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Review

Systematic review of teacher attrition rates and their far-reaching implications on STEM education in the context of Society 5.0

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Abstract: Teacher attrition in STEM education poses significant challenges in the era of Society 5.0, where the demand for skilled professionals is at an all-time high. In this systematic review, we examined the primary factors contributing to teacher attrition rates in STEM education within the context of Society 5.0, alongside its implications for the overall quality of STEM education. Through a comprehensive analysis of 110 articles, 28 were deemed fit for review, addressing key questions regarding the factors influencing attrition, its impact on education quality, and the extent of external influences such as societal expectations, technological advancements, and industry demands. Our findings highlight the multifaceted nature of teacher attrition, emphasizing factors such as job satisfaction, opportunities for career advancement, and external pressures. Furthermore, this review underscores the significant impact of teacher attrition on the quality of STEM education. Additionally, external factors such as societal expectations and industry demands intersect to shape educators' career decisions, influencing their overall satisfaction and propensity to remain in the profession. The implications for policymakers include increased investment in teacher support

programs, addressing salary disparities, promoting collaborative school environments, integrating technological resources, and advocating for policies that promote diversity and inclusion. Despite teacher attrition being a global issue, there is a significant lack of research from Asian countries. Overall, this study provides valuable insights into addressing teacher attrition in STEM education within the era of Society 5.0, offering a framework to promote STEM teacher retention and actionable recommendations to promote retention and enhance the quality of STEM education.

Keywords: STEM education, teacher attrition, Society 5.0, teacher shortage

1. Introduction

The STEM education landscape is constantly evolving, driven by technological advancements and societal shifts characteristic of Society 5.0. However, amidst this evolution, the issue of teacher attrition within the STEM educational setting has emerged as a significant concern [28]. According to [29], attrition refers to a decrease in employees due to resignation, retirement, or death. The researchers in [7] characterized teacher attrition as the departure from the teaching profession to pursue other career paths. The dynamics of teacher labor markets significantly impact student learning outcomes and equity [30]. Extensive research over the years consistently demonstrates that teacher effectiveness is the foremost school factor influencing student achievement [12,23]. Furthermore, studies reveal that staffing STEM fields poses considerable challenges, often characterized by high teacher turnover rates [18,22]. As a result, policymakers and educators have dedicated substantial time and resources to ensure classrooms are staffed with qualified teachers [27]. Despite these efforts, retaining quality teachers remains a challenge [38], with STEM educators particularly susceptible to turnover [21]. Research indicates that factors such as training, experience, ability, and achievement play crucial roles in teacher attrition and retention [8].

According to [49], the rapid advancement of digital technologies has transformed various sectors, including education, leading to new challenges and opportunities. In this context, Society 5.0, a concept introduced by the Japanese government, emphasizes a human-centered approach to technological integration, leveraging artificial intelligence, big data, and the Internet of Things (IoT) to create a more sustainable and inclusive society. Unlike previous industrial revolutions that focused primarily on economic growth, Society 5.0 seeks to balance technological innovation with social well-being, particularly in education [49].

STEM education plays a pivotal role in preparing students for the digital economy, yet high teacher attrition rates threaten its sustainability. Retaining qualified STEM educators is crucial for equipping future generations with the skills needed for a technology-driven workforce [22]. However, the evolving demands of Society 5.0, including the integration of digital tools, shifting pedagogical expectations, and increased societal pressures, have introduced new challenges for STEM educators [50].

Science, technology, engineering, and math (STEM) teacher attrition is the term used to describe the departure of STEM educators from the teaching profession for a variety of reasons, such as moving to a non-teaching role, taking on personal responsibilities like childcare, health issues, or retirement [34]. This phenomenon is particularly significant within STEM disciplines because there is a growing need for highly qualified math and science experts. However, there are insufficient

qualified math and science teachers to meet the demand. The consequences of STEM teacher turnover include a shortage of trained teachers, lower retention rates, and negative effects on students' academic achievement [26].

Following the industrial era of machine-made, mass-produced goods, we find ourselves in an information-based society. Advances in computing, networking, and communications enable the collection and utilization of large amounts of data to create networks of information, virtual goods, and assets [43]. The vision for Society 5.0 relies heavily on the continued integration of technology into daily life, necessitating a clear understanding of how technology will be incorporated into society and the significant downstream effects this will produce [44].

Society 5.0 aims to integrate technological developments with society to reduce concerns about the negative effects of technology and to create societies where technology can be effective [1]. According to the researchers in [43], the STEM fields have become a top priority worldwide for nations to secure and enhance their competitiveness in an increasingly globalized and knowledge-based economy. In turn, the directions of higher education programs have sought to cope with this demand by prioritizing and retrofitting STEM field education [13]. Within this framework, STEM education is pivotal in preparing individuals to thrive in an increasingly technology-driven world [36]. However, the persistent challenge of retaining qualified STEM teachers has the potential to hinder the realization of Society 5.0's goals [42]. Drawing on theoretical perspectives such as the Job Demands-Resources (JD-R) model Bakker and Demerouti [51] and the Technology Acceptance Model (TAM) [52], we aim to shed light on the complex interplay between teacher attrition rates and the advancement of STEM education within the context of Society 5.0. By examining the factors that contribute to the departure of STEM teachers, the following research questions guide this study:

(1) How does teacher attrition impact the overall quality of STEM education in the context of Society 5.0, considering the evolving technological and societal landscape?
(2) What internal and external factors contribute to teacher attrition rates in STEM education within the framework of Society 5.0, and to what extent do external influences, such as societal expectations, technological advancements, and industry demands, impact attrition?
(3) How do job satisfaction, societal pressures, and institutional support influence teacher attrition in STEM fields across countries?

2. Methodology

The methodology adopted in this study involved a thorough systematic review, employing a rigorous and methodical method to comprehensively explore, assess, and consolidate literature on "Teacher Attrition Rates and their Far-reaching Implications on STEM Education in the Context of Society 5.0". The systematic collection and analysis of data strictly followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, as outlined by [3,25,35,40]. Embracing this methodological framework facilitated the extraction of evidence-based insights, enabling well-founded conclusions to be drawn and informed recommendations to be formulated for both future research efforts and practical implementations.

2.1. Eligibility criteria

In this review, only studies meeting specific criteria were considered. These criteria included

peer-reviewed status, publication in a scholarly journal between 2011 and 2024, English language of publication, and addressing at least one of the research questions posed in the review.

2.2. Data sources

The search encompassed electronic databases focusing on STEM education and social science. Specifically, the databases queried included Google Scholar, Web of Science, and Scopus. A total of 110 articles were retrieved from these databases.

2.3. Search

The search strategy employed the following terms in each database query: "Teacher Attrition" AND "STEM" AND "Society 5.0," "STEM Teacher Attrition" AND Factors OR Impact AND "Society 5.0". This is visually represented in Table 1 below.

Table 1. Search keywords.

Database	Keywords
Google Scholar Web of Science Scopus	Teacher Attrition" AND "STEM" AND "Society 5.0," STEM Teacher Attrition" AND Factors” "STEM Teacher Attrition" AND Factors OR Impact AND "Society 5.0"

2.4. Study selection

2.4.1. Screening

Figure 1 illustrates the screening process. The selection of studies for inclusion was conducted sequentially against article abstracts using the following criteria:

- Criteria 1: Study published between 2011 and 2024 in English.
- Criteria 2: Study published in a scholarly journal.
- Criteria 3: Study is empirical (qualitative, quantitative, mixed methods).
- Criteria 4: Extracted data aligns with the current study's focus and research questions.

110 articles were screened at this phase and a total of 79 articles were retained after the screening stage.

2.4.2. Evaluation

Following the screening phase, all eligible articles underwent a quality assessment. This evaluation entailed seven criteria (Objectives and Purposes, Review of the Literature, Theoretical Frameworks, Participants, Methods, Results and Conclusions, and Significance), which were applied to the full-text contents of each article. Each component was meticulously examined to ensure compliance with standards of quality reporting. Subsequently, of the assessed articles, 22 were excluded after screening the title and abstract, while 79 met the criteria and were retained for further analysis. To mitigate bias, a second round of evaluation was conducted. This involved reassessing

both the included and excluded articles against the established criteria. This confirmed that all retained articles meet the predefined quality standards, and the articles whose findings did not address the research question were removed. At this final stage, 28 articles were included in the study.

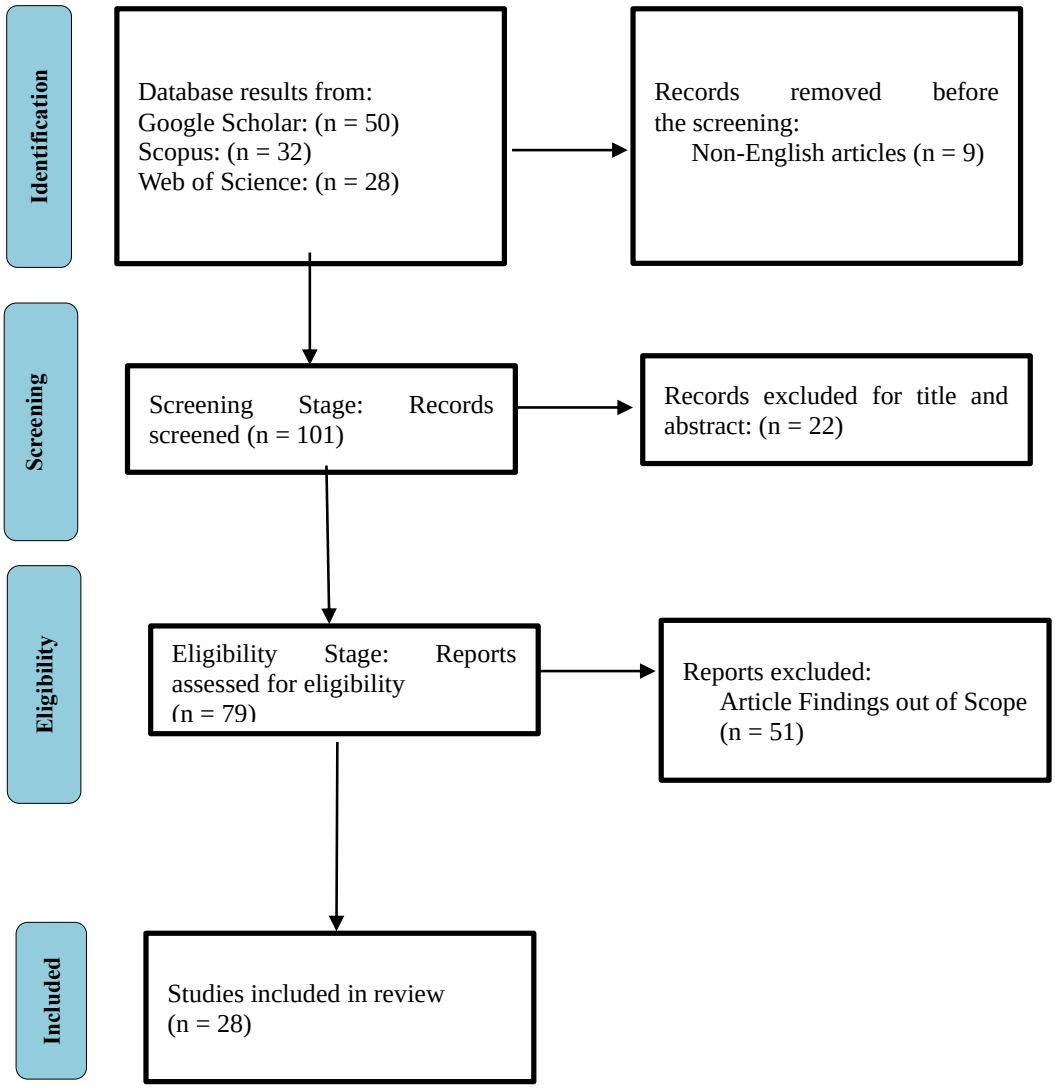

Figure 1. PRISMA flow chart.

3. Data extraction table and analysis

The 28 articles that meet the study criteria and are pertinent to the research objectives are presented herein. Furthermore, a comprehensive analysis of the gathered data is conducted, encompassing the extraction of details such as author names, publication years, research methodologies employed, study locations, research findings, and corresponding journals.

Table 2. Data extraction table.

S/N	Author Name and Year	Methodology	Country	Internal/External Factors	Findings	Journal
1	[16]	Mixed Method	USA	Teacher Experience	The primary factors contributing to teacher attrition rates in STEM education within the framework of Society 5.0, as revealed by the study, center on the preparation experiences of teachers.	Advancing Research & Innovation
2	[19]	Quantitative	South Korea	Job satisfaction and opportunities for career advancement	The study shows that the primary factors contributing to teacher attrition rates in STEM education within the framework of Society 5.0 revolve around teachers' job satisfaction and opportunities for career advancement.	Education and Urban Society
3	[37]	Quantitative	USA	School leadership	School leadership, particularly in STEM-related fields, plays a crucial role in influencing teacher attrition rates in STEM education.	Journal for STEM Education Research
4	[28]	Quantitative	USA	Socioeconomic impact, student truancy, years of experience, and administrative support.	Socioeconomic impact, student truancy, years of experience, and administrative support are seen as factors contributing to teacher attrition rates in STEM education within the framework of Society 5.0	International Journal of STEM Education
5	[33]	Quantitative	USA	Year of experience and course load	The findings highlight factors such as years of teaching experience, school-level socioeconomic status, school locale, and course load taught in physics as significant predictors of physics teacher attrition and	Journal of Science Teacher Education

					migration.	
6	[32]	Quantitative	USA	Resources	Factors such as school poverty levels, school resources and support systems play a significant role in influencing teacher attrition rates in STEM education.	AERA Open
7	[30]	Quantitative	USA	Teachers' salary	Teachers' salary and job satisfaction are seen as crucial factors contributing to Kansas STEM teachers' attrition.	Online Journal of Rural Research & Policy
8	[31]	Qualitative	USA	Burnout and job dissatisfaction	The study identifies teacher dissatisfaction and burnout as primary factors driving teacher attrition rates in STEM education within the Society 5.0 framework.	The Elementary School Journal
9	[10]	Quantitative	USA	Administrative support and teacher's salary	Factors such as administrative support, teacher salaries, and alternative certification pathways are seen as factors influencing teacher attrition rates in STEM education within the Society 5.0 framework.	Education Policy Analysis Archives
10	[41]	Quantitative	USA	Administrative support	Administrative support, discipline enforcement, and school safety are identified as factors influencing teacher attrition rates in STEM education within the Society 5.0 framework.	Education Research Alliance
11	[17]	Quantitative	USA	School structures	Teacher attrition in rural STEM education negatively impacts the quality of education within the evolving societal and technological landscape of	The Rural Educator

					Society 5.0	
12	[24]	Qualitative	Belgium	Lack of recognition	The findings show that teachers leaving STEM fields disrupt schools' social fabric, impeding knowledge sharing and collaborative problem-solving among educators and students, which is critical for fostering innovation and collaboration.	Teachers and Teaching
13	[14]	Qualitative	USA	Goal limitation	The attrition of proficient STEM teachers, driven by perceived goal limitations, not only reduces the number of qualified teachers but also undermines the quality of STEM education.	Behavioral and Brain Sciences
14	[9]	Quantitative	USA	Lack of motivation	Teacher attrition disrupts the continuity and quality of STEM instruction, leading to decreased student engagement and interest in STEM subjects.	Social Psychological and Personality Science
15	[39]	Qualitative	USA	Salary	Teacher attrition poses unique challenges that can hinder progress in advancing STEM learning and innovation in Society 5.0.	Research in Education
16	[5]	Qualitative	England	Knowledge	The findings highlight how deficiencies in teachers' knowledge and understanding of STEM can limit the effectiveness of STEM delivery in classrooms.	International Journal of Technology and Design Education
17	[6]	Qualitative	USA	Factors not addressed	Teacher attrition hinders efforts to address gender disparities and promote diversity in STEM fields, ultimately impacting the overall quality of STEM education.	Frontiers in Education

18	[11]	Quantitative	USA	Salary, working conditions, professional development opportunities, and leadership support	Findings show that within the framework of Society 5.0, the primary factors contributing to teacher attrition rates in STEM education include salary, working conditions, professional development opportunities, and leadership support.	School Effectiveness and School Improvement
19	[4]	Quantitative	USA	The experience of stereotype threat	One primary factor identified is the experience of stereotype threat, particularly among minorities, which contributes to their higher likelihood of leaving STEM.	Social Psychology of Education
20	[34]	Quantitative	USA		Societal expectations, deeply ingrained in gender roles and stereotypes, shape the academic environment for women teachers in STEM.	Social Psychology of Education
21	[26]	Quantitative	China	Burnout and dissatisfaction	The pressure to excel in STEM fields due to their perceived importance for technological advancement and economic growth can lead to burnout and dissatisfaction among STEM teachers.	Education and Urban Society
22	[15]	Qualitative	USA, Turkey	Technological advancements	Technological advancements can indirectly contribute to teacher attrition in STEM education by exacerbating existing barriers and challenges related to teachers' attitudes and beliefs toward technology.	Computers & Education
23	[20].	Qualitative	Malaysia	Promotion	The study findings show that instructional promotion and supervision contributed to teachers' attrition.	Life Science Journal

24	[2].	Quantitative	Malaysia	Cost implications and heightened workload	Factors contributing to teacher attrition include cost implications, heightened workload, students' underperformance, and burdens on school administration.	International Journal of Education and Literacy Studies
25	[48]	Mixed Method	South Africa	Low motivation	The attrition of STEM teachers is driven by low motivation.	African Renaissance
26	[45]	Mixed-Method	China	Instructional challenges, knowledge gaps, and training differences.	Internal factors identified are instructional challenges, knowledge gaps, and training differences.	International Journal of STEM Education
27	[46]	Qualitative	South Africa	Low remuneration	STEM teacher attrition is driven by systemic challenges such as low remuneration and insufficient career incentives in South Africa.	International Journal of Social Science Research and Review
28	[47]	Qualitative	South Africa	Shortage of qualified teachers and emigration	STEM teacher attrition in rural South Africa is driven by shortages of qualified educators (scarce skills) and emigration.	African Identities

3.1. Article methodology analysis

Most studies included in this review involved quantitative methodologies, with 64% opting for such approaches. In contrast, 32% utilized qualitative methods, while two studies contained a mixed-method design integrating qualitative and quantitative research techniques. The graphical representation below depicts this distribution.

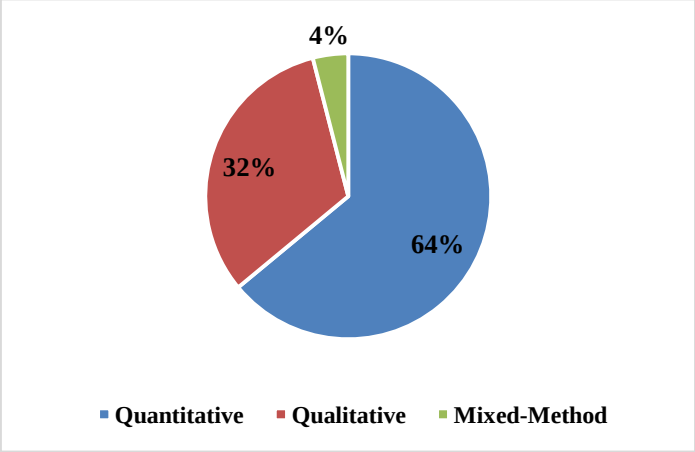

Figure 2. Methodology analysis.

3.2. Articles' years of publication

The chosen scholarly articles that meet our inclusion criteria cover the timeframe from 2011 to 2024, enabling an exploration of key trends, evolving methodologies, and shifts in research emphasis over this period. This temporal scope enables a comprehensive analysis of the subject matter, providing insights into the nuanced developments over time. Notable observations reveal that 2019 stands out with the highest number of articles, totaling five. Following this, 2020 contributed four articles, while 2012, 2018, and 2023 contributed three articles each, and 2021 featured two articles. The remaining years from the dataset extraction table contained one article each.

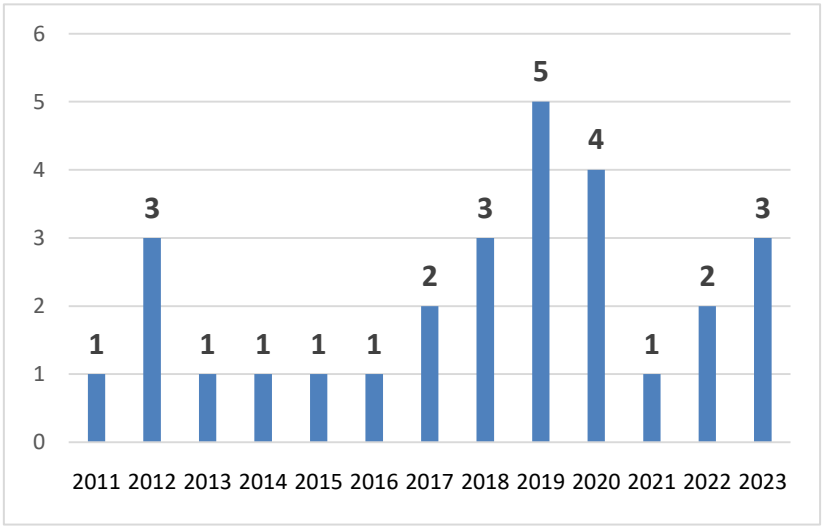

Figure 3. Article publication.

3.3. Research study location

While our criteria regarding country inclusivity are global, analysis of the reviewed articles indicates a significant relevance to the USA, given that most studies originate from this location. This observation underscores the importance of STEM in the United States. The graphical

representation of research country affiliations is presented below to visually depict this trend.

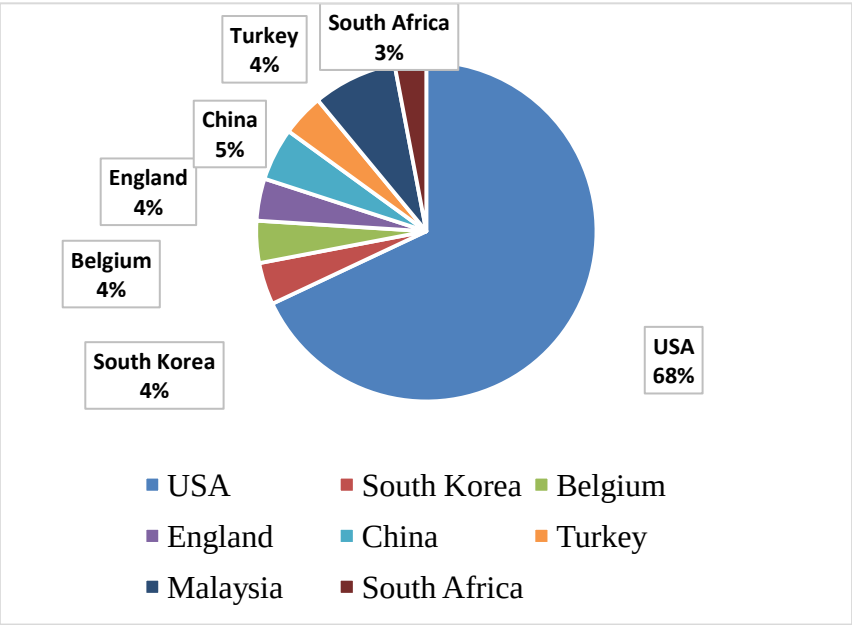

Figure 4. Research country affiliation.

3.4. Analysis of factors affecting teacher retention

The categorization of factors influencing teacher attrition highlights key themes, with some factors appearing more frequently than others.

The most frequently mentioned factors relate to job satisfaction, burnout, and motivation, with six occurrences. This suggests that teachers' overall well-being, career prospects, and levels of motivation play a significant role in their decision to stay or leave. Similarly, leadership and support appear five times, emphasizing the importance of strong school management and administrative backing in teacher retention.

Financial concerns, particularly salary and socioeconomic factors, also emerge as a crucial theme with five mentions, reinforcing the idea that low remuneration and financial insecurity contribute to teacher turnover. Resources and working conditions appear four times, highlighting the challenges of inadequate infrastructure, technological gaps, and professional training disparities.

On the lower end, teacher shortages and migration are referenced twice, indicating that while these factors are important, they may not be as frequently cited as internal school-related challenges. Additionally, recognition and professional growth are mentioned three times, suggesting that career progression opportunities, promotions, and acknowledgment play a moderate role in retention.

Finally, student truancy and unaddressed factors appear the least, with just two mentions. While these may contribute to teacher attrition, they are less emphasized than broader systemic issues like workload, burnout, salary, and leadership. This analysis indicates that addressing teacher well-being, leadership quality, and financial incentives should be a priority in efforts to improve teacher retention, especially in rural areas.

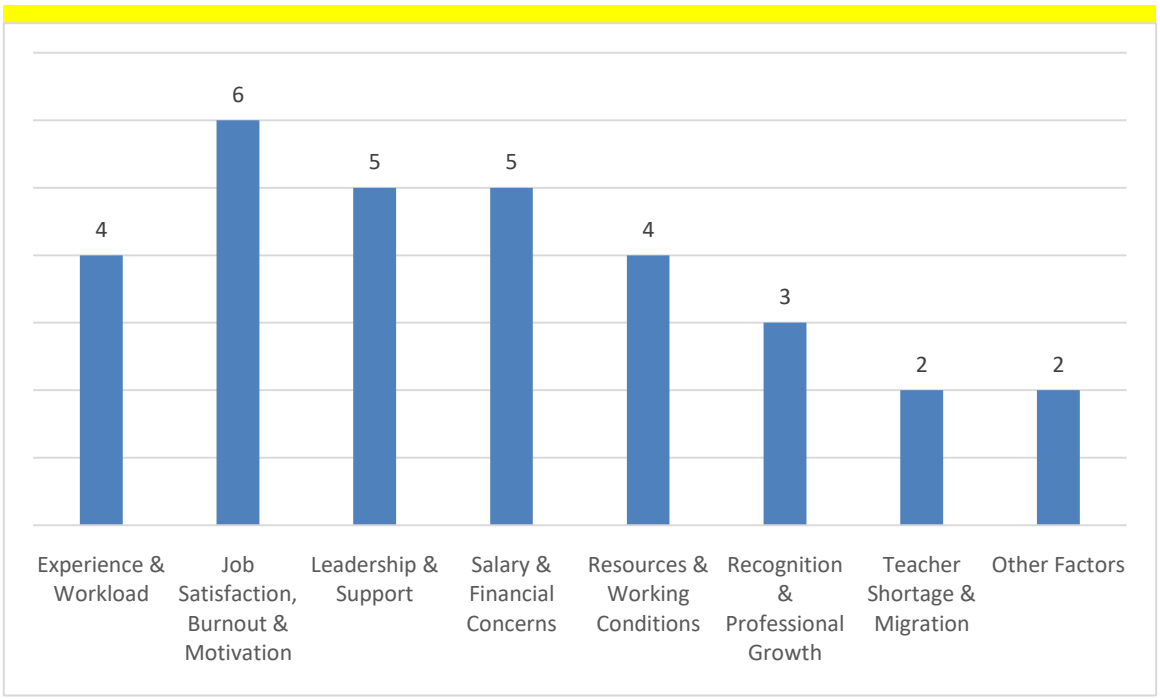

Figure 5. Factors affecting teacher retention.

4. Discussion

In this systematic review, we delve into the intricate dynamics surrounding teacher attrition rates and their profound implications on STEM education within the context of Society 5.0. Through a meticulous synthesis of the literature, we aim to provide comprehensive insights derived from a thorough analysis of studies spanning various contexts and methodologies. By examining the multifaceted impact of teacher attrition on STEM education, particularly within the framework of Society 5.0, we seek to unravel the complex interplay between educator turnover and the advancement of STEM learning. This section is dedicated to discussing and answering our research questions using findings from the reviewed articles, shedding light on the nuanced dynamics that define the relationship between teacher attrition rates and STEM education in the context of Society 5.0. Through the synthesis of diverse perspectives, we endeavor to contribute valuable knowledge to the discourse surrounding the pivotal topic: "What are the far-reaching implications of teacher attrition rates on STEM education within the framework of Society 5.0?"

Research Question 1: How does teacher attrition impact the overall quality of STEM education in the context of Society 5.0, considering the evolving technological and societal landscape?

Teacher attrition poses significant challenges to the quality of STEM education in the era of Society 5.0, where innovation, digital transformation, and inclusive technology integration are paramount. Rather than isolated disruptions, attrition affects STEM education through interconnected pathways, such as instructional continuity, institutional knowledge loss, and diminished innovation capacity which are crucial in preparing learners for a technology-driven society.

1. **Instructional Continuity and Learning Outcomes:** Attrition interrupts the learning process

by breaking instructional continuity, particularly in high-need and rural areas [17,19]. The loss of skilled teachers often results in classrooms led by less experienced or underqualified replacements, which undermines curriculum delivery and student engagement [9,14]. In Society 5.0, where STEM literacy underpins societal progress, such as disruptions compromise students' preparedness for roles in emerging fields such as robotics, artificial intelligence, and digital engineering.

2. **Institutional Knowledge and Mentorship Loss:** The departing teachers leave with institutional knowledge, pedagogical expertise, and mentorship capacity [14,24]. This weakens collaborative teaching cultures and inhibits peer learning among educators, which are essential for continuously updating STEM practices to align with Society 5.0's dynamic digital requirements. The erosion of these knowledge networks delays innovation in STEM instruction and limits the system's ability to adapt to technological change.
3. **Innovation and Implementation Gaps**: Attrition hinders the implementation of innovative pedagogies, such as STEM Project-Based Learning (PBL), interdisciplinary problem-solving, and AI-integrated teaching strategies [6]. These approaches require not just technical know-how but continuity and confidence among educators. A high turnover rate means fewer teachers with the training and commitment necessary to deploy such pedagogies effectively, leading to inequities in how students access future-ready STEM learning opportunities.
4. **Workforce Readiness and Equity:** The shortage of qualified STEM educators also exacerbates recruitment challenges in critical subjects and limits efforts to foster diversity and inclusion in STEM [5,39]. Society 5.0 prioritizes equitable access to advanced technologies and learning systems. However, high attrition rates may reinforce disparities, particularly in underserved communities, by removing the personnel equipped to address them through inclusive teaching practices.

Teacher attrition in STEM education has deep-rooted, multifaceted effects that extend beyond staffing gaps. It undermines the foundations needed to cultivate a technologically literate, innovative, and equitable workforce aligned with Society 5.0's goals. Addressing these impacts requires targeted strategies that prioritize retention, continuous professional development, and supportive teaching environments that can withstand the pace and demands of technological change.

Research Question 2: What internal and external factors contribute to teacher attrition rates in STEM education within the framework of Society 5.0, and to what extent do external influences, such as societal expectations, technological advancements, and industry demands, impact attrition?

Several researchers have examined the internal factors contributing to teacher attrition rates in STEM education within the framework of Society 5.0. The researchers in [16] found that the preparation experiences of teachers, particularly in high-poverty schools, significantly impact attrition rates. Beginning STEM teachers in high-poverty schools from alternative certification programs are more likely to leave both the teaching profession and their initial school within a five-year timeframe. Moreover, alternative certification programs produce most beginning STEM teachers in Texas, who are more inclined to take initial placements in high-poverty schools. Building upon this, the researchers in [19] suggest that job satisfaction and opportunities for career advancement are central to understanding teacher attrition in STEM education. Lower levels of job

satisfaction, especially concerning location and prospects for advancement, correlate with voluntary turnover among STEM teachers, including movement within the K-12 education sector or switching to other industries. Further insights from the researchers in [37] emphasize the influence of school leadership, particularly in STEM-related fields, on teacher retention. The presence of a principal who majored in a STEM subject positively affects the retention of secondary STEM teachers, underscoring the importance of effective school leadership in reducing attrition rates.

The researchers in [28] identified factors associated with teacher attrition in STEM education, including socioeconomic impact, administrative support, teacher autonomy, and satisfaction with salary. Among these, satisfaction with salary emerges as the most significant predictor of teacher attrition among secondary math and science teachers. Additionally, the researchers in [33] highlight factors such as years of teaching experience, school-level socioeconomic status, and school locale as significant predictors of physics teacher attrition. Novice physics teachers, particularly in urban schools, are vulnerable, emphasizing the importance of understanding demographic and contextual factors in addressing teacher turnover in STEM education.

The researchers in [30] delve into the primary factors driving teacher attrition rates in STEM education within Society 5.0. This emphasizes the link between teacher salary and satisfaction, noting the concerning trend of decreased satisfaction among Kansas STEM teachers due to declining salaries. The researchers in [31] identified dissatisfaction and burnout as critical drivers of STEM teacher attrition. They highlight specific characteristics associated with elevated levels of dissatisfaction, particularly among secondary STEM educators and those teaching in low-income schools. This is further supported by of the researchers in [20], as they found that instructional promotion and supervision contributed to teachers' attrition. The factors identified by the researchers in [2] contributing to teacher attrition include cost implications, heightened workload, students' underperformance, and burdens on school administration. These findings underscore how financial constraints, coupled with the demands of adapting to evolving teaching methods, contribute to teacher dissatisfaction and turnover.

The researchers in [10] stress the importance of addressing administrative support, teacher salaries, and alternative certification pathways to combat teacher attrition in STEM education within Society 5.0. They emphasize the role of these factors in fostering a positive work environment and addressing teacher shortages. Moreover, the researchers in [41] focus on school-level attributes influencing teachers' decisions to stay or leave, emphasizing the importance of malleable school processes such as administrative support and professional development in retaining STEM educators.

Adding to the discourse, the researchers in [11] underscore the significance of factors such as salary, working conditions, professional development opportunities, and leadership support in influencing STEM teacher attrition rates within the Society 5.0 framework. The researchers in [4] shed light on the effects of group performance anxiety and stereotype threat on the attrition of women and minorities from STEM, highlighting the importance of addressing these challenges to promote inclusivity and retention in STEM education. The results in [32] further support this notion by emphasizing the role of school poverty levels, resources, and support systems in influencing teacher attrition rates in STEM education.

Additionally, understanding the extent to which external factors contribute to this phenomenon is crucial for devising effective strategies to address turnover and promote the retention of skilled STEM educators. The researchers in [19] provide insights into the multifaceted nature of teacher

attrition in STEM education, focusing on internal factors like job satisfaction and opportunities for career advancement. However, their findings indirectly suggest the impact of external factors such as societal expectations, technological advancements, and industry demands on teacher turnover. Teachers may feel constrained by societal expectations and industry demands, which influence their decisions regarding career advancement and job satisfaction.

The researchers in [28] suggest that external factors, including societal expectations and industry demands, significantly shape teacher turnover within Society 5.0. This implies that broader societal and contextual influences intersect with factors like job satisfaction and career advancement opportunities, influencing STEM educators' decisions. Similarly, although the researchers in [33] primarily focus on internal and contextual factors influencing physics teacher attrition, their findings imply the influence of external factors such as societal expectations and industry demands. Demographic and contextual factors exacerbate teacher attrition rates, suggesting that broader societal and contextual influences intersect with external factors to shape turnover.

The researchers in [41] highlight the heightened societal expectations regarding STEM education in Society 5.0, alongside the pivotal role of technological advancements. These factors can increase stress and dissatisfaction among STEM educators, contributing to higher attrition rates. The researchers in [34] discuss how societal expectations, particularly regarding gender roles and stereotypes, shape the academic environment for women in STEM. This can lead to challenges in fostering inclusive classrooms and may contribute to frustration or disillusionment among teachers.

Moreover, societal expectations contribute to teacher attrition in STEM education through various mechanisms, as highlighted by [26]. Gender biases, resource allocation disparities, and pressure to ensure student achievement in STEM subjects all play a role in influencing STEM teachers' decisions to leave the profession. Additionally, technological advancements indirectly contribute to teacher attrition in STEM education, exacerbating existing barriers and challenges related to teachers' attitudes and beliefs toward technology, as noted in [15].

These findings underscore the complex interplay between internal and external factors in shaping teacher attrition in STEM education within the context of Society 5.0, emphasizing the need for comprehensive strategies to address turnover challenges and promote retention in critical STEM fields.

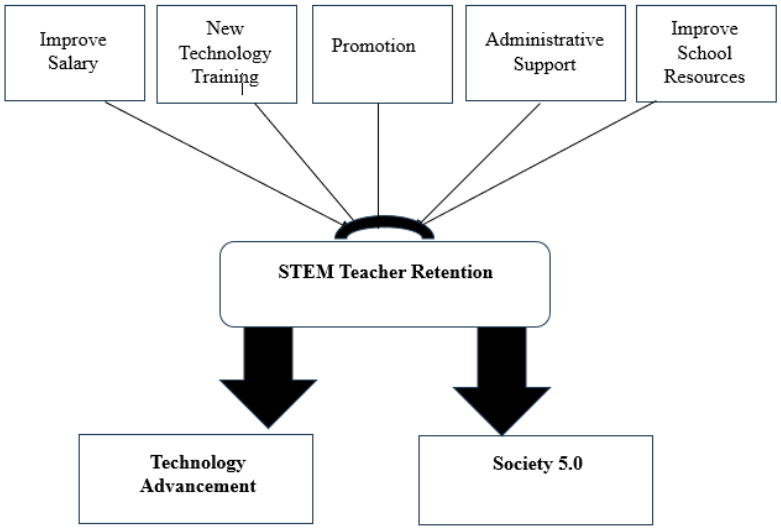

Figure 6. A conceptual framework for STEM teacher retention.

Research indicates that various critical factors influence STEM teacher retention, each playing a pivotal role in cultivating an environment conducive to professional satisfaction and growth. One significant factor is the availability of resources in STEM schools, which has been identified as a primary driver of teacher attrition [16]. Addressing this challenge requires providing adequate resources to both schools and teachers, thereby fostering an environment supportive of STEM teacher retention. Moreover, job satisfaction and opportunities for career advancement are paramount in retaining STEM educators [19]. Studies have consistently shown that investing in promoting STEM teachers and offering avenues for their professional development significantly enhances retention rates [37]. Administrative support also plays a crucial role in creating a conducive work environment for STEM teachers, fostering a sense of value and motivation to remain in the field [28]. Furthermore, salary considerations are fundamental to teacher retention, with competitive compensation being essential to ensure continued dedication to the profession [30].

In addition to these factors, the researchers in [26] emphasize the importance of training in new technologies as a means to promote STEM teacher retention. Providing opportunities for STEM teachers to receive training in emerging technologies equips them with the skills necessary to adapt to evolving educational landscapes. Such training not only enhances their professional development but also fosters a sense of competence and relevance in their roles. By investing in continuous training initiatives, educational institutions can empower STEM teachers to effectively integrate new technologies into their teaching practices, thus increasing job satisfaction and retention rates.

By addressing factors such as resource allocation, professional development opportunities, administrative support, competitive salaries, and ongoing training in new technologies, we can create an environment that promotes the retention of STEM teachers. This, in turn, contributes to broader societal advancements, particularly in technology, aligning with the vision of a human-centered Society 5.0 empowered by innovation and technological progress.

Research Question 3: How do job satisfaction, societal pressures, and institutional support influence teacher attrition in STEM fields across countries?

Teacher attrition in STEM fields is shaped by a combination of job satisfaction, societal expectations, and institutional support, with notable variations across countries. While some nations struggle with systemic challenges like low wages and poor working conditions, others face cultural and policy-driven barriers that contribute to teacher attrition.

1. Job satisfaction and working conditions

In many regions, low job satisfaction is a major driver of STEM teacher attrition. In South Africa, for instance, rural schools struggle to retain STEM teachers due to poor working conditions, inadequate salaries, and a lack of career incentives, leading to persistent vacancies in critical STEM subjects [46]. Similarly, in China, STEM teachers report intrinsic challenges related to their subject knowledge and pedagogical beliefs, particularly when integrating interdisciplinary STEM approaches, which increase their workload and stress levels [45]. Additionally, novice STEM educators across multiple countries cite limited career growth, low administrative support, and inadequate compensation as key reasons for leaving the profession [19].

2. Societal and cultural pressures

Beyond financial and institutional factors, societal expectations and cultural norms also influence teacher attrition. In Saudi Arabia, non-native English-speaking STEM teachers (NNESTs) encounter professional disadvantages, including lower wages, restricted career mobility, and cultural isolation, making them more likely to leave the profession. Moreover, research highlights that urban areas often provide better career mobility, drawing teachers away from rural and underserved regions that desperately need STEM educators [19].

3. Institutional support and policy interventions

The role of institutional support in teacher retention cannot be overstated. Many studies emphasize that insufficient government funding, weak mentorship programs, and poor professional development opportunities exacerbate STEM teacher shortages. In response, improving teacher training programs, providing financial incentives, and strengthening school-level support structures are necessary interventions. Countries experiencing high STEM teacher attrition must implement targeted policy measures, such as salary adjustments, housing support, and workload reductions, particularly for educators in rural and underserved communities [47].

Synthesis and future directions

A key insight from this review is that teacher attrition in STEM fields is not driven by a single factor but rather by an intersection of personal, societal, and institutional challenges. Addressing these issues requires a comprehensive approach that enhances job satisfaction, reduces societal pressures, and reinforces institutional support mechanisms. Future research should explore long-term policy impacts, compare teacher retention strategies across education systems, and identify best practices for improving STEM teacher retention globally.

5. Conclusions

Our purpose of this study is to conduct a thorough and methodical review exploring Teacher Attrition Rates and their Implications on STEM Education in the Context of Society 5.0. Based on the systematic review conducted using the PRISMA approach, our findings provide valuable insights into the primary factors contributing to teacher attrition rates in STEM education within the framework of Society 5.0. We identified various factors influencing teacher turnover, with key contributors including job satisfaction, opportunities for career advancement, and external pressures stemming from societal expectations, technological advancements, and industry demands. These factors intersect to shape educators' decisions regarding their careers, impacting their overall satisfaction and propensity to remain in the profession. As technological and societal landscapes continue to evolve, the departure of skilled and experienced STEM educators disrupts instruction and diminishes the quality of education provided to students. This disruption not only affects student engagement and interest in STEM subjects but also hinders efforts to cultivate the next generation of innovators and problem-solvers. Societal expectations, technological advancements, and industry demands intersect to create additional pressures on STEM educators, leading to increased stress and dissatisfaction. These external factors shape educators' perceptions of their roles and opportunities for career advancement, influencing their decisions to remain in the profession or seek alternative career paths.

In conclusion, the systematic review highlights the complex factors in shaping teacher attrition rates in STEM education within the era of Society 5.0. By understanding and addressing these factors, policymakers, educational leaders, and stakeholders can develop targeted interventions to promote teacher retention and ensure the continuity and quality of STEM education in an ever-evolving technological and societal landscape.

6. Study implications

Our findings provide policymakers with critical insights into addressing STEM teacher attrition within the evolving framework of Society 5.0. To enhance teacher retention, policymakers must implement context-specific support systems tailored to the unique challenges faced by educators in different educational settings.

1. **Professional Development & Mentorship Programs**: Governments and educational institutions should establish structured mentorship programs, particularly in under-resourced regions, to support early-career STEM educators. Additionally, region-specific professional development initiatives that integrate technology, industry collaboration, and modern pedagogical methods should be prioritized. These programs should be sustainable rather than one-time workshops, ensuring continuous skill development and career progression.
2. **Competitive Compensation & Incentives**: Addressing salary disparities is crucial, but policy design should account for economic and institutional variations. While performance-based incentives might work in high-income countries, alternative retention strategies, such as loan forgiveness programs or housing benefits, may be more effective in regions with budgetary constraints. Policymakers should conduct localized salary benchmarking studies to determine competitive compensation levels within different educational systems.
3. **Technology Integration & Institutional Support**: As technology plays an increasing role in STEM education, policies should provide clear guidelines for its integration, ensuring equitable access across educational settings. This includes:

- Investment in digital infrastructure for underserved schools.
- Technology-focused training to help teachers navigate AI-driven educational tools.
- Collaboration with tech industries to create adaptable learning models aligned with job market demands.

4. **Addressing Societal and Industry Expectations:** Policymakers must recognize the pressure STEM educators face from societal demands and industry competition. Strategies such as industry-academia partnerships can offer teachers real-world exposure while retaining them in education. Additionally, advocating for public awareness campaigns that highlight the value of STEM educators can help shift societal perceptions and increase respect for the profession.

7. Recommendation

In this systematic review, we synthesize insights from 28 relevant articles, providing a broad understanding of STEM teacher attrition within the context of Society 5.0. However, several research gaps remain that require further investigation. Since this study is based on a systematic review of

existing literature rather than primary data collection, future research should entail empirical studies that explore the dynamics of teacher attrition in different educational systems. Qualitative, quantitative, and mixed-method approaches would be valuable in uncovering deeper insights, while longitudinal studies could track educators over time to identify key factors influencing long-term retention.

There is also a need for policy-focused research that evaluates the effectiveness of teacher retention strategies. Many policies aim to address attrition, yet few researchers have examined how well these interventions work in different contexts. Future studies should explore how policies such as financial incentives, mentorship programs, and workload adjustments impact retention across diverse educational settings. Comparative research between different countries could provide insights into which strategies are most effective based on economic, cultural, and institutional differences.

A key limitation in current research is the overrepresentation of studies from the United States, with limited contributions from other regions, particularly Asia, Africa, and Latin America. This imbalance restricts the global applicability of existing findings and fails to capture the full range of factors influencing STEM teacher retention worldwide. While we tried to ensure that Asia and Africa were not excluded, it is crucial to note that there are limited studies from these regions, and we encourage research from the underrepresented regions as this would help develop context-specific solutions and highlight regional variations in attrition drivers, including socio-economic conditions, cultural expectations, and education policies.

Interdisciplinary research approaches could further enhance understanding of teacher retention. The intersection of education, workforce development, and technology offers new avenues for investigation. Researchers could explore how digital tools, artificial intelligence in education, and collaboration between schools and industries influence teacher retention in STEM fields. Insights from educational psychology, labor economics, and digital learning sciences would provide a more comprehensive perspective.

Addressing these gaps would lead to a more globally inclusive and policy-relevant understanding of STEM teacher attrition. By expanding research efforts beyond well-studied contexts, future studies can provide stronger evidence to guide policies that support teacher retention in the evolving landscape of Society 5.0.

Author contributions

Monsuru Salisu: Conceptualization; Ridzwan Che Rus: Conceptualization, Methodology; Muhammed Yusuf: Methodology, Data curation, Resources; Nuurudeen Bamiro: Resources, Formal analysis, Investigation; Mariam Idris: Inverstigation. All authors: Writing – original draft, Writing – review & editing.

Use of Generative-AI tools declaration

The authors declare they did not use Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare there’s no conflict of interest in this paper.

Ethics declaration

All data used in this study was collected from a popular database Google Scholar, Web of Science, and Scopus. The data doesn't involve animal or human subjects.

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