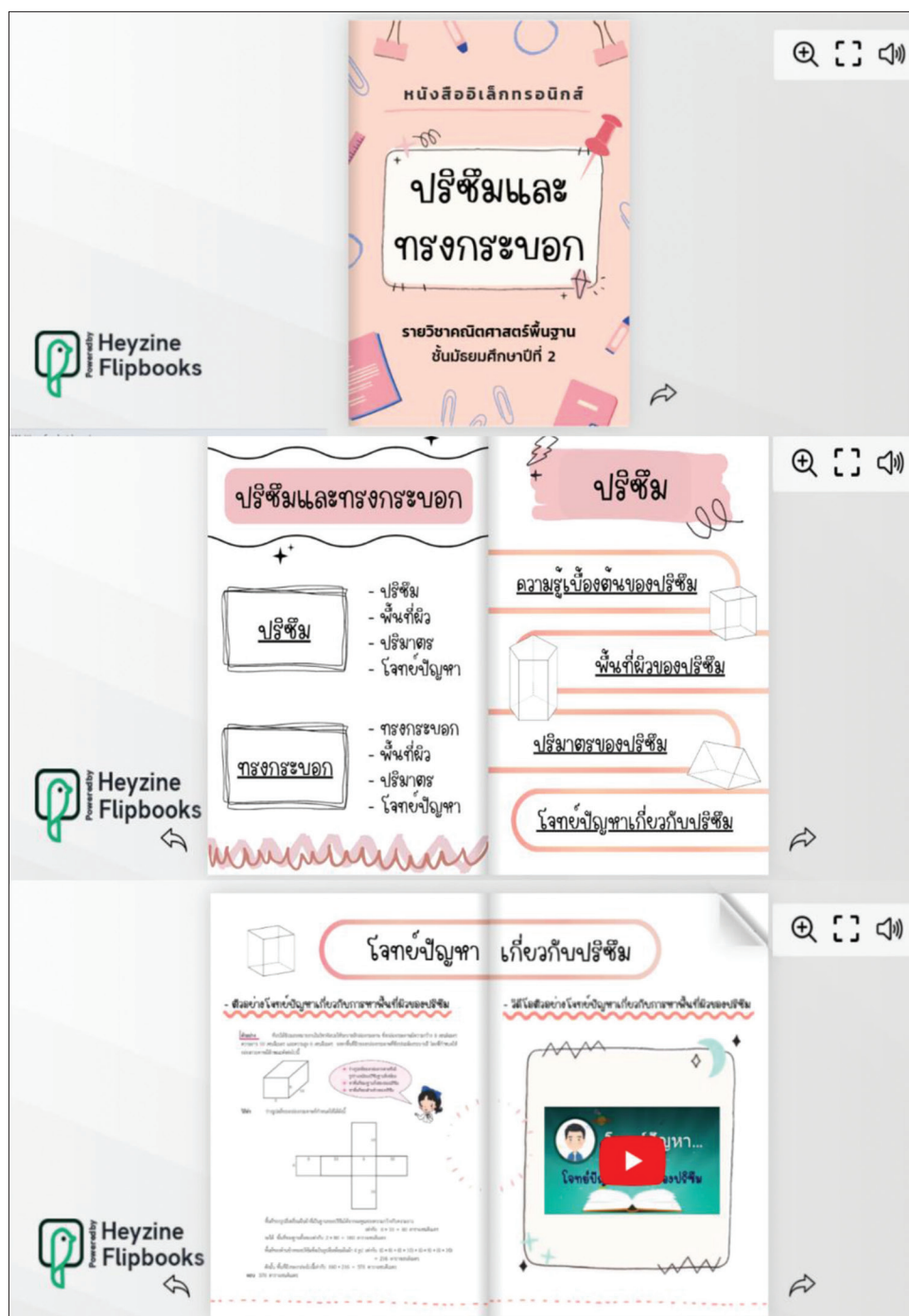* Statistically significant at the level of 0.05

Figure 1. Teachers' electronic learning media for teaching prisms and cylinders in mathematics (Source: Phuntipa Julakarn, 2024)

- Step-by-step illustrations of volume and surface area calculations
3. Audio components including:
   - Verbal explanations of concepts
   - Mathematical vocabulary pronunciation
   - Problem-solving guidance
4. Video content featuring:
   - Real-world applications of prisms and cylinders
   - Interactive demonstrations
   - Worked examples of calculations

 This electronic learning media allows students to: Learn at their own pace, Review concepts as needed, Visualize 3D shapes from multiple angles, Practice calculations with immediate feedback and Connect mathematical concepts to real-world applications. The multi-modal approach (text, images, audio, and video) helps accommodate different learning styles and makes abstract geometric concepts more concrete and understandable for students.

 Teachers' digital technology implementation through innovative electronic learning media for teaching multiplication (Figure 2) includes:

1. Learning Media Components:
   - Interactive multiplication lessons with text explanations

Figure 2. Teachers' electronic learning media for teaching multiplication in mathematics (Source: Phuntipa Julakarn, 2024)

- Visual demonstrations of multiplication concepts
- Audio narration for step-by-step problem solving
- Video tutorials showing different multiplication methods
- Practice exercises

2. Assessment Design:
- Digital quizzes to evaluate student understanding
- Multiple choice questions testing multiplication facts
- Automated scoring

The electronic learning media allows students to: Receive immediate feedback on their work and Review concepts as needed. The combination of interactive learning content and integrated assessment tools creates a comprehensive digital learning environment for teaching multiplication effectively.

Teacher Satisfaction with the Development Process

The satisfaction of participating teachers (Table 2) overall highest satisfaction (Mean=4.80, SD=0.38), reveals that most teachers express highest satisfaction with speakers who provide opportunities for questions and discussions (Mean=4.96, SD=0.20). Next, speakers with knowledge and experience about training content receive highest satisfaction (Mean=4.90, SD=0.30). Speakers with appropriate content presentation techniques receive highest satisfaction (Mean=4.88, SD=0.32), and speakers who arrange appropriate content presentation steps receive highest satisfaction (Mean=4.78, SD=0.41) respectively.

Regarding knowledge, understanding, and knowledge application, most teachers express highest satisfaction in project participation that develops electronic learning media creation through technology (Mean=4.80, SD=0.40). Next, participating teachers can apply knowledge from training to integrate digital age teaching with highest satisfaction (Mean=4.76, SD=0.43).

Training process/procedures, most teachers express highest satisfaction with appropriate training duration (Mean=4.82, SD=0.38). Next, training documents with easy-to-understand language receive highest satisfaction (Mean=4.68, SD=0.47), and training format and

Table 2. Satisfaction of participating teachers

Evaluation Items	Mean	SD	Satisfaction Level
1. Speakers Aspect			
1.1 Knowledge and experience about training content	4.90	0.30	Highest
1.2 Appropriate arrangement of content presentation steps	4.78	0.41	Highest
1.3 Appropriate content presentation techniques	4.88	0.32	Highest
1.4 Opportunities for questions and discussion	4.96	0.20	Highest
2. Knowledge Understanding and Application Aspect			
2.1 Project participants develop electronic learning media creation through technology	4.80	0.40	Highest
2.2 Project participants can integrate knowledge into digital age teaching	4.76	0.43	Highest
3. Training Process/Procedures Aspect			
3.1 Training format and procedures	4.64	0.48	Highest
3.2 Training documents with easy-to-understand, useful language	4.68	0.47	Highest
3.3 Appropriate training duration	4.82	0.38	Highest
4. Training Quality Aspect			
4.1 Direct response to digital age learning management needs	4.78	0.41	Highest
4.2 Enhanced electronic learning media creation skills with worthwhile and beneficial knowledge	4.82	0.38	Highest
overall	4.80	0.38	Highest

procedures receive highest satisfaction (Mean=4.64, SD=0.48) respectively.

Training quality, most teachers express highest satisfaction with enhanced electronic learning media design skills and worthwhile, beneficial knowledge (Mean=4.82, SD=0.38), and training participation that responds directly to digital age learning management needs receives highest satisfaction (Mean=4.78, SD=0.41).

DISCUSSION

The finding that teachers' knowledge and understanding of electronic learning media development significantly increased after participating in the research project aligns with Mishra and Koehler's (2006) TPACK framework, which emphasizes the integration of technological, content, and pedagogical knowledge. Teachers' ability to create at least two electronic learning media pieces demonstrates that they developed technological knowledge and could integrate it with content and pedagogical knowledge. Moreover, the highest level of satisfaction among participating teachers reflects the effectiveness of professional development design based on Knowles' (1984) adult learning theory and Lave and Wenger's (1991) Situated Learning concept. Teachers were supported in learning within contexts relevant to their actual work and engaged in creating learning media that could be practically implemented in their classrooms. Teachers' ability to create electronic learning media for teaching prisms and cylinders and multiplication instruction demonstrates the development of digital competencies according to Redecker and Punie's (2017) DigCompEdu framework, particularly in creating and developing digital resources. The learning media created by teachers featured interactive content that allows students to learn at their own pace, review content as needed, and receive immediate feedback, which aligns with the principles of student-centered learning.

The professional development of teachers in technology shown in this research demonstrates growth in digital competency through teachers' ability to create and implement electronic learning media. However, as Falloon (2020) notes, the continuous evolution of technology presents ongoing challenges for teachers who must regularly update their skills. The development of these digital teaching materials, particularly in mathematics, shows teachers' commitment to enhancing their pedagogical approaches through technology integration. The creation of interactive assessments and learning materials indicates a shift in teaching methodologies, requiring teachers to balance traditional teaching methods with digital innovations. This transformation demands significant investment in professional development programs and support systems, as suggested by Tour (2015), who emphasizes the need for continuous rather than one-time training interventions. Moreover, the successful implementation of these digital tools suggests that teachers are developing not only technical skills but also pedagogical knowledge in effectively utilizing technology for student learning, supporting Boholano's (2017) findings on the importance of digital literacy for effective technology integration. While these advancements are promising, the varying levels of digital literacy among teachers highlight the need for continued professional development opportunities

and technological support in educational settings. The development of teacher professional competency in technology usage thus emerges as a crucial factor in modern education, requiring ongoing attention and resources, as emphasized in Starkey's (2020) research on teacher preparation for the digital age.

Promoting teachers' digital literacy through innovative e-learning media creation demonstrates a commitment to modern educational practices, yet the long-term sustainability of these initiatives requires careful consideration. As Amhag et al. (2019) suggest, educational institutions face ongoing challenges in maintaining and upgrading technological infrastructure, which demands significant financial investment and resource allocation. The continuous evolution of technology necessitates regular updates to both hardware and software, raising questions about the long-term viability of digital learning platforms. Teachers' efforts to create and maintain digital content, particularly in subjects like mathematics, require consistent support and resources to ensure their effectiveness over time. The sustainability of these technological innovations also depends on the development of robust maintenance systems and technical support structures.

Furthermore, the issue of digital equity and access becomes crucial in ensuring sustainable technology implementation across different educational settings, a concern reflected in the work of Foulger et al. (2017) on teacher educator technology competencies. While digital tools offer innovative teaching and assessment methods, their long-term success relies on establishing sustainable funding models and professional development programs. The challenge lies not only in implementing technology but in creating sustainable systems that can adapt to emerging educational needs and technological advancements while maintaining quality and accessibility. Teacher training and ongoing technical support emerge as vital components for ensuring the sustainable use of technology in education, highlighting the need for comprehensive, long-term planning in educational technology integration, a perspective supported by Darling-Hammond et al. (2017) in their research on effective teacher professional development

CONCLUSION

Innovative electronic learning media creation involves text, still images combined with video animation and sound, using technology to convey content. It includes technology and Course Management System for managing various teaching aspects, enabling questions and exchange of ideas between learners. Post-learning tests measure learning outcomes, with systems to record, track, monitor and evaluate learning to address student differences and support effective teaching activities. This can be implemented as a complete teaching process or as part of the overall process, facilitating learning and eliminating obstacles related to location and time constraints. Instructional design is a systematic planning process that analyzes learning components, teaching theories, learning media activities, and assessment to enable teachers to effectively transfer knowledge to learners. The design helps

teachers plan systematically, access information quickly, and maintain data persistence. It promotes new skill acquisition, provides up-to-date content responsive to current topics, leading to achievement of teaching objectives and success. Electronic learning media creates broad-reaching educational formats without travel, time or location restrictions. Therefore, electronic learning media supports Life Long Learning and provides educational opportunities for those lacking access to higher education. Research by Konchalard and Julakarn (2023) shows satisfaction of 6th graders with learning activities using electronic learning media had overall satisfaction at the highest level.

REFERENCES

Amhag, L., Hellström, L., & Stigmar, M. (2019). Teacher educators' use of digital tools and needs for digital competence in higher education. *Journal of Digital Learning in Teacher Education, 35*(4), 203-220. https://doi.org/10.1080/21532974.2019.1646169

Boholano, H. B. (2017). Smart social networking: 21st century teaching and learning skills. *Research in Pedagogy, 7*(1), 21-29. https://doi.org/10.17810/2015.45

Dap-og, E. R., & Orongan, M. J. Q. (2022). Computer-assisted instruction on students' academic achievement and engagement in science. *International Journal of Teaching and Learning, 1*(1), 46–57. https://doi.org/10.17501/26827034.2021.1104

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute. https://learningpolicyinstitute.org/product/effective-teacher-professional-development-report

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199. https://doi.org/10.3102/0013189X08331140

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*(5), 2449-2472. https://doi.org/10.1007/s11423-020-

Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D., & Slykhuis, D. A. (2017). Teacher educator technology competencies. *Journal of Technology and Teacher Education, 25*(4), 413-448.

Fruchter, B., Comrey, A. L., & Michael, W. B. (1989). J. Paul Guilford (1897-1987). *Multivariate Behavioral Research, 24*(1), 3-15.

Gilster, P. (1997). *Digital literacy*. Wiley Computer Publishing.

Kamaruddin, E., Wijaya, Y. S., Avianti, R. A., Rahardjo, I. A., & Sunawar, A. (2021, March). Development of prototype e-learning mathematics learning tools using Moodle. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1098, No. 2, p. 022095). IOP Publishing.

Klangburum, C. (2023). The development of Thai language teaching has preserved Thai identity and embraced the new normal in higher education in the 21st century. Buddhist Principles. *Journal of Graduate Saket Review, 8*(1), 35-48.

Knowles, M. S. (1984). Andragogy in action: Applying modern principles of adult learning. Jossey-Bass.

Konchalard, P., & Julakarn, S. (2023). Enhancing Electronic Learning Media Design Skills for Learning Management in Digital Age. *Education Journal Faculty of Education, Nakhon Sawan Rajabhat University, 6*(1), 218–226. Retrieved from https://so02.tci-thaijo.org/index.php/edunsrujo/article/view/259220

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge University Press.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Redecker, C., & Punie, Y. (2017). *European framework for the digital competence of educators*. Publications Office. https://data.europa.eu/doi/10.2760/159770

Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education, 50*(1), 37-56. https://doi.org/10.1080/0305764X.2019.1625867

Tour, E. (2015). Digital mindsets: Teachers' technology use in personal life and teaching. *Language Learning & Technology, 19*(3), 124-139. http://dx.doi.org/10125/44437