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Systematic Review: Integrating Technology-Enhanced Design-Thinking into Civic Education (Works In Progress)

Mrs. Munirah Almutairi, North Carolina State University at Raleigh

PhD Student in Learning and Teaching in STEM - Engineering and Technology Education

Dr. Tamecia R. Jones, North Carolina State University at Raleigh

Tamecia Jones is an assistant professor in the STEM Education Department at North Carolina State University College of Education with a research focus on K-12 engineering education, assessment, and informal and formal learning environments. She is a grad

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Abstract

Background: Integrating design-thinking methodologies into civic education, supported by technology, has the potential to transform traditional learning environments by enhancing student engagement and improving learning outcomes. As civic education aims to equip students with the skills and knowledge necessary for active societal participation, understanding the effectiveness and implementation of design-thinking approaches is essential. However, existing literature lacks a comprehensive analysis of how technology facilitates this integration and its impact on education.

Purpose: This mixed-methods systematic review investigates the effectiveness of integrating design-thinking into civic education through technology. Recognizing the increasing importance of fostering civic competencies alongside technical skills in students, innovative educational approaches are necessary.

Methods: We conducted a comprehensive search of relevant databases, including EBSCO's Academic Search Complete, ProQuest Central, and Web of Science, focusing on studies published in the last decade. The review synthesizes findings from 60 studies conducted across K-12 and higher education settings.

Results: Integrating design-thinking into civic education through technology enhances student engagement and learning outcomes. Digital tools bridge the gap between theoretical education and real-world application, fostering civic participation. They also facilitate collaborative learning experiences, enabling students to work on civic projects and engage with communities. Aligning technology with pedagogical strategies creates interactive learning environments that enrich civic education. Quantitative studies confirm that technology integration leads to improved civic understanding, motivation, and participation, with AI-driven chatbots and immersive virtual reality demonstrating positive effects on engagement and learning outcomes.

Conclusions: Integrating design-thinking into civic education using technology offers demonstrable benefits for student engagement and learning outcomes. Practical recommendations for educators and policymakers are provided, along with suggestions for future research. This study contributes to the field by offering a consolidated understanding of best practices and innovative strategies for integrating design-thinking into civic education through technology.

Keywords**:** Design-thinking, civic education, technology integration, student engagement, learning outcomes, K-12 education, higher education, gamification, participatory learning, systematic review.

Introduction

Civics education has dropped in priority due to educational reforms over the last few decades where accountability measures are tied to math, reading, and science only, resulting in less classroom instruction and thus decreased basic civics understanding and engagement [1]. Yet, civic education is increasingly enhanced through the integration of technology and design-thinking methodologies, fostering student engagement and critical thinking. Project RISE considers civic education the process of enabling students to have civic knowledge, civic skills, and civic dispositions and actions [2]. Civics education, within the context of Project RISE, is the active, informed, and justice-oriented participation of individuals in their communities and democratic institutions. It encompasses the development of civic knowledge, skills, and dispositions that enable individuals to critically analyze societal challenges, collaborate across disciplines, and employ problem-solving frameworks—such as engineering design thinking—to address real-world issues. Traditionally taught in government, history, or social studies courses, the three dimensions of civic education are described in the Table 1.

Table 1

Dimensions of Civics Education

Dimension	Aspects
Civics Knowledge	1. Understanding democratic principles, institutions, and processes (e.g., voting rights, governance structures, and constitutional protections). 2. Awareness of historical and contemporary issues related to social justice, equity, and policy-making. 3. Recognition of how local, national, and global contexts shape civic life.
Civic Skills	1. Inquiry and Critical Thinking: Applying frameworks like the RISE Inquiry Model to analyze problems, assess evidence, and formulate reasoned conclusions. 2. Collaboration and Communication: Engaging in civil discourse, deliberation, and community-based problem-solving. 3. Engineering Design Thinking: Using structured methodologies to define civic problems, develop creative solutions, and evaluate the feasibility and impact of interventions
Civic Dispositions and Actions	1. Commitment to ethical responsibility, civic agency, and democratic participation. 2. Engagement in authentic civic actions, such as community organizing, advocacy, policy analysis, and technological innovation for public good. 3. Willingness to challenge systemic inequalities by applying interdisciplinary approaches, particularly in justice-centered areas such as health equity, environmental sustainability, economic justice, and urban development.

Projects like RISE utilize engineering design and design thinking to address community issues, promoting civic purpose and empathy among students [2]. Additionally, civic action research encourages youth to engage in their communities, creating critical ecosystems of civic learning that extend beyond traditional classroom settings [3]. Furthermore, digital tools facilitate critical thinking and citizen participation, transforming students into more active and responsible citizens [4]. These innovative approaches collectively highlight the potential of technology in enriching civic education and preparing informed citizens.

The aim of this mixed-methods systematic review is to evaluate the effectiveness of integrating design-thinking enhanced by technology in civic education to enhance student engagement and learning outcomes. By examining existing research, this review seeks to highlight current trends, such as the use of gamified elements and collaborative tools, while also identifying significant gaps, particularly in long-term efficacy studies. The findings from this review will offer insights for educators, curriculum developers, and policymakers to better implement technology-enhanced practices within civic education. This review systematically analyzes peer-reviewed studies published over the last decade, focusing on both K-12 and higher education settings. A range of research designs including qualitative, quantitative, and mixed-method studies were included to provide a comprehensive view of how technology-supported design-thinking approaches influence student outcomes in civic education. By using a structured methodology, this review ensures that only relevant studies are considered, enabling a thorough synthesis of the evidence.

Guided by the following research questions, this review explores the relationship between technology integration and design-thinking in civic education: (1) How effective is the integration of design-thinking into civic education using technology in enhancing student engagement and learning outcomes? (2) What role does specific technology play in supporting design-thinking within civic education?

Methodology

This systematic review was conducted to evaluate the effectiveness of integrating design-thinking with technology in civic education to enhance student engagement and learning outcomes. This systematic review was conducted following the guidelines provided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement to ensure a transparent and comprehensive reporting process [5]. PRISMA enhances clarity and comprehensiveness in reporting systematic reviews, which is crucial for publication readiness [6]. The review followed the SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research Type) framework to structure the search strategy, eligibility criteria, and study selection process. The SPIDER framework was chosen for its suitability in identifying relevant qualitative and mixed-method studies, which align with the objectives of this review [7]. The SPIDER framework offers significant benefits by enhancing the relevance and efficiency of literature searches, improving the study selection process, providing flexibility for mixed-methods research, and highlighting the need for better indexing practices. These advantages can contribute to a more robust and focused qualitative review [7]. The Covidence software was

utilized for screening, data extraction, and managing references throughout the review process. The use of Covidence as an automation tool in systematic reviews can lead to increased efficiency, improved accuracy, streamlined workflows, enhanced collaboration, comprehensive data management, and better integration of processes. These benefits ultimately contribute to the production of high-quality evidence synthesis [8].

Literature mapping

The literature mapping process adhered to an adapted version of the PRISMA checklist [5]. Figure 1 (below) illustrates the stages of identifying, cataloging, and appraising the literature included in this review. The process began with an extensive search across multiple databases, yielding [4723] initial articles. These were narrowed down through a multi-phase screening and evaluation process. Following the PRISMA guidelines, the inclusion and exclusion of studies were based on a multi-phase screening process, starting with the initial search results and proceeding through several stages of refinement. After the initial identification of [4723] articles, duplicates were removed, and studies were assessed for relevance based on titles and abstracts. Studies that did not meet the inclusion criteria, such as those outside the defined population (K-12 or higher education students), or those that did not integrate both design-thinking methodologies and technology in civic education, were excluded. In the full-text screening phase, studies that did not align with the specific objectives of this review, or did not have appropriate methodologies or outcomes related to student engagement and learning in civic education, were further excluded.

The articles included in this review were assessed by the members of the research team based on several criteria to ensure their relevance and quality. First, the clarity of the study's problem, purpose, or aim was evaluated to confirm alignment with the objectives of this review. Second, the relevance of the study to the review's focus was considered, specifically whether it explicitly addressed the integration of design-thinking methodologies with technology in civic education contexts. Third, the methodological rigor of the studies was assessed, ensuring that data collection procedures were clearly described and appropriate for the study's aims. Fourth, the analytical approach was examined to determine if the information and methods of data analysis were suitable for addressing the research questions or objectives. Fifth, the sampling strategies employed in the studies were reviewed to ensure they were appropriate and representative of the target populations, specifically K-12 and higher education students. Finally, the outcomes and measures were scrutinized to verify that they were sufficiently defined and measured, particularly regarding their relevance to student engagement and learning outcomes within the context of civic education.

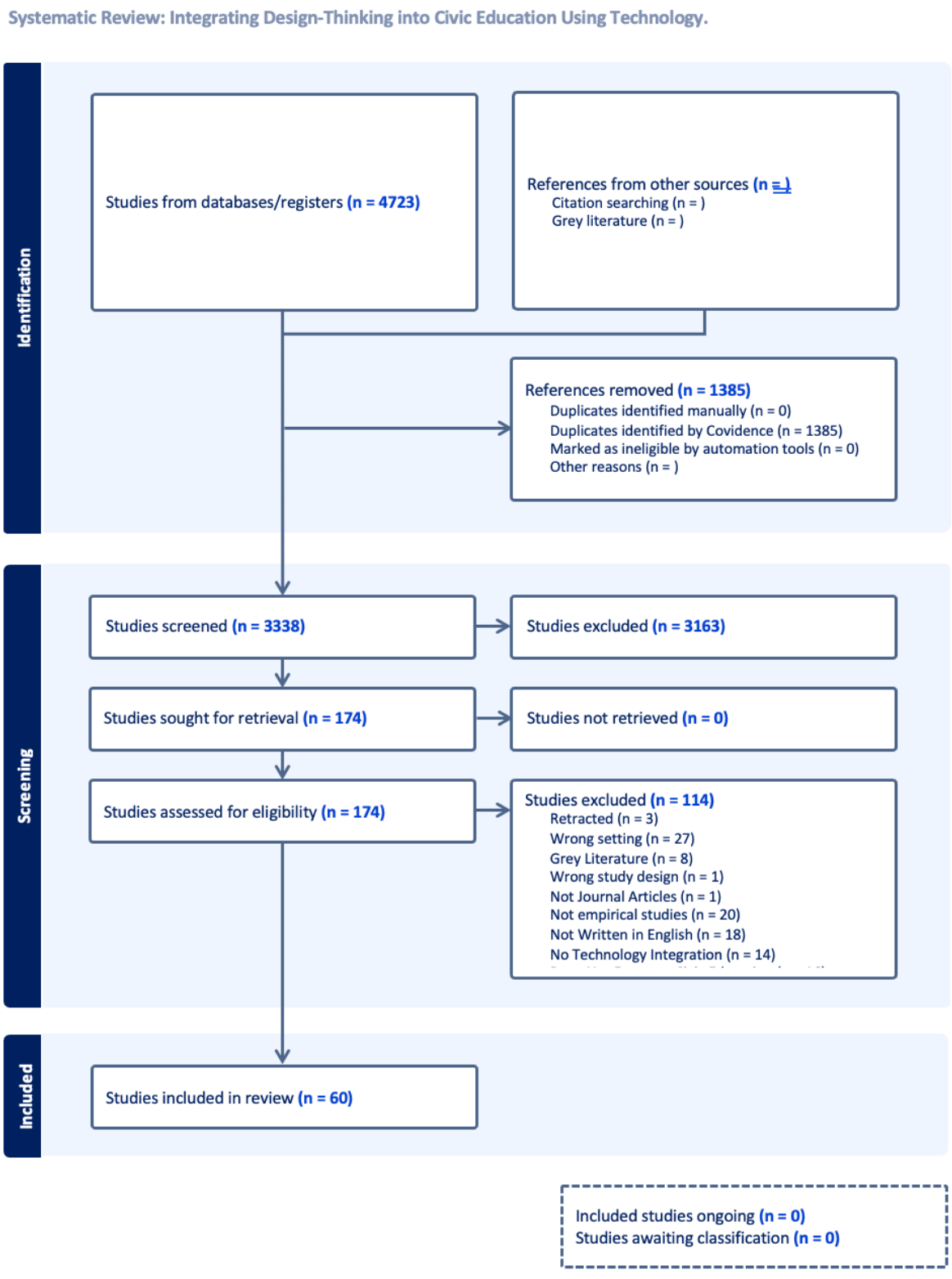

Figure 1: PRISMA Flow Diagram Depicting the Literature Mapping and Study Selection Process

The final dataset of studies included in this review comprises a diverse range of methodologies to ensure comprehensive insights into the integration of design-thinking and technology in civic education. The distribution of study types includes 19 qualitative studies, 20 quantitative studies, and 21 mixed-methods studies. As shown in Figure 2, this balanced representation across different methodologies highlights the diversity in research approaches used to explore the integration of design-thinking with technology in civic education.

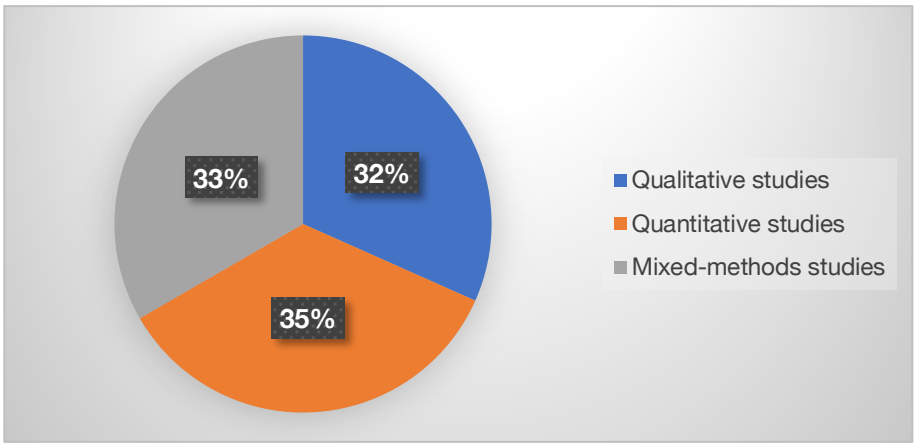

Figure 2: Distribution of Study Types (Qualitative, Quantitative, and Mixed-Methods)

Setting inclusion criteria and identifying sources

To ensure a rigorous and comprehensive review, this study employed inclusion criteria guided by the SPIDER framework [7]. The selected studies had to meet specific criteria across five dimensions. First, the Sample (S) was limited to studies involving K-12 or higher education students, with those focusing on non-educational settings or general adult populations excluded. Second, the Phenomenon of Interest (PI) focused on the integration of design-thinking methodologies with technology in civic education contexts. Studies without a clear connection to both design-thinking and civic education were deemed ineligible. Third, a wide range of Designs (D) was considered, including qualitative, quantitative, mixed-methods, case studies, and experimental designs, provided their methodologies were clearly described. Fourth, the Evaluation (E) focused on outcomes related to student engagement and learning within civic education, excluding studies that evaluated unrelated outcomes. Finally, the Research Type (R) was restricted to empirical studies, encompassing qualitative, quantitative, and mixed-methods research, ensuring a robust and evidence-based review.

As with many systematic reviews, there may be a potential bias towards studies that only report positive outcomes. This is a common challenge in educational research, where studies showcasing successful integration of technology or design-thinking methodologies may be more likely to be published. While efforts were made to ensure the selection of a diverse range of studies, the possibility of publication bias toward positive findings should be considered when interpreting the results. Additionally, the search focused on studies published within the last 10 years to ensure up-to-date and relevant findings related to the integration of design-thinking with technology in civic education.

A systematic search was conducted in EBSCO's Academic Search Complete, ProQuest Central, and Web of Science databases. Boolean operators were used to combine key terms across four major concept blocks: design-thinking, civic education, K-12/higher education, and technology. The Table 2 below outlines the Boolean search strings used for each database.

Table 2:

Boolean Search Strategy and Database Results

Search Combination	Boolean Search String
DesignThinking + Civic Education + K-12 and Higher education	("design thinking") AND (Civic* OR "social studies" OR "government education" OR "citizenship education" OR "democracy education" OR "service learning") AND (kindergarten OR "elementary school" OR "middle school" OR "high school" OR "1st grade" OR "grade 1" OR "2nd grade" OR "3rd grade" OR "grade 3" OR "4th grade" OR "grade 4" OR "5th grade" OR "grade 5" OR "6th grade" OR "grade 6" OR "7th grade" OR "grade 7" OR "9th grade" OR "grade 9" OR "10th grade" OR "grade 10" OR "11th grade" OR "grade 11" OR "12th grade" OR "grade 12" OR "secondary education" OR "higher education" OR "college" OR "university" OR "undergraduate" OR "graduate" OR "post-graduate education")
Civic Education + K-12 and Higher Education + Technology	(Civic* OR "social studies" OR "government education" OR "citizenship education" OR "democracy education" OR "service learning") AND (kindergarten OR "elementary school" OR "middle school" OR "high school" OR "1st grade" OR "grade 1" OR "2nd grade" OR "3rd grade" OR "grade 3" OR "4th grade" OR "grade 4" OR "5th grade" OR "grade 5" OR "6th grade" OR "grade 6" OR "7th grade" OR "grade 7" OR "9th grade" OR "grade 9" OR "10th grade" OR "grade 10" OR "11th grade" OR "grade 11" OR "12th grade" OR "grade 12" OR "secondary education"OR "secondary education" OR "higher education" OR "college" OR "university" OR "undergraduate" OR "graduate" OR "post-graduate education") AND (tech* OR AI OR "artificial intelligence" OR VR OR "virtual reality")
Design Thinking + K-12 and Higher Education + Technology	("design thinking") AND (kindergarten OR "elementary school" OR "middle school" OR "high school" OR "1st grade" OR "grade 1" OR "2nd grade" OR "3rd grade" OR "grade 3" OR "4th grade" OR "grade 4" OR "5th grade" OR "grade 5" OR "6th grade" OR "grade 6" OR "7th grade" OR "grade 7" OR "9th grade" OR "grade 9" OR "10th grade" OR "grade 10" OR "11th grade" OR "grade 11" OR "12th grade" OR "grade 12" OR "secondary education"OR "secondary education" OR "higher education" OR "college" OR "university" OR "undergraduate" OR "graduate" OR "post-graduate education") AND (tech* OR engineering OR AI OR "artificial intelligence" OR VR OR "virtual reality")

Result and Discussion

Figure 3 provides an overview of the geographic distribution of studies included in this systematic review. The United States is the most represented country, contributing 24 studies, reflecting its significant focus on integrating design-thinking into civic education using technology. Indonesia follows with eight studies, showcasing a growing interest in this area in Southeast Asia. China contributed four studies, while Turkey accounted for five studies, indicating a moderate level of research activity in these regions. Other countries with multiple contributions include Taiwan and Spain, each with three studies, and Denmark with two studies. Several countries, including Saudi Arabia, Brazil, Japan, Italy, and Canada, had a single study each, highlighting their emerging engagement in this field. This distribution underscores the global interest in the topic while also revealing significant gaps in research from other parts of the world, particularly in regions such as Africa and South America, aside from Brazil.

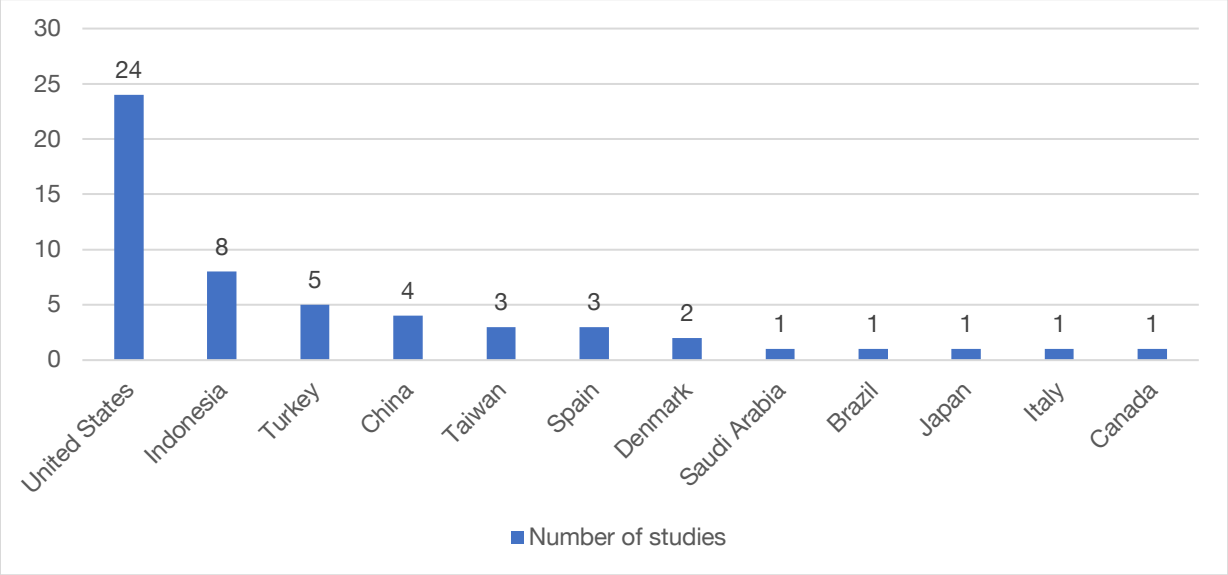

Figure 3: Geographic Distribution of Studies on Design-Thinking and Technology in Civic Education

The studies reviewed indicate a significant focus on K-12 education, with 40 studies, compared to 20 in higher education. Out of the studies reviewed, 67% focused on K-12 education, while 33% focused on Higher Education.This disparity suggests a greater emphasis on integrating technology within K-12 settings. The findings highlight that innovative technological applications, such as web-based GIS modules, social media platforms, and immersive virtual reality, have been effectively utilized to enhance civic engagement and education across both educational levels. These technologies have demonstrated positive impacts on students' understanding, motivation, and participation in civic activities. The higher number of studies in K-12 education may reflect a broader interest in exploring and implementing technological solutions to address diverse learning needs and promote active citizenship among younger students.

The findings reveal a diverse range of technological tools used in the studies reviewed. The most prevalent tool is the Interactive Virtual Learning Environment, with 17 studies highlighting its significant role in civic education. This is followed by Social Network Analysis (SNA) with 14 studies, emphasizing its use in collaborative learning and social interactions in educational settings. Other notable technologies include Digital Media Production (9 studies), Virtual Reality (VR) and Digital Gamification (5 studies each), which show their potential to engage students and enhance learning experiences. Lesser-known tools such as Global Positioning System (GPS), 3D printers, Educational Simulation, and AI each contributed to a smaller number of studies (2 studies or less). The data indicates a trend toward leveraging digital technologies to foster engagement, collaboration, and real-world applications in educational settings. Figure 4 illustrates the distribution of studies across various educational technologies, highlighting the prevalence and application of each tool in the reviewed research.

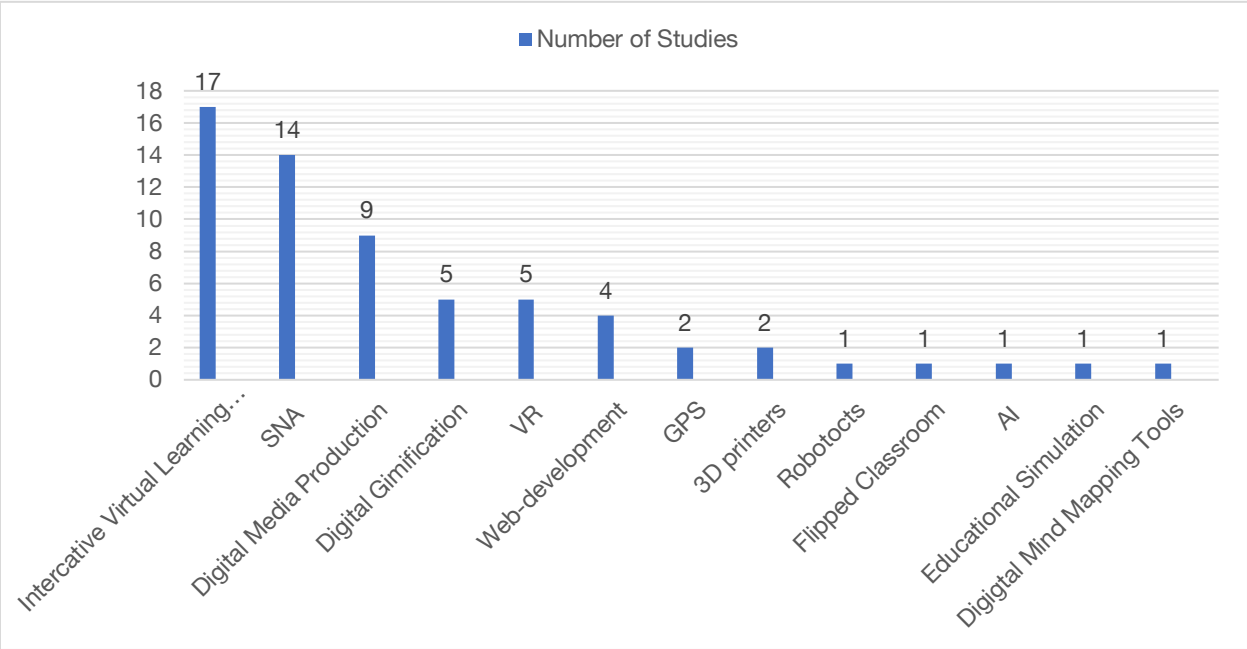

Figure 4: Distribution of Technological Tools Used in Studies on Civic Education.

Qualitative findings

In this review, three emerging themes have been identified: *Technology as a Medium for Civic Engagement, Collaborative Learning and Community Involvement, and Technology Integration with Pedagogy.* These themes encapsulate the multifaceted role of technology in enhancing civic participation, fostering collaborative educational experiences, and integrating technological tools with pedagogical strategies. Each theme reflects a significant area of interest within the current literature, highlighting the diverse ways in which technology influences and shapes various aspects of society and education.

Theme 1: Technology as a Medium for Civic Engagement

Technology as a medium for civic engagement has consistently emerged as a crucial theme in the studies, highlighting the role of digital tools and platforms in fostering civic participation and engagement among students. Several quantitative studies illustrate how technology, including social networking sites (SNSs) and web-based modules, enhances students' engagement with civic issues. For instance, Luo & Park [9] developed a web-based GIS learning module to enhance service learning in social work education. The students used the GIS module to identify and map community assets, such as local resources, public services, and community centers. By applying these GIS tools, students developed both technical skills and a deeper understanding of the importance of community assets in social work practices. The students then presented their findings in a community forum, inviting local stakeholders to engage in discussions about these resources and collaborate on potential improvements. This project demonstrates how digital tools can connect classroom learning with real-world civic engagement, allowing students to directly contribute to community-based discussions and solutions.

In qualitative studies, technology is frequently used to create collaborative spaces for students to engage in discussions and projects related to civic matters. Schattle & Plate [10] used Skype seminars to connect students from the U.S. and South Korea, where they collaborated on a paper about a global issue, fostering cross-border dialogues on global citizenship, democracy, and social justice.This real-time, virtual interaction allowed students to actively engage in a global civic discourse, transcending national boundaries, reducing othrering [11], and fostering a sense of belonging to a global civic community. In Schattle & Plate [10], the project involved students being organized into pairs, with one student from each university, allowing them to engage in meaningful conversations about civic issues. Students presented their collaborative work during the Skype seminars, which provided them with an opportunity to share their ideas with international peers. This aspect of the project helped foster a sense of global civic responsibility. The project demonstrated how technology, specifically Skype, facilitated cross-border dialogue and enabled students to engage in collaborative discussions that enhanced their understanding of global civic engagement.

Mixed-method studies further emphasize the significance of technology in fostering civic engagement. For example, in the study by Al Ansari & Alnasser [12], AI-driven chatbots were used to engage students in knowledge sharing about civic duties and the use of AI in civic engagement. Students interacted with the chatbot to learn about civic issues, particularly through social media platforms. The study found that students appreciated the interactive nature of the chatbot, which facilitated deeper exploration of civic topics. However, some students expressed concerns about the depth of conversation and whether the chatbot could facilitate more meaningful discussions. These findings emphasize the need for selecting technology that not only promotes engagement but also ensures depth in facilitating comprehensive civic education.

Theme 2: Collaborative Learning and Community Involvement

Collaborative Learning and Community Involvement is an essential theme that highlights how students work together and engage with their communities through technology. In several quantitative studies, students are shown to use digital tools to collaborate on civic projects that

directly involve the community. For instance, Chen [13] investigated how Chinese university students utilized digital technologies for civic education, specifically focusing on the use of interactive platforms to enhance political engagement. The study found that students in the experimental group who used digital tools like Moodle and other internet-based platforms demonstrated higher levels of participation in civic activities compared to those in the control group. The study underscores how digital tools in political education can facilitate increased student engagement with democratic processes and the local community. Students interacted with both their peers and local stakeholders, fostering a deeper understanding of civic responsibilities and enhancing their sense of social engagement.

In qualitative research, the theme of collaborative learning extends to the deepening of student engagement with community partners. For example, Spyridakis et al. [14] students in a human-centered design program utilized an interactive platform, Meal Matchup, to address food insecurity by facilitating food recovery between university dining halls and local homeless shelters. The platform allowed students to participate in service-learning classes, collect and analyze data, and contribute to the coordination of food donations. Students not only worked with peers but also interacted with community stakeholders, gaining valuable experience in addressing a real-world issue while simultaneously contributing to the community.

Mixed-method studies further highlight the significant impact of collaborative learning in civic engagement. For example, Dassin & Belda [15] utilized virtual classrooms and collaborative digital tools to enable students from different countries to work together on international development projects. The students focused on creating digital media-based solutions to issues like environmental conservation, education, and civic engagement, highlighting the application of technology in addressing real-world global challenges. These projects enabled students to collaborate across borders, enhance their understanding of community needs, and apply digital tools for civic purposes, such as promoting local action or facilitating global discussions.

In addition to the positive impacts of digital tools on student engagement, some studies have identified barriers and negative impacts. For instance, Manca & Grion [16] highlight challenges when using Facebook for student participatory practice, such as mistrust of school policies, reluctance to engage with the platform, and limited participation due to unclear project goals and fear of judgment. These findings underscore the need to carefully consider potential barriers when implementing digital platforms for fostering civic engagement

Theme 3: Technology Integration with Pedagogy

Technology Integration with Pedagogy is a pivotal theme that examines how digital tools are seamlessly incorporated into educational practices to enhance civic learning outcomes. In quantitative studies, integrating technology with pedagogical strategies has been shown to improve student engagement and understanding of civic issues. For instance, Borrero & Borrero-Domínguez [17] conducted a study exploring the role of Facebook in promoting youth civic engagement and participation. The research found that using Facebook for civic purposes allowed students to engage in both online and offline political activities, such as organizing discussions, sharing political content, and participating in social movements. The study highlighted the importance of social influence in encouraging students to use Facebook for these

civic purposes. Through these online activities, students developed a deeper understanding of civic issues, as their engagement on Facebook fostered real-world action, demonstrating how social media platforms can bridge the gap between digital tools and active civic participation. This integration of technology with pedagogy creates an interactive and dynamic learning environment, where students not only learn about civic responsibility but actively engage with it in a meaningful way.

In qualitative research, the focus is often on how educators incorporate technology into their teaching methods to foster deeper engagement with students. Saddiqa et al. [18] investigated the use of open data visualization tools in Danish schools to engage students with local issues. The study found that integrating open data, such as environmental data, into various subjects like geography and social sciences enabled students to critically analyze real-world problems. Students worked with data to better understand local environmental challenges and participated in discussions about how such data can be used to address civic issues. It emphasizes the importance of incorporating open data into the curriculum to enhance critical thinking, problem-solving skills, and civic engagement. The study also underscores how technology can foster a more interactive and collaborative learning environment, allowing students to connect theoretical knowledge with real-world applications and thereby enrich their civic education experience.

Mixed-method studies further highlight the value of integrating technology with pedagogy to achieve effective learning outcomes. Hirakoso & Hamada [19] utilized digital fabrication technologies, specifically 3D printing, to support student teachers in creating 3D educational materials for social studies education. The students participated in a self-learning program where they created original 3D educational materials, which were then used in mock classrooms to teach social studies concepts. This hands-on approach allowed students to integrate technology into their teaching, making abstract concepts more tangible and fostering collaborative learning. The study highlights the value of using digital fabrication in STEAM education and its potential to enhance teaching and learning outcomes in social studies.

Such efforts demonstrate how the thoughtful integration of digital tools with pedagogy goes beyond supplementing traditional methods; it transforms the learning environment into one that is dynamic, interactive, and deeply engaged with real-world issues. This approach supports the development of critical thinking, problem-solving, and collaborative skills, all while making civic education more relevant and accessible.

Quantitative findings

The quantitative studies examined in this review showcase various innovative uses of technology to enhance civic engagement and education. Luo & Park [9] studied the impact of a web-based GIS learning module for community asset mapping among 87 graduate students in Canada, revealing that 61% of the respondents found the module helpful, particularly when integrated into assignments. The study demonstrated significant improvements in students' understanding of GIS concepts and skills, with the data collected using Statistical Package for the Social Sciences (SPSS) analysis showing that 68.5% of students in the Community Practice course revisited the module after its initial use, underscoring its effectiveness [9]. Similarly, , Borrero & Borrero-Domínguez [17] explored Facebook's role in fostering youth civic engagement through an

extended Unified Theory of Acceptance and Use of Technology (UTAUT) model. Their findings showed that social influence (SRW = 0.51, $p < 0.05$) and performance expectancy (SRW = 0.36, $p < 0.01$) significantly influenced students' intention to use Facebook for civic engagement, revealing that the use of Facebook as a platform for political participation contributed to offline civic involvement [17].

Furthermore, several studies revealed the powerful role of social media and mobile platforms in encouraging civic participation. Cheng et al. [20] conducted a study on social network service (SNS) usage among 760 university students in China. Their findings showed that SNS use significantly predicted civic engagement, especially regarding the frequency of use ($\beta = 0.18$, $p < 0.001$) and amount of posting ($\beta = 0.15$, $p < 0.01$). The study also highlighted that SNS gratifications such as accessibility and recognition needs were strong predictors of civic engagement, contributing to 14% of the variance in civic behaviors [20]. Similarly, in the context of mobile learning, Zahra et al. [21] investigated the use of the Edmodo web tool for environmental awareness among 90 middle school students. The experimental group demonstrated significantly higher motivation ($M = 146.42$, $SD = 7.83$) and better post-test performance ($M = 17$, $SD = 1.69$) compared to the control group, highlighting the importance of integrating technology and constructivist teaching methods to enhance civic education [21].

In addition to these studies, other research demonstrated the impact of innovative technologies such as AI-driven knowledge sharing and immersive virtual reality (IVR) in civic education. Ansari & Alnasser [12] conducted an experimental study using a Facebook chatbot for knowledge sharing, which resulted in significant positive influences on civic engagement ($p < 0.01$) and trust ($p < 0.01$). The study concluded that AI-based platforms could foster stronger civic participation by enhancing values related to trust and knowledge sharing [12]. Similarly, Alazmi & Alemtairy [22] explored the use of IVR in social studies education, finding that students in the IVR group achieved higher academic scores ($M = 39.0$, $SD = 1.4$) and demonstrated lower cognitive load ($M = 1.29$, $SD = 0.46$) compared to those in the control group, emphasizing the potential of immersive technology to enhance learning outcomes and engagement in civic education [22].

The studies reviewed collectively highlight the transformative potential of technology in enhancing civic engagement and education. By integrating digital tools such as web-based GIS modules, social media platforms, mobile learning applications, AI-driven chatbots, and immersive virtual reality, these studies demonstrate that technology can significantly improve understanding, participation, and trust in civic processes. The consistent finding across these studies is that when thoughtfully implemented, technology not only facilitates access to information but also fosters a more engaged and informed citizenry. This underscores the importance of leveraging technological innovations to strengthen democratic processes and promote active civic involvement.

Recommendations

In engineering education, despite the lack of engineering-specific projects identified during the systematic review, the search revealed valuable insights into the integration of design-thinking and technology into civics education. Only 5 out of the 60 studies reviewed were related to

engineering education, which highlights a lack of interaction between the discipline and presents an opportunity for future partnership and research. This low representation indicates that most engineering educators may not be engaging with civic education or engagement and fully leveraging design-thinking methodologies with technology, which could greatly enhance the problem-solving and innovation skills of students. The findings suggest that there is significant potential for integrating digital tools, such as GIS, AI, and immersive virtual reality, into engineering curricula with a context of civic engagement to foster engagement, collaboration, and practical application. Research shows that Generation Z engineering undergraduate students have motivations toward social change in addition to simply being technically trained [23]. Educators and researchers are encouraged to explore the integration of these technologies within engineering education, particularly in areas such as community engagement and hands-on learning towards socio-technical problems. There are examples of service learning in or as courses [24] or programs [25], [26], but those do not specifically use design-thinking and technology as pedagogical tools. The findings from other educational settings, including K-12 and higher education, can provide useful frameworks and inspire future projects in engineering, especially in areas where technology integration can bring transformative impacts to student outcomes. Based on those findings, we present the following recommendations for educators, policymakers, and researchers.

Educators are encouraged to embrace the integration of design-thinking methodologies with technology to foster a more engaging and interactive civic education experience. In no way are the authors suggesting replacing personal engagement activities with technology, but by leveraging tools such as interactive virtual learning environments, digital media production, and AI-driven platforms, educators can enhance students' critical thinking and problem-solving skills. It is essential for educators to incorporate technology in a way that encourages active participation, collaboration, and real-world application of civic concepts. . Once educators determine their pedagogical goals, they should find a technology that complements and facilitates them. They must be mindful that while integrating technology, authenticity and depth are important. Students will quickly discove shallow interactions with chatbots or AI-driven experiences. Teachers must also take into consideration the ability of the tool to foster real-time interaction and dynamic data acquisition and manipulation. Technology that supports the design-thinking components of human-centered, user-focused, and criteria-constraint tension has more potential to navigate the wicked nature [27] of real-world problems. Furthermore, professional development programs should be offered to help teachers effectively integrate these tools into their curriculum, ensuring they are equipped with the skills needed to use technology to its full potential in civic education.

Policymakers play a vital role in supporting the successful integration of technology in civic education by developing policies that ensure equitable access to these digital tools. First, it is crucial for policymakers to allocate funding to ensure schools and educators are provided with the necessary resources to implement interactive technologies effectively, especially in underserved regions. Second, creating policies that encourage the inclusion of design-thinking methods in educational standards can help standardize innovative teaching practices. Third, leaders must prioritize protecting resources and creating logistical infrastructure for professional development of in-service teachers interested in integrating technology or design-thinking. Finally, policymakers should also advocate for comprehensive teacher training programs,

focusing on technology integration and the development of collaborative learning environments to foster civic engagement among students.

There are many opportunities for research. Researchers should focus on investigating the long-term impact of design-thinking integration with technology in civic education, particularly its effects on students' civic engagement and participation beyond the classroom. While there is substantial evidence supporting short-term benefits, long-term studies could provide more insights into the enduring impact of these technologies. Furthermore, researchers are encouraged to explore the barriers that hinder technology adoption, such as issues with accessibility, teacher preparedness, and funding inequalities, to create strategies for overcoming these challenges. Assessments of pedagogies that integrate such technologies must also be created and updated. Lastly, expanding research to include diverse educational settings across different cultural and geographical contexts will help ensure that civic education methods are inclusive and applicable to a broad range of students.

Conclusions

This systematic review investigated the integration of design-thinking methodologies into civic education, supported by technology, and demonstrated that the combination significantly enhances student engagement and learning outcomes. The review identifies three key themes: the role of technology as a medium for civic engagement, the benefits of collaborative learning in community involvement, and the importance of technology integration with pedagogy. The findings underscore the potential of technologies such as interactive virtual learning environments, AI-driven tools, and digital media production in fostering a more interactive and collaborative civic education experience. Despite the promising results, challenges related to accessibility and the need for teacher training remain. The study contributes to the growing body of literature on technology-enhanced civic education and offers insights into choosing appropriate technology based on pedagogical goals. Future research should focus on addressing the gaps identified, including long-term efficacy studies and the exploration of emerging technologies to further improve civic education practices.

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