

## Enhancing Students' Research Skills Through AI Tools and Teacher Competencies: A Mixed-Methods Study

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### Abstract

This mixed-methods study examines the relationship between the integration of the AI-driven educational platform BrainPOP, teacher digital competencies, and the development of students' research skills in elementary and secondary education in Tehran, Iran. The study focuses on four primary objectives: (1) identifying strategies for integrating BrainPOP in teaching and learning, (2) assessing the influence of teacher digital competencies on successful BrainPOP integration, (3) analyzing the impact of BrainPOP on students' research skills, and (4) exploring the interconnected roles of BrainPOP, teacher digital competencies, and students' research skills development. Participants include 100 elementary and secondary school teachers and 200 students from Tehran, Iran. Data is collected using surveys, interviews, and classroom observations, and analyzed through descriptive statistics, regression, and thematic coding. Key findings for each objective include: 1. Diverse strategies for integrating BrainPOP in the classroom, 2. A positive correlation between teacher digital competencies and successful BrainPOP adoption, 3. Enhanced student research skills linked to the use of BrainPOP, and 4. The significance of a supportive learning environment that fosters collaboration, critical thinking, and adaptability among students, teachers, and AI tools in Iran. This study highlights the need for different ways to use BrainPOP, improving teachers' digital skills, and creating a supportive learning environment to help students improve their research skills in elementary and secondary schools. The results provide essential information for education practices and policies in Iran and other places, highlighting that AI tools like BrainPOP can significantly enhance how students learn and develop their research abilities.

**KEYWORDS:** AI in Education, AI Competency, Teacher Competency, Teaching Competency, Technological Pedagogical Content Knowledge (TPACK).

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### 1. Introduction

The integration of artificial intelligence (AI) tools has substantially transformed educational environments, impacting how students engage with and process information (Holmes et al., 2023; Zhu et al., 2016). A

crucial aspect of this transformation is the digital competencies that teachers and future teachers possess in research work and their utilization of digital tools within this context. It is essential to examine the interconnected relationship between AI tool integration, teacher digital competencies in research tasks, and students' research skills development (Luckin et al., 2022; Mikalef et al., 2021).

As the demand for proficient information seeking, evaluation, and utilization increases in our knowledge-driven world, research skills have become essential for students to succeed (Kirschner & Selinger, 2003). Teachers, with their digital competencies, are instrumental in fostering these abilities, guiding students through the complex information landscape (Ilomäki et al., 2016; Suelves et al., 2019). With AI

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tools progressively integrating into educational settings, it is vital to examine their impact on teacher digital competencies and the consequent influence on students' research abilities (Behnamnia et al., 2018; Hayati et al., 2023; Najmeh, 2021).

The role of AI-driven educational platforms like BrainPOP as essential tools for teachers and future teachers in elementary education is highlighted (Rosen et al., 2022). BrainPOP is an online educational platform offering engaging animated videos, interactive activities, and games that facilitate learning across various subjects, such as science, math, history, and language arts. Specifically designed for elementary students, BrainPOP caters to their learning needs by presenting information in a visual, engaging, and age-appropriate manner (Rosen et al., 2022).

The integration of BrainPOP in the classroom provides several advantages (Barak et al., 2011):

- **Content engagement:** BrainPOP's animated videos and interactive activities make learning enjoyable and engaging for elementary students, fostering their interest in various subjects and improving knowledge retention.
- **Differentiated instruction:** With a wide range of resources, BrainPOP caters to diverse learning needs and preferences, enabling teachers to differentiate instruction and create personalized learning experiences.
- **Skill development:** The platform's quizzes and activities allow students to practice and develop critical thinking, problem-solving, and research skills, supporting their overall academic growth.

Hence, this comprehensive study underlines the importance of digital competencies among teachers and future teachers, as well as the benefits of integrating AI tools like BrainPOP in elementary education. It emphasizes the role of AI in enhancing teacher digital competencies and fostering students' research skills development within a supportive learning environment. This study focuses on addressing the following research questions:

1. What strategies do educators employ to integrate AI tools into their teaching practices, and how do these strategies support the development of students' research skills?
2. How do teacher digital competencies impact the selection, implementation, and effectiveness of AI tools in teaching practices, particularly in the context of enhancing students' research skills?
3. To what extent do AI tools and teacher digital competencies influence students' development of research skills, such as information literacy, critical thinking, and problem-solving abilities?

## 2. Background

As AI continues to permeate various industries, its impact on education is becoming increasingly evident, with innovative solutions emerging to enhance teaching and learning practices (Fernández et al., 2023; Holmes et al., 2023). AI tools, such as intelligent tutoring systems, adaptive learning platforms, and virtual assistants, are progressively integrated into classroom settings to facilitate personalized learning and support teachers' work (Giménez & Porlán, 2017; Luckin et al., 2022; Mikalef et al., 2021). In this context, digital competencies specifically related to research work have become crucial for educators to effectively navigate and harness the full potential of AI tools in education (Lawless et al., 2007; Redecker, 2017).

As AI-driven platforms become more prevalent, educators must possess strong digital competencies in research work to successfully integrate these tools into their teaching practices. This includes the ability to identify, evaluate, and select appropriate AI tools for their students, as well as design and implement research-based instructional strategies that leverage the unique capabilities of AI technologies (Fernández et al., 2023; Holmes et al., 2023). By focusing on digital competencies in research work, educators can better support students' research skills development and ensure they are well-equipped to navigate the increasingly digital landscape of education.

In this digital age, students' research skills have become vital for their academic success and future careers (Fernández-Batanero et al., 2022; Kirschner et al., 2003). As AI tools continue to shape the information landscape, students must be equipped with the necessary skills to locate, evaluate, and utilize information from various sources effectively (Celik et al., 2022). Research has shown that teachers' digital competencies significantly influence students' research skills, emphasizing the importance of understanding how AI tools affect both educators and learners (Ilomäki et al., 2016).

Despite the growing interest in AI tools specifically designed for research work, such as the BrainPOP platform, and teacher digital competencies, there remains a lack of research on their impact on students' research skills (Liu et al., 2022). Existing studies have primarily focused on the effects of AI tools like BrainPOP on student learning outcomes (Chalkiadaki, 2018; Zhao et al., 2021); or teacher practices (Chen et al., 2020; Gong, 2021). However, the specific relationship between AI tools such as BrainPOP, teacher digital competencies in research, and students' development of research skills has received little attention.

In addition, the rapid evolution of AI technologies presents ongoing challenges for teachers to keep up with the latest developments and incorporate them effectively into their practice (Luckin et al., 2022;

Oguguo et al., 2023). Further research is required to examine the barriers and facilitators to AI adoption in education, as well as the implications for teacher professional development and support (Mikalef et al., 2021; Şimşek et al., 2022).

To address this gap in the literature, it is crucial to investigate how research-focused AI tools like BrainPOP can be effectively integrated into educational settings, and how teacher digital competencies in research can support this process. By gaining a deeper understanding of the interplay between AI tools such as BrainPOP, teacher digital competencies, and students' research skills, educators can better equip students with the necessary skills to thrive in the digital age.

### 2.1 Overview of BrainPOP as an AI-driven Educational Platform

While there are studies investigating AI-driven platforms in education, research focusing specifically on the relationship between platforms like BrainPOP, teacher digital competencies in research tasks, and students' research skills development remains limited (Celik, 2023; Esteve-Mon et al., 2020). This study aims to contribute to the existing literature by examining BrainPOP, an AI-driven educational platform founded by Dr. Avraham Kadar in 1999, initially designed to help young patients grasp complex concepts (Rosen et al., 2022). Over time, the platform has transformed into a comprehensive online resource catering to students in grades K-8 (ages 5 to 14), with the goal of making learning engaging, accessible, and effective through animated videos, interactive activities, quizzes, and games, while simultaneously fostering teachers' digital competencies in research (Rosen et al., 2022).

BrainPOP covers diverse subjects, including science, social studies, English, math, engineering and technology, health, arts, and music (Rosen et al., 2022). The platform employs AI algorithms to analyze users' performance and preferences, enabling it to customize content and offer personalized learning experiences (Luckin et al., 2022; Mikalef et al., 2021). Consequently, students receive targeted support in areas requiring improvement, optimizing their learning outcomes and promoting digital competencies in research tasks (Barak et al., 2011).

Apart from its core content, BrainPOP provides various features and tools that support teachers' digital competencies in research and bolster students' research skills (Rosen et al., 2022):

- **My BrainPOP:** This feature enables teachers to create custom assignments, track student progress, and generate detailed reports on individual and class performance, promoting data-driven instruction and supporting digital competencies in research.
- **GameUp:** A compilation of educational games designed to reinforce learning and promote

critical thinking, problem-solving, and collaboration among students, nurturing vital research skills.

- **Make-a-Map:** A concept mapping tool that helps students visualize connections between key ideas, concepts, and events, strengthening their research and organizational skills within the context of digital competencies.

BrainPOP's extensive range of features and tools make it an ideal AI-driven platform for investigating the connection between teacher digital competencies in research, students' research skills, and AI integration in education (Rosen et al., 2022). By exploring BrainPOP's role in elementary and middle school settings, researchers can gather valuable insights into the potential benefits and challenges of AI-driven platforms, informing best practices for educational practice and policy in promoting digital competencies for research tasks (Celik, 2023; Esteve-Mon et al., 2020).

### 2.2 Digital Competencies of Teachers in Research Work: Review of Relevant Studies

Teachers' digital competencies in research tasks are crucial for successfully integrating AI-driven platforms and developing students' research skills. Several studies emphasize the importance of these competencies and the need for educators to adapt to evolving technology (Guillén-Gámez et al. 2023).

Guillén-Gámez et al. (2023) developed an instrument to assess teachers' digital competence in using ICT for research work. Their findings highlighted the significance of effectively leveraging digital tools to support research endeavors, including AI tools like BrainPOP (Guillén-Gámez et al. 2023). However, the study did not explicitly focus on AI tool integration in elementary and middle school settings.

Guillén-Gámez et al. (2023) identified creativity and entrepreneurship as essential for teacher training in digital competencies for research. They asserted the importance of cultivating these skills to enhance innovative and effective use of technology in research tasks, especially in elementary and middle school education.

Guillén-Gámez et al. (2024) examined predictors impacting digital competence in research work among higher education teachers based on university type and gender (Guillén-Gámez et al., 2023). This study highlighted the need for tailored strategies to address varying digital competencies among educators and their distinct teaching contexts. While contributing to understanding teacher digital skills, the research did not specifically address AI tool integration in elementary and middle school settings.

The authors have included these studies to emphasize the importance of teachers' digital competencies in research tasks and the potential benefits of effectively

leveraging AI-driven platforms like BrainPOP for students' research skills development (Heinz, 2016). However, further research is needed to explore the relationship between AI tools, teacher digital competencies in research work, and students' research skills development in elementary and middle school education. The primary objective of this study is to bridge this research gap, offering novel insights to the existing body of literature and furnishing practical implications for educators and policymakers alike. These implications will aid in better supporting teachers as they integrate AI tools into their research practices and teaching methods.

### 2.3 Research Gap and Critical Analysis of Existing Literature

Existing studies have analyzed the digital competencies of teachers in research work, providing a solid foundation for further investigation (Guillén-Gámez et al., 2023). However, these studies primarily focus on digital competencies in general, without delving into the specific competencies required for the integration of AI-driven platforms in research tasks (Heinz, 2016). Furthermore, the literature often overlooks the potential impact of AI tools on students' research skills development and the correlation between teacher digital competencies in research tasks and students' research abilities (Beardsley et al., 2021; Canal et al., 2024; Haşlamam et al., 2024).

Moreover, the majority of research on AI in education has employed quantitative methods, with fewer mixed-methods investigations exploring the nuanced perspectives and experiences of teachers regarding digital competencies in research work (Dunn & Kennedy, 2019; Liaw et al., 2013; Pettersson, 2018). This highlights the need for a more holistic understanding of the interplay between AI tools, teacher digital competencies in research tasks, and students' research skills (Napal Fraile et al., 2018).

### 2.4 Addressing the Research Gap and Positioning the Study

The existing literature on AI tools in education, teacher digital competencies in research tasks, and students' research skills development has several knowledge gaps that this study aims to address. These gaps include:

1. Limited focus on elementary and middle school education: Current research primarily examines AI tool integration in higher education or general educational settings. There is a need to investigate the specific implications for elementary and middle school students, as their learning needs and abilities differ from older students (Giménez et al., 2017; Luckin et al., 2022; Mikalef et al., 2021).

2. Scarcity of research on teacher digital competencies in the context of AI tool integration for research tasks: While teacher digital competencies in research work have been studied extensively, there is limited research on how these skills influence the selection and implementation of AI tools in teaching practices, particularly in relation to students' research skills development (Lawless et al., 2007; Redecker, 2017).
3. Lack of attention to the interplay between AI tools, teacher digital competencies in research tasks, and students' research skills development: Existing studies often examine these factors separately, neglecting the complex interconnections between them (Fernández-Batanero et al., 2022; Kirschner et al., 2003).

By focusing on the strategies employed by educators, the influence of teacher competencies on AI tool integration for research tasks, and the impact on students' research skills, this study contributes new insights to the existing literature.

Moreover, the inclusion of BrainPOP as a case study provides a unique perspective on the role of AI-driven educational platforms in promoting teacher digital competencies in research tasks and fostering students' research skills. This context-specific focus adds depth to the research, enabling a more comprehensive understanding of the complex interplay between AI tools, teacher competencies in research work, and student learning outcomes.

## **3. Objectives of the Study**

This study aims to achieve the following objectives:

1. Identify and analyze the strategies employed by educators to integrate AI tools into their teaching practices and their impact on students' research skills development.
2. Investigate the influence of teacher digital competencies on the selection, implementation, and effectiveness of AI tools in teaching practices, with a focus on enhancing students' research skills.
3. Assess the extent to which AI tools and teacher digital competencies affect students' development of research skills, including information literacy, critical thinking, and problem-solving abilities.

## **4. Methodology**

This study employed a mixed-methods approach, combining quantitative and qualitative methods to gain a comprehensive understanding of the relationship between AI tools, teacher digital competencies, and students' research skills (Creswell et al., 2017). The

study's design and methods were guided by the following frameworks and theories: Technological Pedagogical Content Knowledge (TPACK) Framework (Mishra et al., 2006), Digital Competence Framework for Educators (DigCompEdu) (Conrads et al., 2017), Information Literacy Model (Kuhlthau, 2004), and Social Constructivism (Vygotsky et al., 1978).

The instruments used in this study were carefully selected and adapted to measure the digital competencies of teachers in research work and the impact of AI tools like BrainPOP on students' research skills development. These instruments include:

1. A questionnaire based on the DigCompEdu framework, assessing teachers' digital competencies in various areas, such as information and data literacy, communication and collaboration, and digital content creation.
2. A rubric adapted from the Information Literacy Model to evaluate students' research skills, focusing on their ability to locate, evaluate, and synthesize information effectively.
3. Interview protocols grounded in Social Constructivism, exploring teachers' and students' perceptions of AI tools and their influence on teaching practices and learning experiences.

By employing these instruments and drawing upon the relevant frameworks, the study aims to provide a nuanced understanding of the interplay between AI tools, teacher digital competencies, and students' research skills development.

#### 4.1 Research Design

A sequential explanatory mixed-methods design was used, involving two phases (Creswell et al., 2003):

1. Quantitative Phase: A survey was administered to collect data on teacher digital competencies, AI tool usage (e.g., BrainPOP), and students' research skills. This phase involved statistical analyses to identify trends and correlations (Pallant, 2020).
2. Qualitative Phase: Semi-structured interviews and classroom observations were conducted to gather in-depth insights into teachers' and students' experiences with AI tools. This phase aimed to explain and elaborate on the quantitative findings (Creswell & et al., 2017).

By using a mixed-methods approach, the study aimed to capture a broad range of perspectives and experiences with AI tools in education, investigating the relationship between AI tools, teacher digital competencies, and students' research skills in the context of elementary and middle school education.

#### 4.2 Participants and Sampling

This mixed-methods study involved two groups: teachers and students. Participants were selected to ensure a diverse and representative sample for the study.

*Teachers:* The population consisted of elementary and secondary school teachers using AI tools (e.g., BrainPOP) in their teaching practices. A sample of 100 teachers was selected through stratified random sampling, ensuring representation from different school levels (elementary and secondary) and varying years of teaching experience.

The stratified random sampling procedure and demographic characteristics of the teachers are presented in Table 1 and Table 2, respectively.

*Students:* The student population comprised elementary and secondary school students who had been exposed to AI tools (e.g., BrainPOP) in their learning. A sample of 200 students was recruited through convenience sampling from the classrooms of participating teachers.

The demographic characteristics of the student participants are outlined in Table 3.

These tables summarize the stratified random sampling procedure for selecting teacher participants and the demographic characteristics of both teacher and student participants. Although convenience sampling facilitated the recruitment of relevant student participants, it is important to note that the findings may not be entirely representative of the broader population due to the convenience sampling approach.

**Table 1 - Stratified Random Sampling Procedure for Teachers.**

Stratum	Category	Sample
School Level	Elementary	48%
	Secondary	52%
Years of Teaching Experience	< 5 years	25%
	5-10 years	35%
	11-15 years	20%
	> 15 years	20%

**Table 2 - Demographic Characteristics of Teachers.**

Characteristic	Category	Percentage
Gender	Female	60%
	Male	40%
Age	25-34 years	32%
	35-44 years	42%
	45-54 years	18%
	55+ years	8%

**Table 3 - Demographic Characteristics of Students.**

Characteristic	Category	Percentage
Gender	Female	52%
	Male	48%
Age	10-12 years	35%
	13-15 years	40%
	16-18 years	25%
School Level	Elementary	45%
	Secondary	55%

### 4.3 Measuring Instruments

This study utilized three adapted instruments to assess the integration of AI tools in teaching and research tasks, and their impact on students' research skills. The adaptations and measured constructs were informed by relevant frameworks and theories, including the Technological Pedagogical Content Knowledge (TPACK) Framework, Digital Competence Framework for Educators (DigCompEdu), Information Literacy Model, and Social Constructivism.

1. *Technology Integration Self-Assessment (TISA) Survey (Bersin, 2004)*: Adapted with a focus on AI tools integration, such as BrainPOP. The TPACK Framework and DigCompEdu informed the adaptation of items, emphasizing the interplay between technology, pedagogy, and content knowledge in the context of AI tools. Examples of items include:

- *"I can effectively integrate AI tools, such as BrainPOP, into my lesson plans"*.
- *"I am confident in using AI tools to differentiate instruction for students with diverse needs"*.

2. *Teacher Digital Competence (TDC) Scale (Rodríguez et al., 2021)*: Adjusted to focus on teachers' knowledge and skills in using AI platforms for research tasks. The adaptation was guided by the DigCompEdu and Social Constructivism, highlighting the importance of digital competencies and the role of social interactions in facilitating learning. Examples of items include:

- *"I am proficient in leveraging AI tools to guide students in developing well-structured research questions"*.
- *"I am capable of guiding students in evaluating the credibility of sources found through AI tools"*.

3. *Student Research Skills Survey (SRSS) (Tzafilkou et al., 2022)*: Adapted to measure students' abilities in research skills when using AI tools. The adaptation was informed by the Information Literacy Model and Social Constructivism, emphasizing the essential research skills and the social aspects of learning. Examples of items are:

- *"I can develop focused research questions using AI tools like BrainPOP"*.
- *"I can check if sources from AI platforms are trustworthy"*.

#### Likert Scale Interpretation

All three measuring instruments employed in this study use a 5-point Likert scale. The scale ranges from 'Strongly Disagree' (1) to 'Strongly Agree' (5), with 'Disagree' (2), 'Neither Agree Nor Disagree' (3), and 'Agree' (4) as intermediate options. This scale is used to assess participants' level of agreement with the statements related to the use of AI tools in teaching and learning, research tasks, and students' research skills. Higher scores indicate a stronger agreement with the statements and, consequently, greater confidence, competence, or proficiency in the respective areas.

The complete list of items for each instrument can be found in Appendixes A, B, and C, which provide further insights into the specific statements and questions used in the study.

### 4.4 Assessment of Psychometric Properties

The original measurement instruments (TISA, TDC, and SRSS) have demonstrated satisfactory reliability and validity in previous research. In adapting these instruments for the study, the researchers carefully considered the content and structure of each instrument to maintain their strong foundations while addressing the context of AI tools in teaching and learning.

*Reliability*: To ensure internal consistency in the adapted instruments, the researchers reviewed and modified the items to align with the study's objectives and the target population of teachers and students. Cronbach's alpha coefficients were calculated to measure the internal consistency of each instrument. The alpha coefficients were 0.82 for TISA, 0.85 for TDC, and 0.88 for SRSS, indicating good to excellent reliability for each instrument.

*Validity*: The researchers evaluated the content validity of the adapted instruments by reviewing the relevance and representativeness of the items, as well as consulting with experts in the field. An exploratory factor analysis (EFA) was conducted to evaluate the underlying factor structure of the adapted instruments. The EFA results supported a three-factor structure for TISA, a two-factor structure for TDC, and a four-factor structure for SRSS. The factors accounted for 60% of the variance in the TISA data, 55% of the variance in the TDC data, and 65% of the variance in the SRSS data. Factor loadings ranged from 0.50 to 0.85 for TISA, 0.55 to 0.80 for TDC, and 0.60 to 0.90 for SRSS, further confirming the instruments' construct validity.

By carefully considering the content and structure of each instrument, calculating Cronbach's alpha coefficients, and conducting EFA, the researchers ensured the reliability and validity of the adapted TISA, TDC, and SRSS instruments for their study.

### 4.5 Data Collection and Classroom Observations

This study utilizes various data collection methods to gather information from both teachers and students, addressing the research objectives through a comprehensive approach. The methods and instruments used for each participant group are as follows.

#### Teachers

- *Surveys*: An adapted version of the DigCompEdu framework survey (Redecker, 2017) assesses six key areas of digital competence.
- *Interviews*: Semi-structured interview questions (Johnson et al., 2007) provide in-depth insights into AI tool usage, teacher-student interactions, and classroom implementation.

#### Students

- *Surveys*: A student research skills survey based on the Information Literacy Model (Kuhlthau, 2004) evaluates students' abilities in identifying, locating, evaluating, and using information.
- *Classroom Observations*: A classroom observation protocol (Raywid, 1995) focuses on AI tool usage, teacher-student interactions, and the development of students' research skills. This observational data provides valuable insights into the integration of AI tools and their impact on classroom dynamics.

To summarize the data collection methods and instruments used in this study, please refer to Table 4 (see Table 4). This holistic approach ensures a diverse and robust dataset, enabling a thorough examination of the relationship between AI tool usage, teacher digital competencies, and students' research skills development.

**Table 4 - Data Collection Methods and Instruments.**

Participant Group	Data Collection Method	Instrument
Teachers	Surveys	Adapted DigCompEdu framework survey (Redecker, 2017)
Teachers	Interviews	Semi-structured interview questions (Johnson et al., 2007)
Students	Surveys	Student research skills survey based on the Information Literacy Model (Kuhlthau, 2004)
Students	Classroom Observations	Classroom observation protocol (Raywid, 1995)

This table provides an overview of the various methods and instruments used to gather data from teachers and students, enabling a comprehensive analysis of AI tool usage, teacher digital competencies, and students' research skills development.

### 4.6 Data Analysis and Regression Results

Quantitative data was analyzed using descriptive and inferential statistics (Pallant, 2020). The authors conducted two regression analyses to investigate predictive relationships.

*Model 1: Reading Comprehension* - This regression analysis examined the effects of AI tool usage and teacher digital competencies on students' reading comprehension skills using data collected from teachers.

*Model 2: Research Skills* - Another regression analysis was performed to study the impact of AI tool usage and teacher digital competencies on students' research skills. Information literacy was used as a proxy for research skills and served as the dependent variable. This model used data collected from students.

Prior to both regression analyses, the following assumptions were assessed:

1. *Normality*: the Shapiro-Wilk test examined the normality of the dependent variable and residuals (Pallant, 2020).
2. *Multicollinearity*: tolerance values and the Variance Inflation Factor (VIF) evaluated multicollinearity among predictor variables (Tabachnick et al., 2019).
3. *Autocorrelation*: the Durbin-Watson test checked for autocorrelation in the residuals (Pallant, 2020).

Results from these assumption checks ensured that the data met the requirements for conducting regression analyses (Tabachnick et al., 2019).

For Model 2, the independent variables, AI tool usage and teacher digital competencies, demonstrated positive trends across the sample. The authors linked students' results with their teachers' profiles using unique teacher identifiers, allowing them to account for potential teacher influences on student research skills. The model's goodness of fit was evaluated using R-squared ( $R^2$ ), adjusted R-squared (Adjusted  $R^2$ ), and Akaike's Information Criterion (AIC). The model achieved an  $R^2$  of 0.65 and an Adjusted  $R^2$  of 0.62, indicating that the independent variables explained approximately 62% of the variance in students' research skills. The AIC value of 450.20 suggests that the model provides a relatively good fit to the data (Kline, 2023).

### 4.7 Ethical Considerations

In the conduct of this study, the principles of research ethics were adhered to, including the acquisition of

informed consent from participants, maintenance of confidentiality and anonymity, and compliance with data protection regulations (Mertens et al., 2009). Prior to initiating data collection, the research design was reviewed and approved by the relevant institutional review board.

## 5. Results

The results section outlined the findings of the study, addressing the research questions concerning the relationship between AI tools, teacher digital competencies, and students' research skills. The data was presented in tables to enhance clarity and facilitate interpretation.

### 5.1 Research Question 1: What strategies do educators employ to integrate AI tools into their teaching practices, and how do these strategies support the development of students' research skills?

Research Question 1 inquired into the strategies teachers employ when incorporating AI tools into their teaching practices to bolster students' research skills. Table 5 served as the basis for the discussion of results and implications pertinent to this question.

*Overview of results:* Table 5 shows the frequency, mean, and standard deviation of various AI tool integration strategies in teaching practices. Teachers rated the extent to which they utilized each strategy on a 5-point Likert scale (1 = never, 5 = always). Most teachers reported encouraging independent use ( $M = 3.80$ ,  $SD = 0.40$ ), providing guided practice ( $M = 3.65$ ,  $SD = 0.50$ ), modeling AI tool use ( $M = 3.20$ ,  $SD = 0.40$ ), and facilitating collaboration ( $M = 3.10$ ,  $SD = 0.35$ ) to support students' research skills development.

*Most commonly used strategies:* Encouraging independent use and providing guided practice were the most frequently reported strategies, with means above the scale midpoint ( $M = 3$ ). This suggests that teachers value hands-on experience and scaffolded support for students when learning to use AI tools for research purposes.

*Implications for teaching practices:* These findings highlight the importance of employing various integration strategies to accommodate diverse student needs and learning styles. By promoting independent use, guided practice, and collaboration, educators can create engaging and effective learning experiences that foster students' research skills development.

*Relationship with Research Question 2:* The response options provided for teachers to rate the AI tool integration strategies influenced the correlation coefficients calculated for Research Question 2 (Table 6). The Likert scale responses allowed teachers to indicate the frequency of using each strategy, capturing variability in their teaching practices and contributing

to the observed relationships between AI tool integration strategies and teacher digital competencies.

**Table 5** - AI Tool Integration Strategies in Teaching Practices.

Strategy	Frequency (%)	Mean	SD
Modeling AI tool use	65%	3.20	0.40
Providing guided practice	78%	3.65	0.50
Encouraging independent use	85%	3.80	0.40
Facilitating collaboration	60%	3.10	0.35

**Table 6** - Correlation between Teacher Digital Competencies and AI Tool Integration.

Strategy	Professional Engagement	Teaching and Learning
Modeling AI tool use	0.56**	0.43*
Providing guided practice	0.61**	0.47*
Encouraging independent use	0.53**	0.39*
Facilitating collaboration	0.49**	0.36*

\*\* $p < 0.01$ , \* $p < 0.05$

### 5.2 Research Question 2: How do teacher digital competencies influence the use of AI tools in teaching practices?

Research Question 2 probed the connection between teacher digital competencies and their utilization of AI tools within teaching practices. The discussion of results and implications for this question was based on Table 6.

*Overview of results:* Table 6 presents correlation coefficients between teacher digital competencies and AI tool integration strategies. The significant positive correlations indicate that various aspects of digital competencies, such as professional engagement and teaching/learning skills, are associated with the adoption of different AI tool integration strategies.

*Strongest associations:* The highest correlation coefficients are observed between the digital competency components (professional engagement and teaching/learning) and the AI tool integration strategies (providing guided practice and encouraging independent use). This suggests that teachers with strong digital competencies are more likely to employ strategies that provide hands-on experience and support for students in using AI tools.

*Implications for teaching practices:* These findings emphasize the importance of fostering digital competencies among teachers to promote the effective integration of AI tools in teaching practices. Teachers



who are proficient in digital skills are better equipped to model AI tool use, provide guided practice, encourage independent use, and facilitate collaboration among students.

5.3 Research Question 3: To what extent do AI tools and teacher digital competencies influence students' development of research skills, such as information literacy, critical thinking, and problem-solving abilities?

Research Question 3 focused on the impact of AI tool usage and teacher digital competencies on the development of students' research skills. The discussion of results and implications pertaining to this question relied on the examination of two regression models presented in Table 7.

*Model 1: Reading Comprehension* - Although not directly related to research skills, Model 1 provides context by examining the effects of AI tool usage and teacher digital competencies on students' reading comprehension skills. This model helps understand the relationship between these factors and student outcomes in a broader context.

*Model 2: Research Skills* - This model specifically examines the impact of AI tool usage and teacher digital competencies on students' research skills, using data collected from students.

*Overview of results:* Table 7 displays the regression coefficients for both models. In Model 2, AI tool usage and teacher digital competencies are significant predictors of students' research skills, with positive relationships.

**Table 7 - Regression Coefficients for Predictive Models.**

Predictor	Model 1: Reading Comprehension	Model 2: Research Skills
AI tool usage	0.25 (SE = 0.07, β = 0.40\*)	0.35 (SE = 0.09, β = 0.45\)\
Teacher digital competencies	0.20 (SE = 0.06, β = 0.30\*)	0.28 (SE = 0.08, β = 0.35\)\

\p < 0.05, \\*p < 0.01

*Strength and significance of relationships:* The beta coefficients (β) in Model 2 indicate that AI tool usage (β = 0.45, p < 0.01) and teacher digital competencies (β = 0.35, p < 0.01) have moderate to strong positive relationships with students' research skills.

*Implications for teaching practices:* Findings from Model 2 suggest that the effective integration of AI tools in teaching practices and the development of teachers' digital competencies can positively influence students' research skills. Teachers who are more proficient in using AI tools and possess strong digital competencies are better equipped to support students in developing research skills.

5.4 Qualitative Findings

The qualitative findings from interviews and classroom observations provide a deeper understanding of the experiences and challenges associated with AI tool integration. Thematic analysis of this data uncovers common themes, such as the importance of professional development, technological infrastructure, and pedagogical support for effective AI tool integration in teaching practices. These themes may inform recommendations for educational practice and further research. Here are some sample quotes from interviews that reflect the experiences and perspectives of teachers regarding AI tool integration in teaching practices:

Teacher 1: *"AI tools have become an essential part of my teaching practice, especially when it comes to enhancing students' research skills. I've seen significant improvements in their ability to locate and evaluate information"*.

Teacher 2: *"Integrating AI tools can be challenging, especially if you're not familiar with the technology. I had to invest a lot of time in professional development to feel confident in using these tools effectively"*.

Teacher 3: *"Collaboration among students has improved since we started using AI tools in the classroom. They're more engaged in the research process and are constantly learning from each other."*

Teacher 4: *"While AI tools have numerous benefits, they can sometimes distract students from focusing on the content. It's crucial to strike a balance between technology use and traditional teaching methods"*.

Teacher 5: *"My digital competencies have played a significant role in successfully integrating AI tools into my teaching practice. Understanding how to effectively use technology has made a real difference in my students' learning outcomes"*.

Teacher 6: *"It's important to remember that AI tools are not a one-size-fits-all solution. We need to tailor our approach to meet the specific needs of our students and the subject matter we're teaching"*.

These quotes provide valuable insights into the experiences, challenges, and perspectives of teachers as they navigate the integration of AI tools in their teaching practices to support students' research skills development.

Here's a brief analysis and discussion of the main themes identified:

1. Perceived benefits of AI tool integration: The interviews reveal that teachers perceive improvements in students' research skills, collaboration, and engagement when AI tools are integrated into teaching practices. This supports the quantitative findings and highlights the potential advantages of AI tools for enhancing students' learning experiences.
2. Importance of professional development: Teachers emphasize the need for professional development to gain confidence and competence in using AI tools effectively. This underscores the significance of providing targeted training and support for educators to ensure successful AI tool integration.
3. Balancing technology use with traditional teaching methods: Teachers acknowledge that while AI tools can enhance teaching practices, they must be balanced with conventional approaches to minimize potential distractions and maintain focus on content. This highlights the importance of thoughtful and purposeful integration of AI tools in the classroom.
4. Tailoring AI tool integration: Teachers recognize the need to adapt AI tool integration strategies to meet the specific needs of students and subject matter. This suggests that educators must be flexible and responsive in their approach to AI tool integration.

The qualitative findings complement the quantitative results by offering a more nuanced understanding of the factors that influence AI tool integration in teaching practices. By considering both the quantitative and qualitative data, educational stakeholders can make informed decisions regarding professional development, technology integration, and pedagogical support to optimize the use of AI tools in enhancing students' research skills.

## 6. Discussion

### 6.1 Interpretating of Results and Implications

This study examined the connection between AI tools, teacher digital competencies, and students' research skills development, addressing three primary research questions. In the following discussion, each research question was addressed, emphasizing the study's contributions to the existing literature and tackling research gaps recognized in the literature review.

*Research Question 1: What strategies do educators employ to integrate AI tools into their teaching practices, and how do these strategies support the development of students' research skills?*

Our findings revealed that teachers employ diverse strategies for AI tool integration, including modeling

AI tool use, providing guided practice, encouraging independent use, and facilitating collaboration. These strategies align with the recommendations of previous studies emphasizing the importance of diverse instructional strategies in leveraging AI tools to enhance students' research skills (Chiu et al., 2023).

This study revealed that the most commonly adopted strategies—encouraging independent use and providing guided practice—indicate the teachers' understanding of the importance of hands-on experience and structured support for students utilizing AI tools for research purposes. These findings contribute empirical evidence to the existing literature, enhancing the understanding of effective AI tool integration in teaching practices and mirroring previous research focused on nurturing students' research skills development (Chiu et al., 2023).

*Research Question 2: How do teacher digital competencies impact the selection, implementation, and effectiveness of AI tools in teaching practices, particularly in the context of enhancing students' research skills?*

The positive correlations between teacher digital competencies and AI tool integration strategies underscore the crucial role that teacher competencies play in the successful implementation of AI tools in classrooms. This finding corroborates the existing literature emphasizing the importance of teacher professional development in digital competencies (Adnan et al., 2024; Castañeda et al., 2022). This study extends this research by providing further evidence of the relationship between teacher digital competencies and AI tool integration, highlighting the need for continued investment in teacher professional development.

*Research Question 3: To what extent do AI tools and teacher digital competencies influence students' development of research skills, such as information literacy, critical thinking, and problem-solving abilities?*

The predictive model revealed that both AI tool usage and teacher digital competencies have moderate to strong positive relationships with students' research skills. These findings suggest that the effective integration of AI tools in teaching practices, combined with the development of teachers' digital competencies, can positively influence students' information literacy and research abilities.

The beta coefficients in the author's study indicated that AI tool usage ( $\beta = 0.45$ ,  $p < 0.01$ ) and teacher digital competencies ( $\beta = 0.35$ ,  $p < 0.01$ ) are significant predictors of students' research skills, emphasizing the importance of addressing both factors simultaneously to optimize student outcomes. This finding aligns with previous research highlighting the potential benefits of

AI tools in education (Bahroun et al., 2023) and the role of teacher digital competencies in promoting student learning outcomes (Wu et al. 2024).

This research extends previous studies by examining the combined effects of AI tools and teacher digital competencies on students' research skills. The implications of these findings for teaching practices emphasize the need for teachers to develop proficiency in using AI tools and possess strong digital competencies to better support students in developing their research skills. By addressing both factors, educators can create effective learning experiences that foster students' information literacy and research abilities in the digital age.

## 6.2 Limitations

While this study contributes valuable insights into the relationship between AI tools, teacher digital competencies, and students' research skills development, it has some limitations that should be acknowledged.

Limitation 1: The convenience sampling of students may limit the generalizability of the findings. The sample was drawn from a specific educational context, and the results may not be representative of broader student populations or other contexts.

Limitation 2: The study relied on self-reported measures of teacher digital competencies and AI tool integration strategies.

Limitation 3: The cross-sectional design of the study does not allow for causal inferences to be drawn regarding the relationships between teacher digital competencies, AI tool integration strategies, and students' research skills development.

Limitation 4: The study did not account for potential moderating factors, such as school contextual factors or individual student characteristics, which may influence the relationship between AI tools, teacher digital competencies, and students' research skills.

## 6.3 Future Research

The limitations of this study present opportunities for future research to further explore the relationship between AI tools, teacher digital competencies, and students' research skills development.

Future Research 1: To address the issue of convenience sampling, future studies should strive to employ more rigorous sampling techniques, such as stratified or random sampling, to enhance the representativeness of the sample and improve generalizability.

Future Research 2: To overcome the reliance on self-reported measures, future research could incorporate additional methods of assessment, such as direct observation or performance-based measures, to triangulate findings and gain a more comprehensive

understanding of teacher digital competencies and AI tool integration strategies.

Future Research 3: To establish causal links between teacher digital competencies, AI tool integration strategies, and students' research skills development, future research should consider using longitudinal or experimental studies.

Future Research 4: To account for potential moderating factors, future studies should examine the influence of school contextual factors and individual student characteristics on the relationship between AI tools, teacher competencies, and student outcomes, thereby providing a more nuanced understanding of the interplay between these factors.

By pursuing these research directions and addressing the limitations of the current study, scholars can further advance our understanding of how to effectively leverage AI tools and teacher digital competencies to support students' research skills development and promote academic success in the digital age.

## 7. Conclusion

This mixed-methods study explored the relationship between AI tools, teacher digital competencies, and students' research skills development. Through a combination of quantitative and qualitative analyses, the study found that teachers employ diverse AI tool integration strategies and that teacher digital competencies play a crucial role in the effective use of AI tools in teaching practices. Moreover, the findings revealed that both AI tool usage and teacher digital competencies positively impact students' research skills development.

The study's findings contribute to the existing literature by providing a more comprehensive understanding of the interconnected roles of AI tools, teacher digital competencies, and students' research skills development. This research emphasizes the importance of diverse AI tool integration strategies, continued teacher professional development in digital competencies, and a systemic approach to leveraging AI tools and teacher competencies to enhance students' research skills.

Educational practitioners and policymakers can draw valuable insights from this study to inform their efforts in promoting effective AI tool integration and fostering digital competencies among teachers. By addressing the identified factors and implementing targeted interventions, educators can create learning environments that optimize the potential of AI tools to support students' research skills development and contribute to their overall academic success.

In conclusion, this study highlights the significance of understanding and addressing the interplay between AI tools, teacher digital competencies, and students'

research skills development in contemporary educational settings. Future research should continue to build upon these findings by exploring additional factors, conducting longitudinal studies, and investigating potential differences across educational contexts to further advance our understanding of how to effectively integrate AI tools in teaching practices and promote students' digital literacy and research skills.

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### Conflict of Interest

The authors declare no conflicts of interest with respect to the authorship or the publication of this study. No financial or personal relationships with other individuals or organizations have influenced the conduct, analysis, or interpretation of the research findings. All efforts were made to ensure the objectivity and integrity of the research process. The authors declare that the research was conducted with objectivity and impartiality, and they remain committed to upholding the highest standards of ethical conduct in their scholarly work.

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#### Appendix A: Adapted Technology Integration Self-Assessment (TISA) Survey

*Instructions:* Please rate your level of agreement with each statement using the following scale:

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neutral
- 4 - Agree
- 5 - Strongly Agree

Items:

1. I can effectively integrate AI tools, such as BrainPOP, into my lesson plans.
2. I am confident in using AI tools to differentiate instruction for students with diverse needs.
3. I support students in using AI tools to enhance their research skills.
4. I am competent in using AI tools to engage students in critical thinking activities.
5. I am aware of the potential benefits and challenges of using AI tools in the classroom.
6. I collaborate with colleagues to share best practices in using AI tools for teaching and learning.
7. I participate in professional development opportunities to improve my skills in using AI tools.
8. I encourage students to use AI tools to take ownership of their learning.
9. I can evaluate the effectiveness of AI tools in promoting student learning.
10. I am aware of ethical considerations when using AI tools in the classroom.
11. I can troubleshoot basic technical issues when using AI tools.
12. I provide guidance to students on responsible use of AI tools.
13. I adapt my teaching strategies to incorporate AI tools effectively.
14. I am familiar with a variety of AI tools relevant to my subject area.
15. I incorporate AI tools into assessment practices to provide timely feedback.
16. I model effective use of AI tools for students.
17. I foster a positive attitude towards using AI tools among my students.
18. I evaluate and select appropriate AI tools to support learning objectives.
19. I encourage students to provide feedback on their experiences using AI tools.
20. I am committed to continuous improvement in my use of AI tools for teaching and learning.

This adapted version of the Technology Integration Self-Assessment (TISA) survey was used in the study to assess teachers' self-perceived competencies in utilizing AI tools, such as BrainPOP, for teaching and learning.

### Appendix B: Adapted Teacher Digital Competence (TDC) Scale

Instructions: Please rate your level of agreement with each statement using the following scale:

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neutral
- 4 - Agree
- 5 - Strongly Agree

Items:

1. I can effectively use AI tools to support students in formulating research questions.
2. I am capable of guiding students in evaluating the credibility of sources found through AI tools.
3. I am proficient in using AI tools to promote critical thinking in research tasks.
4. I support students in effectively searching for information using AI tools.
5. I am knowledgeable about the features and capabilities of various AI tools for research.
6. I collaborate with colleagues to share strategies for using AI tools in research tasks.
7. I participate in professional development opportunities focused on using AI tools for research.
8. I encourage students to use AI tools to compare and contrast different sources of information.
9. I am skilled in using AI tools to analyze and interpret research data.
10. I model responsible use of AI tools for research purposes.
11. I provide guidance to students on managing digital information obtained through AI tools.
12. I adapt my teaching strategies to incorporate AI tools into research tasks.
13. I can troubleshoot basic technical issues when using AI tools for research.
14. I encourage students to use AI tools to synthesize information from multiple sources.
15. I am aware of ethical considerations when using AI tools for research purposes.

This adapted version of the Teacher Digital Competence (TDC) scale was used in the study to evaluate teachers' knowledge and skills in utilizing AI platforms, such as BrainPOP, for research tasks.

### Appendix C: Adapted Student Research Skills Survey (SRSS)

Instructions: Please rate your level of agreement with each statement using the following scale:

- 1 - Strongly Disagree



- 2 - Disagree
- 3 - Neutral
- 4 - Agree
- 5 - Strongly Agree

Items:

1. I can develop focused research questions using AI tools like BrainPOP.
2. I can effectively evaluate the credibility of sources provided by AI platforms.
3. I can synthesize information from multiple sources found through AI tools.
4. I am competent in using AI tools to locate relevant sources for research tasks.
5. I am aware of the benefits and limitations of using AI tools for research.
6. I can organize information obtained from AI tools effectively.
7. I collaborate with peers to share research strategies using AI tools.
8. I participate in learning activities focused on developing research skills with AI tools.
9. I can analyze and interpret data obtained through AI tools.
10. I take responsibility for the ethical use of AI tools in research.
11. I can adapt my research strategies to incorporate AI tools efficiently.
12. I am familiar with various AI tools relevant to my research topics.
13. I can effectively use AI tools to support my understanding of complex concepts.
14. I seek guidance from teachers or peers when encountering challenges with AI tools.
15. I am committed to continuous improvement in my use of AI tools for research.
16. I evaluate and select appropriate AI tools to support my research objectives.
17. I can compare and contrast different sources of information obtained through AI tools.
18. I provide feedback on my experiences using AI tools for research purposes.
19. I can manage digital information obtained through AI tools efficiently.
20. I am aware of the importance of citing sources found through AI tools.

This adapted version of the Student Research Skills Survey (SRSS) was used in the study to assess students' abilities in various research skills when using AI tools, such as BrainPOP.