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RESEARCH REPORT

Exploring Evolving Perspectives: Research Trends in Attitudes toward STEAM Education

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Abstract

As the number of scholarly publications on STEAM education grows rapidly, international reviews examining its status and trends are pivotal for advancing the field. This study examines the evolution of attitudes toward STEAM education from 2020 to 2024 through a systematic analysis of research literature. The study reveals a notable increase in contributions from Spain, Taiwan, and Turkey, followed by significant input from the USA, China, and Jordan. In research groups, there is a growing focus on teachers' attitudes, alongside continued interest in K-12 and post-secondary STEAM education, indicating shifting research priorities. As for research topics, findings reveal a predominant focus on K-12 learner experiences, alongside significant attention to teaching practices, and emerging interest in post-secondary STEAM education, indicating a comprehensive approach to addressing educational needs across different levels. This review provides valuable insights into recent trends in attitudes toward STEAM education, providing a comprehensive overview of this evolving field.

Keywords: *Attitudes toward STEAM, Trends, Literature review, STEAM education research*

The trend toward STEAM education swiftly gained prominence in today's schools. STEAM serves an educational method that utilizes Science, Technology, Engineering, the Arts, and Mathematics to stimulate student curiosity, promote discussion, and enhance critical thinking (Tytarenko et al., 2021). This interdisciplinary approach not only fosters creativity but also nurtures essential skills for navigating an increasingly complex world. STEAM integration aims to combine multiple disciplines as way to engage students in topics of interest while teaching critical thinking and core content knowledge for future success in careers (Wieselmann et al., 2020). By intertwining various subjects, STEAM education encourages students to explore connections between seemingly different fields, fostering a holistic understanding of concepts and their real-world applications.

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STEAM education garners significant interest across various educational fields (Kareemet al., 2022). Scholars and educators have responded to this on-going call by sharing their academic contributions through various publishing channels. A basic search on Google using the term "STEAM education research" yielded over 109 million results. The abundance of information highlights the rapidly evolving nature of STEAM education and underscores the extensive volume of research in this field. However, despite the breadth of research, the field still lacks a cohesive understanding of how attitudes toward STEAM vary across different educational levels, regions, and stakeholder groups.

Numerous reviews on STEAM education research offer insights into potential methodologies for locating relevant publications (Brown, 2012; Minichiello et al., 2018; Li et al., 2020). In the review conducted by Wang et al. (2020), the authors analyzed 798 articles from 2000 to 2018 across 36 journals to assess trends in STEM education research. Findings indicate a growing global significance of STEM education, with clearer journal identities emerging over time. Both quantitative and qualitative analyses were employed to understand research topics, methods, and authorship nationalities trends. Even so, these reviews do not reflect developments in recent years, emphasizing the importance of conducting an updated study to examine new advancements in the field.

In contrast to general reviews on STEAM education, other reviews concentrate on specific issues within the realm of STEAM education (Margot & Kettler; 2019; Martynenko et al., 2023; Wu & Rau, 2019; Zhao et al., 2022). For example, Martynenko et al. (2023) focused on attitudes toward STEM education based on 23 empirical journal articles published between 2016 and 2022. Margot and Kettler (2019) concentrated on understanding teachers' values, beliefs, perceived obstacles, and required support regarding STEM education, drawing insights from 25 scholarly articles. While these reviews offer valuable insights into specific populations, such as teachers or K-12 learners, they often overlook cross-contextual and comparative analyses of attitudes across diverse regions and educational levels. This limits their utility in identifying universal trends or region-specific developments in STEAM adoption. This gap highlights the importance of understanding the status of trends in STEAM education. Conducting a systematic literature review to explore these trends is necessary.

Prior reviews have utilized one of two approaches for article selection: (a) initially identifying specific journals and then seeking out articles within those journals, or (b) conducting targeted searches in databases using keywords relevant to their focus. After careful consideration, this research will adopt the latter approach, concentrating on attitudes toward STEAM. By considering the aspects discussed earlier, this study aims to provide a clearer understanding of the evolving perspectives on STEAM education, with a focus on developments from 2020 to 2024. It links these attitudes to broader educational outcomes and practical implications, providing valuable insights for educators, curriculum developers, policymakers, and researchers.

Research Questions

When examining the research focus, studies that explore participants' attitudes towards STEAM become central to the discussion. Specifically, the following three research questions are of interest for addressing.

1. What countries or regions, as indicated by the locations of the authors, have contributed to journal publications on attitudes towards STEAM education?
2. What research groups have emerged in the field of attitudes towards STEAM education based on journal publications?
3. What are the main topics emerging from research on attitudes towards STEAM education, as reflected in academic journal articles?

Method

This study constitutes a condensed literature review concerning attitudes towards STEAM within electronic databases. The following data collection process was applied to find related publications:

1. Search Strategy: The keywords "Attitudes" and "STEAM education" were used in searches across the electronic databases ERIC and Web of Science (WOS). Considering the focus on analyzing the recent status and trends in STEAM education, the search period was defined as January 2020 to April 2024. This timeframe was chosen to capture contemporary research within the field. At this stage, 147 articles were retrieved.

2. Initial Inclusion and Exclusion Criteria: Articles were included if they provided access to the "full text" and were published in "peer-reviewed journals." These criteria ensured that the selected studies met a high standard of academic rigor and were accessible for detailed review.

3. Article Screening and Selection Process: The titles and abstracts of 69 articles were further examined to assess their relevance. Articles were excluded if they did not explicitly address quantitative research methods or lacked a focus on the development or use of scales to measure attitudes toward STEAM. Based on this closer examination, 29 articles were included for detailed review. This decision was made because only these studies met the specific criterion of focusing on scale development within quantitative research on attitudes toward STEAM.

4. Thematic Analysis Approach: An inductive approach was adopted for the thematic analysis. This method allowed the themes to emerge from the data without being constrained by pre-existing frameworks or hypotheses. During the detailed review, studies were categorized based on recurring themes, such as the specific constructs being measured (e.g., student attitudes, teacher perceptions), the target populations (e.g., elementary students, secondary students, middle school students, high school students, University students or teachers), and research

objectives. This inductive process ensured that themes were grounded in the data and reflective of the diversity within the reviewed literature.

Data Analysis

The researcher conducted a thorough examination of each article, employing a qualitative thematic review methodology. All articles were obtained and scrutinized by the researcher. Among these studies, various measuring instruments were employed based on the focus of the investigation. In most investigations, attitudes were determined using a questionnaire. Some utilized attitude measures that had undergone prior validation and reliability testing.

The thematic categories were developed through a systematic analysis of research on attitudes toward STEAM education from 2020 to 2024. The research followed a structured approach to classify studies into key categories based on their primary focus. These categories emerged by closely examining the research groups, the topics addressed in the studies, and the countries represented. Table 1 presents an overview of the articles included in the analysis.

Table 1.
Distribution of research articles by profile of participants, data collection tools and topics

Participants	Article (ID)	Country	Data collection tools	Topic category
Teachers	(1), (8), (11), (15), (17), (22), (24), (29), (31), (32)	Jordan, Korea, Uzbekistan, Spain, Chile	Attitude Scales, Questionnaires, Surveys	K-12 Teaching
Primary School Students	(4), (10), (16), (23), (34), (37)	Turkey, USA, Taiwan, Ireland	STEAM Attitude Scale, Questionnaires, Surveys	K-12 Learning
Middle School Students	(6), (8), (10), (12), (21), (30), (34)	UK, Spain, USA, Turkey, China, Ireland	Attitude Surveys, STEAM Attitude Scale	K-12 Learning
High School Students	(3), (9), (10), (39)	Finland, Turkey, USA, Taiwan	Questionnaires, STEAM Attitude Scale	K-12 Learning
University Students	(2), (5), (13), (20), (27), (33), (37)	Russia, USA, China, Taiwan	Questionnaires, STEAM Attitude Scale	Post-secondary

Results and Discussion

In the following sections, findings are presented in alignment with the studies' objectives and each of the three research questions.

The Aims of Studies

Before delving into the specific focus of this research, it's essential to outline the objectives of studies by other scholars included in this study. In a study conducted by Alfayez (2024), the aim was to investigate the availability of STEAM approach requirements among teachers and their attitudes toward the STEAM approach in public schools. Another study, undertaken by

Anisimova et al. (2022), examined the effectiveness of professional development training in shaping students' attitudes toward utilizing distance learning tools within the STEAM education framework.

The goal of the study by Aydin Gürler & Kaplan (2023) was to examine the relationship between 21st-century skills, such as STEAM attitudes, critical thinking, decision-making and gender influence among primary school students. The study validated an educational model utilizing Augmented Reality (AR) to enhance learning in secondary science subjects within the STEAM framework, emphasizing the importance of addressing students' attitudes and the necessity for teacher training (Delgado-Rodríguez et al., 2023). Donmez (2021) was to explore how out-of-school STEM activities influence female students' STEAM career choices and their STEAM attitudes, emphasizing changes in STEAM career interests and considering cognitive styles. Another study by Haddad et al. (2022) explored primary teachers' attitudes towards STEAM education, finding higher awareness among experienced private sector teachers, and recommends unified reform plans for enhanced STEAM implementation. Helvaci et al. (2022) attempted to examine how incorporating Visual Arts Education in the STEAM approach affects students' attitudes toward STEM disciplines. Huang (2020) was to assess the impact of STEAM education compared to traditional methods on students learning attitude and outcome among college students.

The goal of study by Kim and Na (2022) was to examine how technology teachers' attitudes toward STEAM education are influenced by factors like collaboration, receptivity to educational change, expertise, and instructional effectiveness. Another study (Konkus & Topsakal, 2022) investigated the impact of STEAM-based activities on gifted fifth-grade students, revealing positive effects on STEAM attitudes, cooperative skills, and career preferences. Lee (2021) aimed to assess STEAM education integration, focusing on teachers' attitudes toward STEAM and recommending strategies for government-led reforms. The study (Liu et al., 2024) aimed to examine the relationship between marketing knowledge, data literacy, skill enhancement, and learning attitude among students in the context of STEAM application for hospitality and tourism education.

The purpose of this study (López et al., 2021) was to examine Brazilian and Spanish mathematics teachers' views on gamified activities in STEAM education, revealing positive perceptions but also concerns about training and implementation. Mou's (2023) study sought to investigate university students' attitudes towards STEAM through a 3D design project. This study (Ortega-Ruipérez & Lázaro Alcalde, 2023) explored teachers' attitudes towards STEAM activities across various grade levels and subjects, emphasizing implications for STEAM integration in course design. The purpose of the study (Silva-Hormazábal & Alsina, 2023) was to assess the impact of integrated STEAM education on Chilean teachers' attitude, with the goal of informing the design of future training programs in STEAM. Sinha et al. (2020) was to assesses a

mobile 3D printing platform's impact on 227 undergraduate students, revealing increased STEAM awareness and positive attitudes towards STEAM education. The study (Togou et al., 2020) sought to assess the impact of Fab Lab-based learning on K-12 students' attitudes towards STEAM subjects, specifically examining motivation, affective state, and perceptions of Fab Lab-based education. The objective of the study by Wu et al. (2022) was to explore the connection between cognitive load, attitude, and learning intention in STEAM education, highlighting key variables influencing students' attitudes and intentions.

Some studies (Lupión-Cobos et al., 2023; Romero-Ariza et al., 2021) aimed to explore the impact of professional development training on teachers' attitudes, addressing associated challenges and opportunities related to teaching collaboration, curriculum, institutional support, methodology, professional development, and student concerns. In some studies, in which students participated, the effect of the STEAM program (Lu et al., 2022), STEAM-based science activities (Aurava & Meriläinen, 2022; Bosman & Shirey, 2023; Boyle, 2021; Flesch et al., 2021; Liu & Ding, 2022; Özkan, 2022) and STEAM workshops (Ying-Yan et al., 2022) on students' attitudes toward STEAM was investigated.

Top 10 countries/ regions where scholars published journals on attitudes towards STEAM education

When it came to the countries/regions where the data was obtained, Figure 1 showed the number of publications by countries/ regions from 2020 to 2024. Most of the research was conducted in Spain, Taiwan and Turkey, followed by the USA, China, and Jordan. In the remaining nations of Chile, Finland, Ireland, Korea, Russia, UK and Uzbekistan, one data set was gathered for each country.

The study reveals a dynamic global research landscape, with Asia, particularly Taiwan and China, leading in research activity. Authors in some countries in Asia were becoming very active in the field over the past several years. This trend is consistent with findings from the IJ-STEM review (Li et al., 2019). Europe, with Spain at the forefront, also shows significant engagement. Contributions from North America, the Middle East, and emerging regions like Turkey also highlight widespread interest.

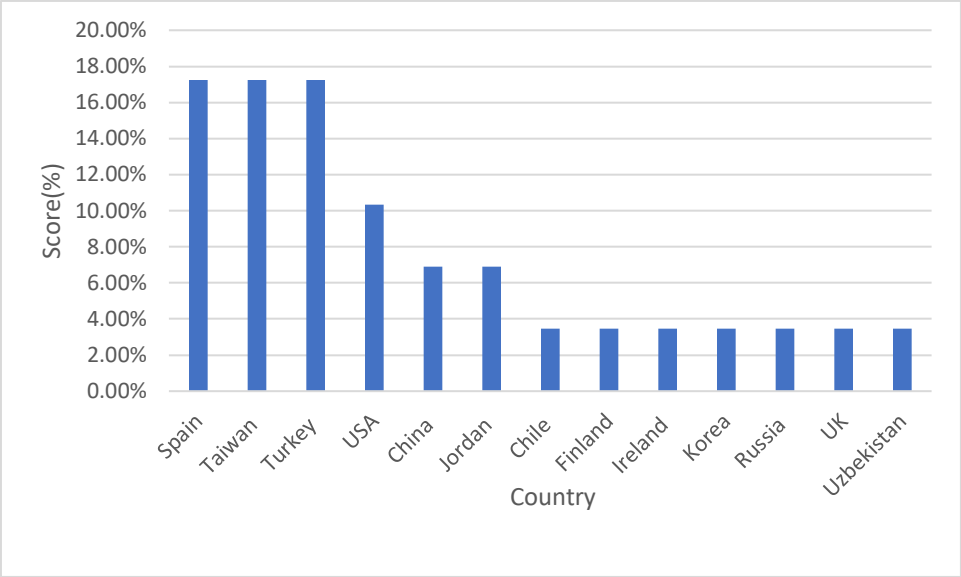

Figure 1. Top 10 authorship countries/ regions (2020-2024)

Published articles by research groups

Upon examination of the research groups, Figure 2 depicted the population distribution within each category. It was observed that studies predominantly featured teachers as the primary group. The research groups were ranked as follows: middle school students and university students constituted the second group, followed by primary school students in third place, and high school students as the last group.

This prioritization of teachers in the research group indicates a strong emphasis on investigating teachers' attitudes toward pedagogical approaches, instructional strategies, and professional development within STEAM education. The ranking of middle school and university students as the second group suggests a secondary focus on understanding learning experiences and outcomes among older students. Primary school students follow, indicating a lesser but still significant emphasis on exploring STEAM education at earlier stages of schooling. Lastly, the recognition of high school students underscores the importance of considering their unique needs and experiences in STEAM education research.

In conclusion, this hierarchical arrangement of research groups indicates a transition from primary student-centered STEAM attitude research to a newfound emphasis on exploring teachers' roles and perspectives. This shift underscores the evolving priorities within the research community, while also recognizing the diverse learning experiences and attitudes of students across various educational stages.

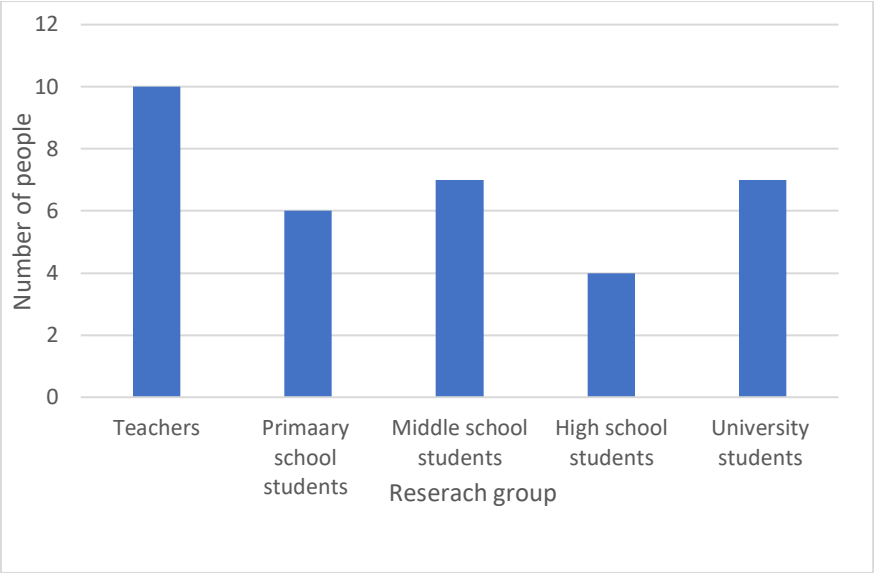

Figure 2. Number of people in different research groups

Published articles by research topics

Figure 3 shows the number of publications in each of the three topic categories. The most frequent category was "K-12 learner, learning, and learning environments," with 13 publications, accounting for 45% of the total. It indicates a strong emphasis on investigating the educational experiences of students in kindergarten through 12th grade across various STEAM disciplines.

The second most researched topic was "K-12 teaching, teachers, and teacher training," comprising 31% of publications, while "post-secondary STEAM education, learners, and learning environments" followed closely behind at 24% of publications. The results suggest that while the research community predominantly centers on K-12 education, there is significant attention given to both teaching and learning aspects within this context.

While "post-secondary STEAM education, learners and learning environments" category receives slightly less attention compared to K-12 education, it still represents a significant portion of the research output, indicating an ongoing interest in understanding and enhancing STEAM education at the post-secondary level. This indicates a notable shift towards addressing STEAM learning in higher education settings. This suggests an acknowledgment of the need to prepare students for STEAM-related careers and lifelong learning beyond the K-12 educational stage, reflecting a comprehensive approach to advancing STEAM education by addressing both learner needs and teaching practices across various educational levels.

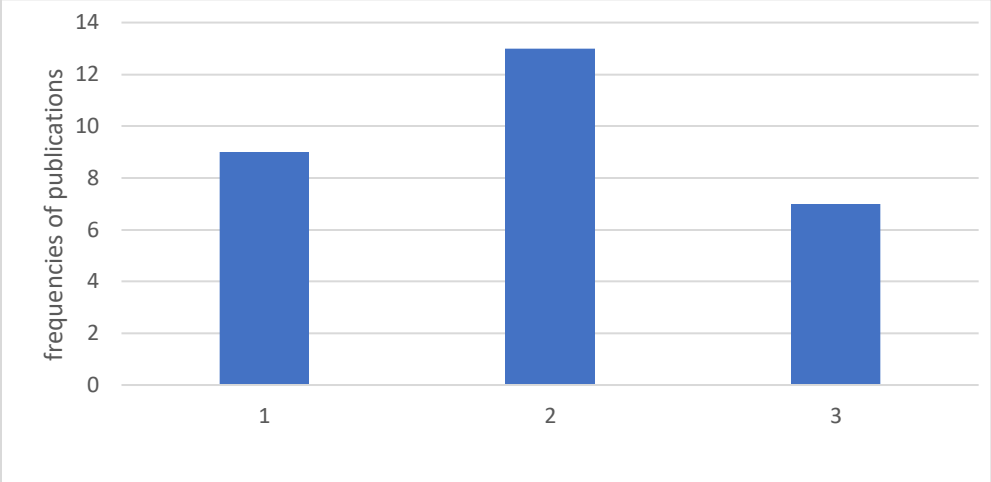

Figure 3. Frequencies of publications' research topic distributions

Note:1=K-12 teaching, teacher and teacher education; 2=K-12 learner, learning, and learning environments; 3=Post-secondary STEAM learner, learning, and learning environments)

Conclusion and Recommendations

Summary of Findings and Significance

In this study, research studies on attitudes toward STEAM between 2020 and 2024 were examined. In contrast to the findings of the previous review (Martynenko et al., 2023), most publications on attitudes toward STEAM were contributed by authors from Spain, Taiwan, and Turkey, with subsequent notable contributions from the USA, China, and Jordan. Authors from various Asian countries have notably increased their activity in this field in recent years, mirroring the findings documented in the IJ-STEM review by Li et al. (2020). This trend underscores the increasing global recognition of STEAM education's importance and reflects a shift towards more diverse, international participation in STEAM scholarship.

Given the rapid evolution of STEAM education globally, researchers often face challenges in gaining a comprehensive understanding of potential leading research groups or topics within the field. This challenge stems from the wide dispersion of STEAM education publications across diverse journals in various fields. The systematic analysis of publications on attitudes toward STEAM education identifies teachers as the predominant research group, with subsequent attention given to middle and university students. This reflects a shift towards understanding the role of teachers in STEAM education, as well as growing interest in how older students engage with STEAM learning. This result may drive a global emphasis on enhancing teacher training and support in STEAM education, as well as targeting the specific needs of older students to better equip them for STEAM careers.

According to the results of the study, the studies in the topic category of "K-12 learner, learning, and learning environments" have been the most prevalent, by far. The analysis also suggests that the research community has a keen interest in both teaching and learning within K-12 STEAM education. This trend is consistent with findings from the IJ-STEM review by Li et al. (2020). The prominence of "post-secondary STEAM education, learners and learning environments" reflects the increasing recognition of extending STEAM learning in higher education settings. This shift could lead to a stronger global focus on early-stage STEAM education, enhancing K-12 curricula and teacher training, while creating smoother pathways to post-secondary STEAM careers and lifelong learning, ultimately preparing a more skilled workforce for future challenges.

Study Limitations

While this study provides an overview of the status and trends of attitudes toward STEAM education research, there are still some limitations. First, the study relied on a specific time frame (2020-2024) for the selection of research publications, which may have excluded important studies published outside this period. Second, the focus was limited to scale development research, excluding other valuable studies that may have contributed to the field. Additionally, the study was restricted to articles indexed in selected databases, which may have overlooked relevant research not captured in these sources.

Future Research Directions and Recommendations

Future research can aim to address these limitations by incorporating a wider range of research sources, including non-indexed studies, and exploring diverse research methodologies beyond scale development. It would also be beneficial to extend the time range for analysis, providing a more comprehensive view of long-term trends in STEAM education. Also, more studies can investigate the evolving roles of teachers and the experiences of students at various educational levels, particularly in non-K-12 contexts.

This study underscores critical implications for educators, curriculum developers, and policymakers in enhancing STEAM education. Given the growing emphasis on post-secondary STEAM education, teachers can prepare students for STEAM-related careers by adopting an interdisciplinary approach that integrates real-world applications to highlight the relevance of STEAM subjects in daily life and future career paths. Curriculum developers are encouraged to design interdisciplinary curriculums, provide professional development for teachers, and integrate global perspectives, particularly from regions with increasing activity in STEAM research, to enhance STEAM education and prepare students for future careers.

Policymakers can prioritize initiatives that advance STEAM education across all levels while promoting global collaboration to facilitate the exchange of best practices and research findings. Such global cooperation can support the dissemination of innovative strategies, enhance

equitable access to quality STEAM education, and foster cross-cultural understanding, contributing to the broader advancement of STEAM education worldwide.

Through this exploration, the study sheds light on the studies on attitudes toward STEAM in recent years, offering valuable insights into this evolving field. Work in attitudes towards STEAM education will continue to evolve and it will be interesting to review the trends in another 5 years.

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