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Total Quality Management and Educational Innovation in Primary and Secondary Education: A Systematic Literature Review with Implications for STEM Schooling

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ABSTRACT

This systematic review examines Total Quality Management (TQM) and educational innovation in primary and secondary education (P&SE). Following PRISMA, 30 Scopus-indexed studies were selected and synthesized through affinity diagramming and thematic analysis. Six interlinked themes emerged: school leadership, stakeholder collaboration, technology adoption, quality assurance, teacher development, and school policy. Quality assurance and school leadership appeared most often; the remaining themes worked as supporting conditions. The review proposes a TQM-Driven Educational Innovation Model and discusses what the findings mean for STEM schooling, where strong quality cultures, inquiry-based teaching, and shared leadership are especially important. The paper offers practical guidance for school leaders and policymakers, with particular attention to the conditions that help STEM-related reforms last over time.

Keywords: Educational Innovation, Primary and Secondary Education, Quality Assurance, STEM Schooling, Systematic Literature Review, Total Quality Management

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INTRODUCTION

Total Quality Management is a management approach that aims to improve organizations through continuous improvement, customer focus, and the active involvement of all members (Deming, 2018; Permana et al., 2021). TQM started in industry but has since been used in education to support better school management, stronger teamwork, and lasting improvement (Syaifullah et al., 2023). In primary and secondary education (P&SE), TQM has helped strengthen leadership, teaching quality, and stakeholder satisfaction (Rosidin et al., 2025; Sfakianaki et al., 2021). Its success, however, depends much more on each school's culture and context than on simply copying industrial models (Bouranta et al., 2020; Psomas & Antony, 2017).

Educational innovation - new teaching methods, redesigned curricula, and digital tools - has become especially important after the digital shift caused by the COVID-19 pandemic (Anthony Jnr & Noel, 2021; Bouranta & Psomas, 2024; Serdyukov, 2017). Schools with adaptive cultures and continuous improvement habits coped better with online and hybrid learning during the pandemic (Bouranta & Psomas, 2024). This shows that TQM and innovation readiness are closely connected.

Quality and innovation matter especially for STEM education (Science, Technology, Engineering, and Mathematics). Recent meta-analytic evidence shows that STEM teaching can produce real gains in student learning, but only when school-level conditions - such as teacher preparation, curriculum coherence, and access to resources - are in place (Cao et al., 2025; Margot & Kettler, 2019). STEM teacher preparation faces ongoing challenges in integrating disciplines and aligning with classroom realities (McGuire et al., 2025; Rehman, Huang, Mahmood, Zafeer, et al., 2025). Furthermore, uneven K–20 transitions and varied conceptual definitions of STEM complicate quality assessments (Fang & Fan, 2026; Means et al., 2016). Even the meaning of STEM education itself is unclear,

because researchers use the term in different ways (Martín-Páez et al., 2019). The basic ideas of TQM — strong leadership, working with stakeholders, evidence-based decisions, and continuous improvement — match closely the conditions that help STEM innovation grow (El Nagdi et al., 2018; Erduran, 2020). Studying TQM and innovation in P&SE is therefore directly relevant to STEM policy and practice, and its significance extends beyond STEM alone.

Despite their theoretical compatibility, TQM and educational innovation are seldom studied together in P&SE. Existing reviews treat them in isolation — TQM implementation (Bouranta et al., 2020; Sfakianaki, 2019) or pedagogical innovation (Ilomäki et al., 2023; Zhao et al., 2023) — and the only review that addresses both simultaneously in schools is restricted to quality assessment during COVID-19 (Sarker & Ullah, 2023). Higher education has attracted sustained attention (Glaveli et al., 2021; Kanan et al., 2023), yet P&SE, the level at which quality cultures and learning dispositions are first formed (Sfakianaki, 2019), remains under-examined. The present review responds to that gap and addresses three research questions:

RQ1. What are the main findings of existing studies on TQM and educational innovation in P&SE?

RQ2. What are the main themes that emerge from these findings?

RQ3. What do these themes mean for STEM schooling in P&SE?

LITERATURE REVIEW

In educational settings, the idea of “quality” is broad. It means not only working efficiently but also being fair, inclusive, and relevant (Kakouris et al., 2022). Concepts like “customer” and “product” need to be rethought when applied to schools, where students, teachers, and communities take the place of typical market actors (Kwan, 1996; Soria-García & Martínez-Lorente, 2014; Töremen et al., 2009). TQM in education seeks to improve how schools work through shared goals, committed leadership, and decisions based on evidence (Ah-Teck & Starr, 2014; Arribas Díaz & Martínez-Mediano, 2018; Psomas & Antony, 2017; Sfakianaki, 2019). Motwani and Kumar (1997) suggested a five-step process — deciding, preparing, starting, expanding, and evaluating — that highlights planning and feedback. Empirical research consistently confirms that TQM practices and innovation are linked (Antunes et al., 2021; Teixeira-Quiros et al., 2022; Yirga & Beshir, 2025), because committed leadership, organized processes, and stakeholder collaboration create the conditions in which continuous learning becomes possible (Alhosani & Yaakub, 2020; Antunes et al., 2017; Wu & Gu, 2022). The increasing focus on digital transformation in schools, driven by post-pandemic demands for resilience and ongoing adaptation, makes the combined examination of these constructs especially timely (Mwenda et al., 2026; Tran et al., 2026).

Quality Management Considerations in K–12 STEM Schooling

STEM schooling raises specific quality questions that deserve attention. The meaning of STEM education is itself debated. Martín-Páez et al. (2019) identified at least four different ways researchers define it, ranging from teaching the four subjects separately to fully integrated, problem-based learning. This matters for how “quality” is measured. A school that judges STEM only through standardized mathematics scores uses a very different definition of quality from one that measures integrated problem-solving or engineering design.

STEM provision also faces structural challenges. Margot and Kettler (2019), in a systematic review of teacher views, found recurring barriers that look very similar to common TQM problems: not enough professional development, weak collaboration between science and mathematics teachers, unstable curriculum coherence, and limited support from school leadership. Studies of new STEM-focused schools also show that teacher identity and the ability to adapt — the kind of cultural conditions Deming (2018) considered essential — are as important as any structural input (El Nagdi et al., 2018). Means et al. (2016) reported that inclusive STEM-focused high schools can improve students’ readiness for higher education in STEM, but only when the school’s curriculum and teaching practices remain coherent over time. This is exactly the kind of system-level alignment that TQM frameworks aim to build.

Theoretical Framework

This review draws on four related theoretical models. Deming’s (2018) 14 Points stress leadership commitment and continuous learning, both directly relevant to school management and culture. Rogers’ (2003) Diffusion of Innovations theory describes how new practices spread through a school step by step, supported by peer influence and perceived value. Lewin’s change management model (Al Basthomi et al., 2023; Mahmud et al., 2022) describes change as a process of unfreezing existing practices, moving to new ones, and then making them stable. Adams et al. (2006) highlight leadership and stakeholder engagement as key drivers of systematic innovation, supported by adaptable structures and evidence-based evaluation. Together, these models support the thematic analysis and the proposed TQM-Driven Educational Innovation Model.

RESEARCH METHOD

This systematic literature review (SLR) follows a three-stage framework adapted from Tranfield et al. (2003) and Kitchenham (2004), both of whom developed structured approaches for evidence synthesis in management and education. The three stages are: planning the review, conducting the review, and reporting and disseminating the findings.

Stage I — Planning the Review

This review aims to examine existing research on TQM and educational innovation in P&SE. Before starting, the authors formed an expert panel made up of two school leaders and two academic researchers in educational management. This panel set the review protocol, defining the objectives, the scope, the search strategy, and the inclusion and exclusion criteria. Following Hu et al. (2015), the panel checked the search strategy for completeness, to reduce bias and ensure coverage.

Data were retrieved from the Scopus database, which provides broad coverage of peer-reviewed research and includes major publishers such as Elsevier, Emerald, Wiley, Springer, and Taylor & Francis. Scopus is widely seen as a reliable platform for systematic evidence synthesis in education and management studies (Ikram & Kenayathulla, 2023; Sabtu & Matore, 2024; Sarker & Ullah, 2023). The search followed the PRISMA framework (Moher et al., 2009; Page et al., 2021), which sets out four steps: identification, screening, eligibility, and inclusion.

Stage II — Conducting the Review

A detailed search query was set up using the Scopus TITLE-ABS-KEY fields, combining keywords with Boolean operators. The search string was:

("TQM" OR "total quality management" OR "quality assurance" OR "quality management" OR "total quality") AND ("innovat*" OR "online learning" OR "online education" OR "e-learning" OR "distance learning") AND ("school*" OR "primary education" OR "secondary education").

The full inclusion and exclusion criteria are shown in Table 1. The Scopus search returned 534 records. After removal of duplicates and records excluded by database-level filters (language, document type, subject area), the remaining records were screened by title and abstract and then assessed in full text. The full selection process is shown in Figure 1. This left 30 studies for the final synthesis.

Table 1

Inclusion and exclusion criteria for the literature review

Inclusion Criteria	Exclusion Criteria
Academic journal articles (no time restriction)	Books, gray literature, theses, conference papers, reports
Scopus-indexed journals (Emerald, Science Direct, Springer, Taylor & Francis)	Non-academic or non-Scopus databases
Full-text accessible articles	Articles without full-text access

Articles addressing TQM and innovation in primary or secondary education

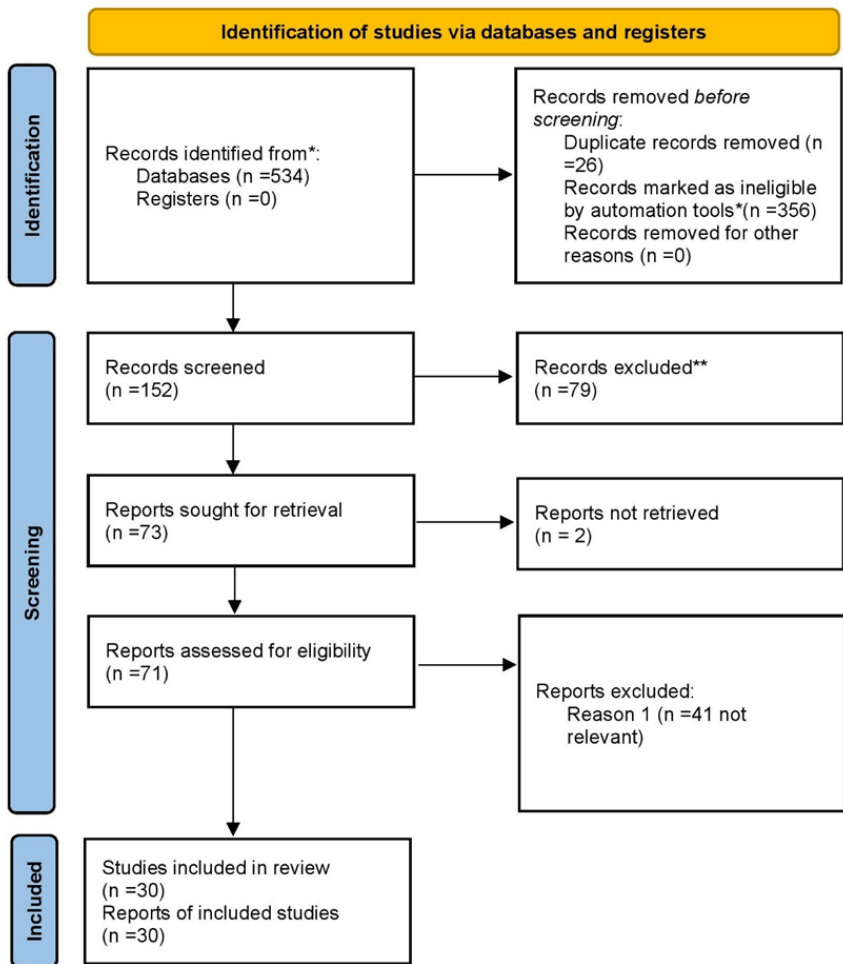
Written in English

Articles on TQM only, innovation only, higher education, vocational, or tertiary settings

Written in languages other than English

Note. Authors' own work

Figure 1
PRISMA flow chart for systematic review



Note. Adapted from Page et al. (2021). *Identification used Scopus database

filters (language, document type, subject area). **Title and abstract screening were conducted manually by two reviewers; no AI-based screening tools were used.

Stage III — Reporting and Dissemination

In the final stage, the authors carried out detailed review, data extraction, and thematic synthesis. Each of the 30 selected studies was independently assessed by two reviewers using the Mixed Methods Appraisal Tool — MMAT (Hong et al., 2018). The MMAT examines clarity of research questions, suitability of design, adequacy of data collection, coherence of interpretation, and acknowledgment of limitations. Differences between reviewers were resolved through discussion. MMAT scores ranged from 3 to 5, with 90% of studies scoring 4 or higher. This indicates moderate to high methodological quality.

The reviewers extracted qualitative and contextual data into Excel spreadsheets for cross-comparison. Findings were grouped into themes using affinity diagramming (Sfakianaki, 2019), with each theme labeled by core-concept keywords. The relative weight of each theme was judged qualitatively based on how often and how centrally the related findings appeared across studies, without imposing a fixed numerical threshold.

RESULTS

Of the 30 studies included, the publications span almost three decades, from Gardner and McNally (1995) to Birasnav et al. (2025). Most were published after 2019. Research activity follows a wave-like pattern and increases during periods of major reform or disruption. The clearest example is the COVID-19 pandemic, which generated a cluster of six included studies on quality and innovation under crisis conditions (Aliyyah et al., 2023; Birasnav et al., 2025; Chen & Mohamed Mokhtar, 2023; Owolabi, 2020; Sarker & Ullah, 2023; Usman et al., 2023). By educational level, four studies focus on primary education, eight on secondary, thirteen on combined primary and secondary, and five do not specify the level. The geographic spread is uneven: eleven studies do not specify the country, three are set in the United States, three in Thailand, two in Singapore, two in Indonesia, two in Africa, and one each in Austria, Bangladesh, Bulgaria, England and Wales, Germany, Kosovo, Mauritius, and South Africa. The 30 studies include a mix of empirical work (surveys, mixed-methods, case studies) and conceptual or review papers. All scored between 3 and 5 on the MMAT, and 90% scored 4 or higher.

Affinity diagramming of the findings produced six interconnected themes: school leadership, stakeholder collaboration, technology adoption, quality assurance, teacher development, and school policy. Table 2 summarizes the consolidated findings, the number of studies contributing to each theme, and the

main authors. The full mapping of every coded finding to its source study is provided in Supplementary_material_appendix_1.

Table 2

Consolidated findings of the 30 included studies, organized by theme

Theme	*Studies (n)	Key consolidated findings	Representative authors
Quality assurance	16	<ul style="list-style-type: none"> • Quality assurance moves through stages (standardization, then local accountability, then diversity and innovation) and reshapes how schools operate, not just measures them. • Performance-based models can limit creativity and curriculum flexibility, leading to "teaching to the test" and superficial collaboration. • Teachers often ignore or misinterpret feedback when internal evaluation cultures are weak. • AI-supported assessment and EdTech certification add value when supported by school institutional structures. 	<p>Aebsapap et al. (2022); Ahmed and Tee (2008); Aliyyah et al. (2023); Chen and Mohamed Mokhtar (2023); Elliott (1997); Kim et al. (2024); Mok (2003); Monova-Zheleva et al. (2021); Ng (2007); Owolabi (2020); Prapphal (2008); Roy et al. (2020); Sarker and Ullah (2023); Terhart (2013); Vrasidas (2003); Webb and Vulliamy (1996).</p>
School leadership	14	<ul style="list-style-type: none"> • Learning-oriented and empowering leadership builds 	<p>Aebsapap et al. (2022); Ah-Teck</p>

Theme	*Studies (n)	Key consolidated findings	Representative authors
		<p>social capital and supports innovation.</p> <ul style="list-style-type: none"> • Hierarchical governance limits how TQM principles are applied in practice, even when school principals support them. • Teachers resist innovations that challenge their existing classroom routines (the "teacher's paradox"). • TQM and similar management ideas spread through schools as fashions; their durability depends on leadership credibility. 	<p>and Starr (2012); Birasnav et al. (2023); Birasnav et al. (2025); Booranamanus and Leksansern (2022); Elliott (1997); Holtzhausen and Botha (2019); Lilyquist (1998); Louis (2007); Ng (2007); Peck and Reitzug (2012); Roy et al. (2020); Usman et al. (2023); Webb and Vulliamy (1996).</p>
Stakeholder collaboration	10	<ul style="list-style-type: none"> • Social capital is the link between leadership and innovation. • Trust shapes whether teachers engage with quality initiatives or treat them as imposed from above. • Curriculum reforms and crisis-driven changes succeed when stakeholder coordination is real, and fail when it is symbolic. 	<p>Aliyyah et al. (2023); Birasnav et al. (2023); Birasnav et al. (2025); Holtzhausen and Botha (2019); Louis (2007); Peck and Reitzug (2012); Sarker and Ullah (2023);</p>

Theme	*Studies (n)	Key consolidated findings	Representative authors
		<ul style="list-style-type: none"> • Cross-sectoral leadership development programs build social capital that travels across institutions. 	Usman et al. (2023); Vrasidas (2003); Weller (1998).
School policy	9	<ul style="list-style-type: none"> • Decentralization can support innovation but may worsen inequality without coherent accountability. • Managerialist reform language reduces real teacher participation and weakens collegiality. • Teachers resist reforms when excluded from their design; relational trust shapes their response. • The policy environment, more than the technical correctness of TQM tools, determines whether reforms last. 	Hackl (1999); Louis (2007); Mok (2003); Ng (2007); Prapphal (2008); Rose and Rochester (2009); Terhart (2013); Vrasidas (2003); Webb and Vulliamy (1996).
Technology adoption	8	<ul style="list-style-type: none"> • Digital innovation succeeds when teamwork, shared vision, and infrastructure are already in place; it fails when teaching method is treated as an afterthought. • Effective virtual learning needs teacher digital skills and adaptable curricula, not just technology. • The pandemic-era acceleration revealed pre-existing gaps between technological 	Aebsapap et al. (2022); Aliyyah et al. (2023); Gardner and McNally (1995); Monova-Zheleva et al. (2021); Owolabi (2020); Prapphal (2008); Sarker and

Theme	*Studies (n)	Key consolidated findings	Representative authors
		readiness and pedagogical integration. • Technology supports teacher development through reflective dialogue, not the medium itself.	Ullah (2023); Vrasidas (2003).
Teacher development	8	• Educational change brings strong emotional reactions; teacher identity and adaptability are decisive. • Self-evaluation and reflective practice support continuous improvement when supported by school structures. • During crises, teacher experience converges around four issues: urgency, challenges, support, and teaching strategies. • Mid-level coordination roles (such as heads of departments) link professionalism, leadership, and quality management.	Aebsapap et al. (2022); Aliyyah et al. (2023); Gardner and McNally (1995); Manea (2021); Owolabi (2020); Prapphal (2008); Terhart (2013); Vrasidas (2003).

Note. Authors' own work. *Studies (n) is the number of distinct studies contributing findings to each theme. Themes are not mutually exclusive; most studies contribute to two or more themes.

Two distributional patterns are evident in Table 2. First, quality assurance (16 studies) and school leadership (14 studies) occur most frequently across the body of evidence, while the remaining four themes - stakeholder collaboration (10 studies), school policy (9 studies), technology adoption (8 studies), and teacher development (8 studies) - appear in fewer studies but consistently alongside the first two. Second, the consolidated findings within each theme show recurring

tensions: between accountability and creativity in quality assurance; between empowering and control-oriented forms of leadership; between substantive and symbolic stakeholder participation; between decentralization and equity-preserving accountability in school policy; between technological provision and pedagogical integration; and between the technical and the relational dimensions of teacher development. A post-hoc analysis of the thirty included studies reveals that only six (20%) explicitly report implementation difficulties, resistance mechanisms, or partial failures (specifically Ah-Teck & Starr, Elliott, Louis, Peck & Reitzug, Terhart, and Webb & Vulliamy) suggesting possible publication bias in the literature, discussed in the Limitations. The remaining 80% of the literature focuses on model feasibility, technical assessment criteria, or positive outcomes.

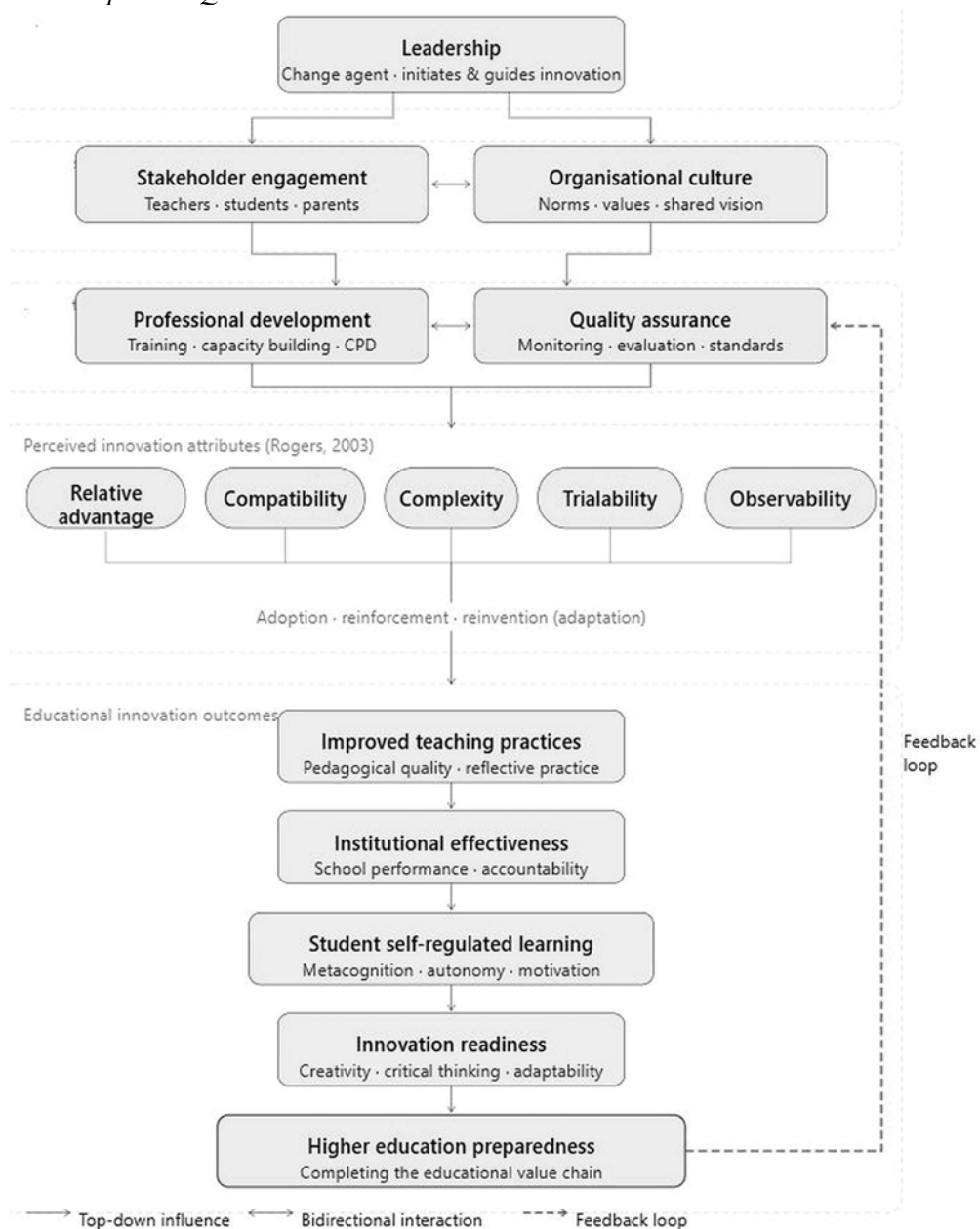
DISCUSSION

The Educational Quality Ecosystem

The six themes are best understood as parts of an Educational Quality Ecosystem, not as independent factors. Read through Rogers' (2003) Diffusion of Innovations theory, school leadership acts as the main change agent: its credibility shapes how quickly innovations spread. Stakeholder collaboration creates social channels along which they travel. Quality assurance provides feedback loops that allow schools to adjust innovations to local conditions. Teacher development reduces the perceived complexity of new practices. Technology adoption provides the infrastructure that helps innovations grow in scale. School policy shapes the governance conditions that either help or block this process. Figure 2 shows the proposed TQM-Driven Educational Innovation Model. The model is consistent with Deming's (2018) emphasis on systematic, evidence-based management and with Lewin's change cycle of unfreezing, moving, and refreezing (Al Basthomi et al., 2023), which fits the quality assurance → innovation → institutionalization pathway shown in the model.

Although the literature generally presents TQM positively, several studies highlight challenges associated with its implementation in schools. Terhart (2013) argues that teacher resistance should be viewed as a rational response to continuous reform pressures, particularly when initiatives are introduced by external actors perceived as disconnected from classroom realities. These pressures may result in symbolic rather than meaningful compliance. Webb and Vulliamy (1996) found that school leaders often respond to accountability demands by producing documentation mainly to satisfy external requirements, while genuine collegial collaboration remains limited. A further challenge concerns the mismatch between industrial management models and educational change. Business-oriented reforms often follow short-term cycles, whereas sustainable school improvement requires long-term stability and continuity.

Figure 2
Proposed TQM-Driven Educational Innovation Model



Note. Authors' own work

Why TQM Fails in Schools: Evidence from the Literature

Limited resources can also intensify these difficulties, as schools may devote considerable time to monitoring performance indicators and administrative procedures instead of instructional improvement. Elliott (1997) suggests that an excessive focus on control and performativity may ultimately undermine authentic educational development. In such contexts, TQM risks becoming a bureaucratic exercise that increases teachers' workload without delivering substantial pedagogical benefits, particularly in schools characterized by low levels of relational trust.

From the Findings to STEM Schooling

Each of the six themes carries specific implications for STEM schooling. Quality assurance, the most common theme in this synthesis, can also be the biggest obstacle to STEM if it is applied without thought. Standard tests of mathematics or science scores capture only part of what integrated STEM curricula aim to develop, such as engineering design, computational thinking, and inquiry skills (Cao et al., 2025; Erduran, 2020). STEM education itself can be defined in at least four different ways, ranging from teaching the subjects separately to fully integrated learning (Martín-Páez et al., 2019). When TQM systems default to convenient single-score measures, the tension that Elliott (1997) described between accountability and creativity becomes especially serious: the assessment system can end up working against the curriculum it is supposed to evaluate.

School leadership in STEM contexts must be more demanding than the general literature suggests. In addition to the social-capital-building leadership identified by Birasnav et al. (2023, 2025) and Holtzhausen and Botha (2019), STEM principals also need subject-specific judgment, about laboratory provision, integrated curriculum design, and partnerships with universities and informal learning organizations (Rehman, Huang, Mahmood, Abbasi, et al., 2025). When this combination is missing, TQM-style continuous improvement risks staying nominal in STEM departments, even when it is working in other parts of the school. Stakeholder collaboration in STEM extends in similar ways. STEM schooling depends on networks that reach into universities, industry mentors, and informal learning organizations such as science museums and maker spaces. Means et al. (2016) showed that lasting STEM pathways depend on these structures, not on goodwill alone. El Nagdi et al. (2018) added an important point: STEM teacher identity is partly formed in these external communities, which gives the multi-stakeholder pattern identified by Aliyyah et al. (2023) and Usman et al. (2023) a clear STEM dimension.

However, supply-side problems, including teacher shortages and uneven national readiness for STEM, mean that even well-designed professional learning rarely reaches the scale needed to produce measurable system-wide effects (Rehman, Huang, Mahmood, Abbasi, et al., 2025). Technology adoption in STEM

is also distinctive: in STEM subjects, technology is not only a way to deliver content. It is often part of the content itself, students use computational tools, simulations, and AI-based resources as part of doing science or engineering (Siddiqi, 2025; Chen et al., 2024). The TQM principle of fitness-for-purpose is therefore harder to apply in STEM than in subjects where technology is mostly a delivery channel. Finally, school policy carries an equity dimension that general literature only partly captures. STEM-focused schools, magnet programs, and specialized academies offer concentrated opportunities for innovation, but they can also widen inequality if they are not paired with equity-oriented quality frameworks (Means et al., 2016).

What Is Settled and What Depends on Context

Some findings appear consistently across studies, while others depend strongly on the country or context. The central role of quality assurance and school leadership is the most consistent finding. It holds across regions and across decades, suggesting that these two themes function as anchors of TQM diffusion in many different governance models. The biggest differences between studies appear at the level of policy architecture. Singapore's combination of decentralized execution and central quality control (Mok, 2003; Ng, 2007), Austria's autonomy without accountability (Hackl, 1999), and post-ERA England's managerial directive culture (Webb & Vulliamy, 1996) all use the same TQM language but produce very different practices. Roy et al.'s (2020) study of faith-based education in Bangladesh extends this difference into a domain rarely covered by mainstream TQM research. The geographical distribution of evidence is also uneven. Eleven of the 30 studies do not specify a country, while large education systems in Latin America, much of sub-Saharan Africa, and the Middle East are barely represented.

CONCLUSIONS & PRACTICAL IMPLICATIONS

This systematic review aimed to identify and synthesize research findings on TQM and educational innovation in P&SE. The evidence shows that the relationship between quality management and innovation is complex and shaped by leadership capacity, collaborative cultures, quality assurance systems, teacher development, technology integration, and governance structures. By bringing together findings from many different national contexts, this review contributes to comparative education by showing how the same TQM principles can produce different outcomes depending on policy environments, cultural norms, and how centralized the school system is. The proposed TQM-Driven Educational Innovation Model places leadership as the main driver, working through stakeholder collaboration and quality assurance to mediate between TQM practices and educational innovation outcomes.

From a K–20 perspective, the quality cultures and self-regulated learning habits that TQM-aligned P&SE practices help build are foundational investments that benefit higher education (Fullan & Langworthy, 2014; Hattie, 2009). Policymakers and higher education administrators should therefore see TQM in P&SE not as a separate concern but as a strategic upstream investment that reduces remedial costs and improves the quality of higher education intake.

Implications for STEM Schooling

Translating these findings into the STEM context produces a sharper implication. STEM schooling is often described as a national priority but remains chronically under-resourced (Cao et al., 2025; Rehman, Huang, Mahmood, Abbasi, et al., 2025). The TQM-Driven Educational Innovation Model proposed here suggests that the most important STEM-specific investments are not the visible technology purchases, but the organizational conditions — leadership credibility, distributed teacher learning, fitness-for-purpose assessment, and equity-oriented governance — that allow STEM innovations to last over time. In practical terms, school leaders should treat STEM departments as integrated parts of the school’s quality system, not as separate structures with their own priorities. Stakeholder networks should be deliberately extended into universities and STEM-related professional communities, recognizing that STEM teacher identity is partly formed outside the school (El Nagdi et al., 2018). Assessment policy should resist the convenience of single-metric accountability and instead develop richer approaches that track the integrated competencies STEM curricula aim to build (Erduran, 2020). Without these organizational commitments, STEM provision risks remaining a curricular layer, not a school-wide cultural commitment, and benefits will continue to be uneven.

The review highlights several persistent tensions — most notably between standardization and creativity, between participation and control, and between technological ambition and practical capacity. These tensions are not just operational obstacles. They reflect deeper structural conditions in educational systems. Recognizing these contradictions is essential when designing reforms that promote innovation without harming educational equity or system coherence. Sustainable quality improvement requires leaders to balance accountability with professional autonomy, and innovation with stability.

More broadly, school leaders should pair quality assurance with shared leadership, professional learning communities, and pedagogically integrated technology, while addressing bureaucratic inertia through participatory decision-making. Against this background, implementing TQM without attending to teacher workload, professional trust, and local school culture risks producing compliance-oriented behaviors rather than genuine innovation. Policymakers should therefore pair TQM frameworks with participatory governance structures, adequate resources, and sustained professional development.

Taken together, the prioritized thematic framework and the TQM-Driven Educational Innovation Model offer practical instruments for strategic planning and reform design. These findings are now informing a follow-up empirical study through a self-administered teacher survey in primary and secondary schools, which will indicate whether the patterns visible in the literature also hold in practitioners' lived experience.

LIMITATIONS & SUGGESTIONS FOR FUTURE RESEARCH

This review has several limitations. First, it relied exclusively on the Scopus database and peer-reviewed English-language journal articles, which may have excluded relevant studies published elsewhere. Second, variations in the definitions of key concepts such as TQM, quality, and innovation limited the consistency of the synthesis. In addition, although the review discusses implications for STEM schooling, the search strategy was not restricted to STEM-specific terms and therefore reflects the broader context of P&SE. The literature also predominantly emphasizes technical criteria and positive outcomes, suggesting a possible publication bias toward successful TQM implementations while overlooking failures and systemic barriers.

Future research should incorporate additional databases, non-English-language studies, and STEM-focused search strategies to provide a broader and more discipline-specific understanding of TQM and innovation in education. Greater attention should also be given to unsuccessful implementations to develop a more balanced and realistic perspective on the challenges of quality management in educational settings.

Acknowledgments / AI Tools statement

The authors used generative AI tools (Writefull; Grammarly) to assist with language editing and formatting during the manuscript preparation process. These tools were not used to strengthen research content, analyze data, or draw conclusions. All ideas, interpretations, and findings are the original work of the authors.

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