Communication Competency of School Leaders: A Systematic Review on the Impact on Effective STEM Teaching Professional Development Strategies

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ABSTRACT

Communication competency among school leaders is crucial for enhancing educational outcomes, particularly in STEM education. This systematic review aims to synthesize existing research on the interplay between school leaders' communication competencies and STEM professional development outcomes, addressing the gap in understanding how these skills impact the effectiveness of STEM teaching strategies. The study's objectives are to identify key communication competencies of school leaders influential in STEM professional development, analyze their impact on the effectiveness of professional development strategies, and provide recommendations for enhancing STEM teaching through improved communication practices. A systematic literature review was conducted using Scopus and ERIC databases, focusing on studies published between 2014 and 2024. From 247 initially identified papers, 21 articles were selected for final analysis based on predefined criteria. The analysis revealed three main themes: (1) Communication competency of school leaders is crucial for effective teaching and leadership; (2) STEM and professional development in education require multifaceted approaches, including cultural competence and collaborative problem-solving; (3) Digitalization and technology integration present both challenges and opportunities for school leaders in enhancing STEM education. The study highlights the significant role of communication competency in school leadership, particularly in fostering effective STEM professional development. The significance of targeted communication training for school leaders, the essential role of cultural awareness in leadership development, and the imperative for strategic support in technology integration in education are emphasized. These results offer valuable perspectives for policymakers and educators aiming to enrich STEM education by advancing leadership communication strategies.

1. Introduction

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In the continuously changing environment of education, the responsibilities of school administrators go beyond mere administrative tasks to becoming crucial facilitators of academic quality and student success [1]. Among the various facets of effective school leadership, communication competency stands out as a critical skill that influences various educational outcomes [2]. This is particularly relevant within the realm of STEM (Science, Technology, Engineering, and Mathematics) education, where there is a need for an interactive and cooperative method in both pedagogy and career advancement [3].

Recent educational reforms have underscored the significance of STEM education in equipping students for the requirements of the workforce in the 21st century [4]. However, the effectiveness of STEM teaching is heavily reliant on the quality of professional development (PD) that educators receive [5]. School leaders, in their capacity as facilitators of professional development (PD), are instrumental in influencing the professional development of educators through their communication strategies. The adept communication skills demonstrated by school leaders have the potential to cultivate a culture of ongoing learning, cooperation, and creativity, consequently enriching the general standard of STEM education [6].

While existing literature has extensively documented the general importance of communication competency in educational leadership [7,8], there remains a significant research gap in understanding the specific mechanisms through which school leaders' communication competencies influence STEM teaching effectiveness. Current research has not adequately addressed how different communication strategies employed by school leaders specifically impact STEM professional development outcomes. Additionally, there is limited empirical evidence synthesizing the relationship between leadership communication approaches and successful STEM teaching practices. This systematic literature review (SLR) aims to address these gaps by examining the intricate relationship between school leaders' communication competencies and STEM educational outcomes.

The objectives of this SLR are threefold: first, to identify the key communication competencies of school leaders that are most influential in the context of STEM PD; second, to analyze the impact of these competencies on the effectiveness of PD strategies; and third, to offer evidence-based recommendations for school leaders and policymakers to enhance STEM teaching through improved communication practices [9]. This review is particularly timely given the increasing emphasis on STEM education and the need for effective leadership in this domain.

In the subsequent sections, we present a comprehensive methodology for this review, followed by a detailed analysis of findings from the literature. Through systematic examination of existing research, this study aims to bridge the identified knowledge gap by providing concrete insights into how school leaders' communication competencies can be leveraged to enhance STEM education outcomes. The findings will contribute to both theoretical understanding and practical applications in educational leadership, particularly in the context of STEM education development [10].

2. Literature Review

Teacher readiness for parental engagement has become a crucial competence due to the heightened emphasis on parent involvement in K–12 education. The standards movement in education has consequently incorporated parental engagement within teacher standards. This literature review critically analyzes how Canadian policy documents address the readiness of teachers and school leaders for parental engagement. Teacher readiness is defined as the ability to establish relationships, support communication, and build partnerships with parents and families. Current policy provisions enhance teachers' capacity for parental engagement by promoting an asset-

based approach and recognizing the diversity among parents. However, these standards fall short in differentiating between parental involvement in schooling and parental engagement in education and learning, and they largely overlook the influence of social inequality on parental engagement. The implications for new teacher standards include the necessity to center parental engagement on parents and families and address inequalities that impact parental engagement [2].

This literature review examines the substantial impact of a short-term international study abroad program in England on the cultural competencies of doctoral students in educational leadership. Focusing on the experiences of six students, the study found significant improvements in their knowledge of educational systems, self-awareness, relationship and travel skills, and attitudes towards diversity. Utilizing pre- and post-surveys and follow-up interviews, the study revealed an enhanced self-efficacy in culturally competent school leadership among the participants. The findings contribute to the limited literature on study abroad benefits for doctoral students in educational leadership, emphasizing the importance of comprehensive preparation and support before, during, and after international experiences. This review calls for further research on the effects of study abroad programs on graduate students across various educational fields, including those in non-English-speaking countries, to enhance cultural competencies and cross-cultural communication skills. This highlights the interconnectedness of cultural competence with effective educational leadership and teacher readiness for parental engagement [3].

This literature review examines the implementation and impact of remote special educational consultation for teachers in a rural municipality in Sweden, highlighting how advances in communication technologies have made this approach a promising strategy for supporting students with special educational needs and their teachers in remote areas. Through the responses of special educators and teachers to an online questionnaire (N=11), the study identifies both challenges and opportunities associated with remote consultation. Challenges include a lack of professional commitment and consensus, insufficient trust, knowledge, and support from school leaders, and barriers related to distance and technology. Conversely, opportunities are found in the increased access to special educational competence, improved structure in consultations, and enhanced professional development and collaboration. The findings underscore the potential of remote special educational consultation as an effective, cost-efficient method to enhance access to special educational expertise and support for teachers in rural and underserved schools, further emphasizing the interconnectedness of cultural competence, effective educational leadership, and teacher readiness for parental engagement in diverse educational contexts [4].

This review critically assesses the Digital Teaching Competencies (DTCs) exhibited by elementary education (EE) instructors across diverse educational institutions in Peru, with a specific focus on the fusion of technological tools and pedagogical strategies within academic settings. Employing a quantitative research methodology, the investigation adopts a non-experimental comparative descriptive design along with a non-probabilistic purposeful sampling technique, encompassing a total of 3,142 EE educators spanning preschool, elementary, and high school tiers situated in both rural and urban regions of Arequipa, Peru. Through the utilization of the DigCompEdu Check-In tool derived from the European Framework of Digital Competence, the research evaluates the digital proficiencies of the teaching cohort. Outcomes reveal a predominant attainment of Integrator (B1) level proficiencies among the instructors, trailed by Expert (B2) and Explorer (A2) competencies, while showcasing lower proportions at the advanced Leader (C1) and Pioneer (C2) tiers. These results underscore the exigency for innovative approaches geared towards augmenting DTCs within the teaching community. The study establishes a connection between the significance of digital adeptness in the realm of education and broader topics encompassing cultural acumen, efficacious educational governance, and the preparedness of educators for fostering parental involvement,

thereby emphasizing the indispensable role of technology in contemporary educational paradigms. [5].

This literature review examines how school leaders in Kazakhstan managed schools during the COVID-19 closures, focusing on crisis leadership and digital pedagogy. An online survey with 1,298 school leaders, representing 17.5% of all Kazakhstani schools, assessed their views on teachers' digital competence, support for digital pedagogy, communication with parents, and teacher autonomy and monitoring. Findings from bivariate tests revealed that many schools provided online professional development to enhance digital instruction, influenced by school location and size. School leaders' confidence in teachers' online teaching abilities significantly increased after digital pedagogy training. Despite regular communication with parents, which increased workloads, especially for women and urban leaders, most leaders allowed teachers to select online platforms and adapt curriculum content while monitoring their attendance and lessons. These practices varied by the school's medium of instruction. This study contributes to understanding crisis leadership by highlighting how school closures impacted digital competence, communication, and teacher autonomy, with variations by school type, location, and leader gender. The findings emphasize the need for equitable professional development, effective stakeholder communication, and a balance between autonomy and monitoring in post-pandemic school leadership. This review connects these insights to broader themes of digital teaching competence, cultural competence, effective educational leadership, and teacher readiness for parental engagement in diverse educational contexts [6].

This literature review explores the use of Eye-Gaze Tracking Technology (EGTT) as both a communication and assessment tool for learners with profound and multiple learning difficulties (PMLD). Focusing on its application in confirming teacher assessments, the research investigates how EGTT addresses assessment barriers faced by teachers in evaluating students with PMLD. Data from four students with profound and multiple learning disabilities (PMLD) and physical disabilities in a special needs school was collected using qualitative methods, including heat map analysis, parent questionnaires, and video observations of teaching. The study reveals that Enhanced Green Technology Tools (EGTT) offer valuable insights into individual learner engagement with learning objectives, which traditional methods may not capture. This underscores the importance of innovative assessment tools in understanding and enhancing student engagement, further emphasizing the need for educational leadership that fosters diverse and inclusive learning environments. This innovative technology offers independent data to inform teachers' assessments of cognitive abilities, enhancing the accuracy and confidence of their professional judgements. This review underscores EGTT's potential to guide Special Educational Needs (SEN) leaders and schools in investing in technology that supports comprehensive assessment practices for students with PMLD, thereby contributing to advancements in educational technology and inclusive educational practices [7].

This literature review examines the self-perceived digital competencies of Lebanese school teachers, comparing their perspectives with those of school leaders and assessing the alignment with school needs. Utilizing the European Framework for the Digital Competence of Educators (DigCompEdu), the study evaluates teachers' proficiency in managing digital resources, promoting learners' digital literacy, and employing digital tools for communication, collaboration, and problem-solving. The findings indicate that while teachers demonstrate strengths in handling digital resources, they exhibit weaknesses in fostering digital literacy among students and effectively utilizing digital tools. Additionally, school leaders' perceptions diverge, highlighting concerns regarding teachers' abilities to promote safe and responsible digital tool use and manage digital resources effectively. Employing a mixed-method approach with a cross-sectional descriptive design, the study includes

170 in-service teachers surveyed and interviews with 10 school leaders across various Lebanese schools. This review connects these findings to broader discussions on digital teaching competencies, educational leadership, and strategies for enhancing digital literacy among educators in diverse educational settings [8].

This literature review investigates leadership practices in Malaysian primary schools with small enrolments, specifically those with up to 150 students situated in rural areas. Focusing on experienced head teachers, the study examines the challenges these schools face, such as financial constraints, infrastructure issues, limited human resources, and teacher competence concerns. Through qualitative analysis of interviews with head teachers from five small schools, the research identifies strategies employed to address these challenges, including innovative fundraising approaches, personal development in information and communication technology skills, and active roles in instructional leadership. The findings underscore the resilience and creativity of school leaders in navigating these obstacles to provide quality education. The study suggests implications for policymakers and school leaders involved in managing small schools, emphasizing the importance of supporting leadership development and resource management. However, further research with a larger sample size is recommended to comprehensively understand the complexities of managing small schools and to identify effective strategies for overcoming these challenges [9].

This literature review delves into the pivotal role of school principals in contemporary educational settings, emphasizing their leadership in fostering academic achievement across diverse school domains. Principals' effectiveness is contingent upon a range of competencies including leadership, communication, analytical thinking, cooperation, creativity, flexibility, and a commitment to ongoing learning. Importantly, the integration of these skills with technology has become indispensable in recent decades. The review conducts a comprehensive analysis of theses and dissertations from Turkey, focusing on school principals' perspectives regarding technological leadership, technostress, and Information and Communication Technology (ICT) proficiency. Following Arksey and O'Malley's (2005) five-stage framework, the review initiates with formulated research questions, proceeds to search the Higher Education Council (HEC) database for relevant studies over the past two decades using the keyword "School Principal," employs PRISMA (2009) methodology for systematic selection based on inclusion and exclusion criteria, conducts analysis using various metrics, and summarizes findings aligned with the research questions. This synthesis offers nuanced insights into how technological leadership, technostress impacts, and ICT proficiency are perceived and addressed by school principals in Turkey, contributing to a deeper understanding of effective educational leadership in the digital age [10].

This literature the review underscores the significance of disability inclusion in medical education, with a particular focus on addressing challenges such as stereotypes, inadequate familiarity with accommodations for students with physical disabilities, and outdated technical standards that impede their full participation. The study highlights proactive measures adopted by medical school leadership, disability professionals, and surgical clerkship teams at the University of Colorado. These efforts were aimed at establishing reasonable accommodations for a third-year medical student with a thoracic spinal cord injury as they embarked on a surgical clerkship. Results demonstrate that with early communication and planning, the student successfully completed the clerkship, achieving honors while utilizing necessary accommodations for procedural and clinical skills. This case underscores the significance of proactive disability-related adjustments in ensuring accessible educational experiences and emphasizes the value of diversity and inclusive practices in enhancing surgical education and broader medical education communities [11].

This literature review explores the incorporation of health systems improvement into medical education, aiming to bridge historical divides in early training that often isolate clinical skills from

systems thinking. A notable example is the Clinical Microsystems Clerkship launched at the University of California, San Francisco School of Medicine in 2016. This initiative pioneers an approach where first-year and second-year medical students are immersed in longitudinal clinical microsystems, collaborating with physician coaches and interprofessional teams. Through weekly participation in these microsystems, students engage in guided learning encompassing medical history taking, physical examination, patient communication, interprofessional teamwork, and health systems improvement. Evaluation methods include standardized patient assessments and reports on improvement projects, with outcomes centered on student satisfaction, proficiency in clinical skills, and demonstrated learning in systems improvement. Findings reveal robust student satisfaction and perceived professional development benefits, supported by assessments demonstrating high accuracy in clinical skills and the successful implementation of multiple improvement projects in various healthcare environments. Graduating students highlight the significance of both clinical proficiency and understanding health systems for their future professional endeavors, showcasing their project experiences in residency applications and scholarly publications. This review underscores the transformative impact of early integration of systems improvement and clinical skills training in medical education, emphasizing the need for continued investigation into long-term impacts and the sustainability of these educational innovations [12].

This literature review investigates the adoption of competency-based medical education (CBME) throughout the continuum from undergraduate medical education (UME) to graduate medical education (GME), with a specific emphasis on the obstacles encountered by medical educators when integrating CBME assessments. Adopting a constructivist-oriented qualitative methodology, the study conducted in-depth, semistructured interviews with UME and GME leaders involved in CBME between February 2019 and January 2020. Interviews were conducted by team members with backgrounds in both UME and GME to capture comprehensive perspectives. Thematic analysis of the transcripts revealed four main themes: mistrust between UME and GME sectors, misalignment of goals especially in residency selection processes, inadequate communication regarding competence, and inflexible training timeframes that do not accommodate individual competency trajectories. Despite shared intentions to adopt CBME principles throughout medical education, these challenges hinder effective implementation across institutions and programs. Addressing these themes is crucial for enhancing the UME-GME transition and facilitating successful integration of CBME across the continuum [13].

This literature review analyzes gender inequalities in qualitative evaluations of resident performance within medical education, specifically investigating narrative feedback given by faculty during inpatient medicine rotations across six Internal Medicine residency programs spanning from 2016 to 2017. Using qualitative content analysis, this study examined thematic variations in faculty comments between male and female residents, focusing specifically on post-graduate years (PGY) 2 and 3 when residents assume leadership roles within teams. Among the 3,383 evaluations reviewed, 55.2% pertained to male residents and 44.8% to female residents. Findings indicated that comments concerning female residents frequently highlighted attributes related to relationships and confidence, particularly in leadership capacities. These comments frequently highlighted communal skills, interpersonal abilities, and efforts in team support, framing confidence as crucial for effective leadership. Conversely, assessments of male residents tended to focus less on relational aspects and more on technical skills and competency in decision-making. The study suggests that gendered expectations may influence how residents are evaluated, potentially leading to biased feedback that disadvantages female residents. Addressing these findings is essential for promoting equitable assessment practices and providing comprehensive feedback across all competencies in medical education [14].

This literature review examines the impact of limited culturally responsive knowledge, skills, and engagement among school leaders on racial disparities in diverse student outcomes such as school pushout, discipline rates, and the opportunity gap in U.S. public schools. It emphasizes the crucial role of authentic engagement by school leaders and teachers in fostering a sense of belonging and connectedness among students, families, and school staff. The study's primary focus is to explore principals' beliefs and insights regarding school leaders' and students' engagement behaviors and their influence on cultural competence, school climate, and educational achievement. Qualitative data were collected via structured interviews with 40 school leaders from a major urban school district in the Midwest, employing thematic coding to identify emerging themes from principals' statements. The results corroborate established literature on effective communication strategies, professional development requirements, and factors influencing cultural competence, school climate, and engagement among leaders and students. The review concludes by offering initial recommendations for future research and practical interventions aimed at addressing these pivotal issues in educational leadership and student outcomes [15].

This literature review explores the growing digital divide between rural and urban regions, focusing on its implications for educational equity stemming from disparities in teachers' competence in digital instruction. A comprehensive survey involving 11,784 K–12 teachers in China (43.40% from rural schools and 56.60% from urban schools) investigated factors affecting digital teaching competence, including attitudes toward ICT, ICT skills, and data literacy. The findings highlighted substantial disparities, indicating that rural teachers demonstrate lower levels of ICT attitude, ICT skills, data literacy, and overall competence in digital teaching compared to their urban counterparts. Employing the Blinder-Oaxaca decomposition method, the study pinpointed data literacy and ICT skills as key factors contributing to this digital divide. These insights underscore the urgent necessity for policymakers, school leaders, and educators to implement focused interventions aimed at reducing the digital gap and improving digital teaching competence in rural schools [16].

This literature review presents a tool aimed at facilitating discussions on expectations between students and supervisors in workplace learning settings. The background underscores the common ambiguity surrounding roles in facilitating learning opportunities at work, emphasizing the importance of clarifying and aligning these expectations to optimize learning outcomes. The study validated the tool using three types of evidence-response process, content, and consequences-drawing on perspectives from educational leaders, medical teachers, and students across four medical schools. Methodologies included cognitive interviews, a modified Delphi approach, and analysis of completed tools and narrative feedback. Results indicated initial misalignment between student and supervisor expectations, with the tool effectively prompting conversations that improved alignment and consensus on responsibilities. Students reported high satisfaction with the process and perceived greater clarity in expectations post-discussion. Overall, this study underscores the tool's value in facilitating constructive dialogues about responsibilities, thereby potentially optimizing learning experiences in workplace settings [17].

3. Methodology
3.1 Identification

The systematic review procedure employs three key stages to select numerous relevant publications for this report. Initially, the process involves identifying keywords and searching for related terms using resources such as thesauruses, dictionaries, encyclopedias, and previous research. Subsequently, search strings tailored to the Scopus and ERIC databases (see Table 1) were

developed based on identified keywords. This approach facilitated the retrieval of 247 papers in the initial phase of the systematic review process from both databases.

Table 1
The search string

Scopus	TITLE-ABS-KEY (communication AND competency AND leader AND school) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))
ERIC	https://eric.ed.gov/?q=communication+AND+competency+AND+leader+AND+school&ff1=dtySince_2015&ff2=pubJournal+Articles

The keywords and search strings were developed based on a thorough review of the relevant literature and discussions among the research team. The search terms "communication", "competency", "leader", and "school" were chosen to align with the study's focus on the impact of school leaders' communication competencies on educational outcomes. Additionally, the search was limited to publications in English, within the social science subject area, and in the final publication stage to ensure the review included high-quality, peer-reviewed research.

3.2 Screening

During the screening phase, the research items collected were scrutinized for their relevance to the predefined research question(s). This involved assessing whether the content of each item aligned with the study's focus on the impact of school leaders' communication competence and cultural sensitivity on educational outcomes. Duplicate papers were initially removed from the list of retrieved publications. The screening process excluded 247 papers in its first stage, with 59 papers undergoing further evaluation based on specified exclusion and inclusion criteria (see Table 2). A primary criterion was the type of literature, prioritizing research papers as sources of practical recommendations. Other publication types, such as reviews, meta-syntheses, meta-analyses, books, book series, chapters, and conference proceedings, were not included in this study. Additionally, the review was confined to papers published in English between 2014 and 2024. It is noteworthy that two publications were excluded due to duplication.

Table 2
The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2014 – 2024	< 2014
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject Area	Social Science	Besides Social Science / Others
Country	All Countries	-

The inclusion and exclusion criteria were developed to ensure the review focused on high-quality, peer-reviewed research articles published in English within the past decade, specifically addressing the impact of school leaders' communication competencies on educational outcomes. The decision to exclude other publication types, such as reviews and conference proceedings, was made to

maintain the study's focus on empirical research findings that could provide practical recommendations.

3.3 Eligibility

Following the application of inclusion and exclusion criteria, the final sample for the review was established. Transparency regarding the specific research items included is essential for readers to understand the basis of the review's findings. The third stage of eligibility yielded a total of 53 articles. During this phase, thorough reviews of article titles and significant content were conducted to ensure alignment with the inclusion criteria and relevance to the study's research objectives. As a result, 32 publications were excluded due to insufficient alignment of their titles and abstracts with the study's purpose, as supported by empirical evidence. Ultimately, 21 papers were selected for detailed analysis.

3.4 Data Abstraction and Analysis

This study employed integrative analysis as a primary assessment approach to systematically explore and synthesize diverse research methodologies, including quantitative, qualitative, and mixed methods. The overarching goal of this comprehensive investigation was to uncover significant themes and sub-themes related to the impact of school leaders' communication competence and cultural sensitivity on educational outcomes. The initial phase of theme development began with rigorous data collection. Illustrated in Figure 1, researchers systematically reviewed 21 selected publications to identify assertions and content pertinent to the study's themes. Subsequently, the authors critically evaluated these studies regarding their findings on the influence of school leaders' communication competence and cultural sensitivity. The methodology applied across all studies and their respective findings underwent meticulous scrutiny. Collaborating with co-authors, the authors derived themes grounded in the evidence relevant to the study's context. Throughout the data analysis phase, a detailed log documented analyses, perspectives, unresolved issues, and pertinent insights for data interpretation. Discrepancies in theme development were identified through comparative analysis of findings, and resolutions were sought through author discussions. Resultant themes were iteratively refined to ensure coherence and consistency. To ensure the validity of the findings, examinations were conducted by two experts, one specializing in educational leadership and the other in STEM education. The expert review phase ensured clarity, importance, and adequacy of each sub-theme by establishing domain validity. Adjustments based on author discretion, informed by expert feedback and comments, were incorporated accordingly.
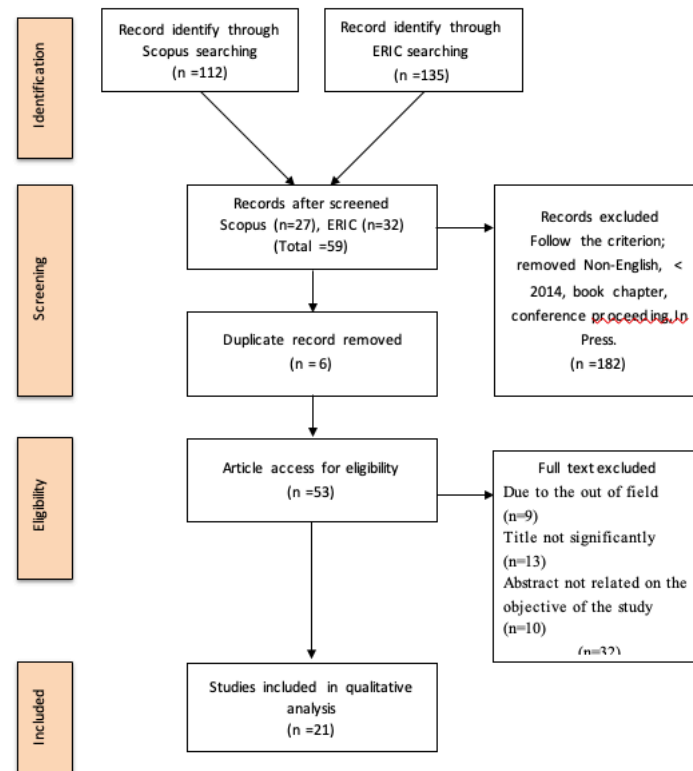
Fig. 1. Flow diagram of the proposed searching study [18]

4. Suggestions for Improvement

While the article provides a comprehensive review of the literature on the communication competencies of school leaders and their impact on educational outcomes, it could be strengthened by incorporating an analysis of how contextual factors may influence these dynamics.

The article could be enhanced by discussing how different contextual elements, such as cultural and socio-economic considerations, shape the development and application of leadership communication skills, and how these competencies may need to be tailored to meet the unique needs and challenges of diverse educational settings. Incorporating this contextual analysis would offer valuable insights into how school leaders can effectively adapt their communication approaches to better serve the communities they work within.

By addressing the influence of contextual factors, the article would provide a more nuanced understanding of the complex relationship between school leaders' communication competencies and educational outcomes. This would help readers gain a deeper appreciation for the importance of considering local contexts when implementing strategies to enhance communication skills and, ultimately, improve educational practices and student success.

5. Result and Finding
5.1 Theme 1: Communication Competency of School Leaders

This study aimed to develop a model for evaluating teaching competence by identifying key constructs and skills. Conducted as a cross-sectional survey, it involved 328 secondary school teachers in Terengganu, Malaysia. Data were collected through questionnaires and analyzed using SEM-AMOS, focusing on loading factor, convergent validity, discriminant validity, and composite

reliability. The study successfully established a measurement model of teaching competency, comprising three primary constructs: communication with students, teaching strategies, and classroom management. Additionally, 21 behavioral skills were identified as critical for enhancing teaching competence. These findings suggest significant implications for educators and policymakers, recommending the integration of these results into teacher training curricula, supervision practices, incentive structures, and promotional criteria to elevate the quality of teaching [19].

This study examined teachers' perceptions of the technology leadership competencies of school administrators in state and private elementary schools in Beylikdüzü, Istanbul, during the 2013-2014 school year. Utilizing the "Technology Leadership for Educational Administrators Scale" with a Cronbach Alpha reliability coefficient of 0.95, data were collected from a sample of 110 teachers selected through simple random sampling. The findings indicated a low arithmetic mean ([x-bar] = 1.72), suggesting that teachers generally perceived administrators as never acting as technology leaders. Despite recognizing administrators' positive attitudes towards technology, teachers noted a lack of engagement with school staff, parents, and students to enhance the use of information technologies. The study concluded that to institutionalize technology leadership, measures should be taken to translate administrators' positive attitudes into practical actions. Recommendations include encouraging school administrators to pursue postgraduate degrees and implementing regulations to involve all school stakeholders in decision-making processes related to information and communication technologies. These findings underscore the importance of structured leadership training in communication and technology, as highlighted in previous studies on teaching competence and communication behaviors of school leaders [20].

This study aimed to identify the key dimensions of a teacher leadership model using the Teacher Leadership Self-Assessment (TLSA) by Katzenmeyer and Moller (2009) [21]. The instrument, consisting of 47 items across seven dimensions, was administered to 130 teachers at Mara Junior Science Colleges in Kelantan, Malaysia. Structural Equation Modelling (SEM) techniques, including Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), were employed to validate the dimensions. The analyses revealed that four dimensions, encompassing 28 items, were most relevant for teacher leadership in the Malaysian context. These dimensions are: (1) self-awareness, (2) communication and change, (3) diversity and instructional proficiency, and (4) organized and continuous improvement. These findings highlight the roles and values essential for teacher leaders and underscore the importance of structured leadership development, resonating with previous research on teaching competence and the critical role of communication skills in educational leadership [22].

This article examines the international contributions to school, family, and community partnerships and highlights several emerging themes. Studies in Part I reveal that future teachers worldwide are inadequately prepared to implement effective partnership programs with students' families. Part II presents intervention results where future teachers practiced communication strategies with parents, which they will use as new teachers. Key topics identified include redefining the 'professional' teacher, recognizing partnerships as essential for effective school organization, emphasizing goal-linked family and community engagement for student success, understanding the community's role in partnership programs, and connecting preservice and inservice education to foster productive home, school, and community relationships. These findings suggest that enhancing teacher preparation in these areas is critical, aligning with prior research on teaching competence and the significance of communication and leadership skills in education [23].

This qualitative study investigated the communication behaviors of principals at high-performing Title I elementary schools in Virginia, where a significant portion of the student population lives in poverty. Through semi-structured interviews with eight principals, surveys, and

analysis of publicly available data, the study identified 11 specific communication strategies utilized by these principals. Five major themes emerged: a student-centered approach to decision-making, transparency, shared decision-making between principals and teachers, the role of faculty trust, and the importance of principal preparation. Key behaviors included frequent face-to-face communication, minimal whole-school meetings, and active participation in grade-level meetings. The study revealed that principal certification programs had minimal impact on communication skills, underscoring the critical role of mentoring and division-level training. The findings highlight the necessity of effective communication skills in building trust between principals and teachers, which is essential for driving effective instruction. These insights emphasize the need for structured leadership training focused on communication to prepare school leaders, aligning with the broader goal of enhancing teaching quality as identified in previous research on teaching competence in Malaysian secondary schools [24].

Table 3
Leadership communication behaviors

Behavior	Key element
Relationship building with teachers	Takes time
Earned trustworthiness	Transparency and honesty
Student-centered decision making processes	Involve teachers
Mentor experience	Purposeful and prior to becoming principal
Mindful listening practices	Includes body language and patience
Face-to-face communication	Daily, formal and informal with teachers
Written communication	Weekly email with key management items only;
Visibility	Limited office time and frequent walk-throughs
Collaborative decision-making	Teacher leaders
Small group meetings	Weekly with rare whole faculty meetings
Positive communication	Acknowledge teachers in writing

5.2 Theme 2: STEM and Professional Development in Education

This article investigates the leadership competencies crucial for supporting teacher professional development from the perspectives of Namibian principals, heads of departments (HODs), and teachers, utilizing functional, distributed, and instructional leadership theories as its theoretical framework. Adopting a pragmatist perspective and a mixed-methods approach, the study employed a sequential explanatory design, integrating quantitative data analyzed via SPSS with qualitative data analyzed through open coding to derive themes. The findings reveal that effective school leaders need a diverse set of competencies, including accountability, effective communication, interpersonal skills, subject-matter expertise, administrative proficiency, digital literacy, and listening abilities, to support teachers' professional growth effectively. This study provides insights into how these leadership competencies enable Namibian principals and HODs to facilitate teacher professional development. It further recommends that Namibian policy makers allocate human and financial resources to equip school leaders with these essential competencies through targeted training initiatives. [25].

This study investigates the factors influencing informal and formal learning strategies utilized by principals for professional development, filling a gap in research on informal learning among educational leadersA sample of 715 school leaders participated in an online self-administered questionnaire, which was analyzed using descriptive statistics, bivariate analysis, and multiple

regression models. The findings underscore the significance of a supportive organizational culture that fosters learning, intrinsic motivation, strong professional commitment, and positive perceptions of professional competencies among principals. These factors significantly impact the adoption of both informal and formal learning methods. The study recommends fostering a shift towards competence-based staff systems to enhance the relevance of informal learning strategies in promoting educational innovation. [26].

This case study explores the impact of a short-term international study abroad program in East London, England, on the cultural competencies of six doctoral students in educational leadership. The study aimed to enhance participants' knowledge, attitudes, skills, and behaviors pertinent to culturally competent school leadership through pre-post surveys and follow-up interviews. The findings reveal significant improvements in participants' cultural awareness, including increased understanding of educational systems and heightened self-awareness of cultural issues. Participants also developed skills in building relationships and empowering teachers, alongside a more inclusive attitude towards diversity. Behavioral changes included improved cultural competence, as evidenced by significant gains in pre-test to post-test assessments. Recommendations emphasize the importance of comprehensive preparation, guidance during the international experience, and structured follow-up to maximize the impact of study abroad programs on developing future school leaders' cultural competencies. Future research should explore similar programs in other educational fields and in diverse cultural contexts to broaden insights into their effectiveness in enhancing graduate students' cultural competence and professional development. [3].

In response to the imperative for educators and school leaders to possess essential skills such as interpersonal communication, teamwork, and leadership, crucial for preparing students for societal integration, this study addresses the gap in existing training programs that inadequately emphasize these competencies. Using the Delphi method, this research defines and validates a novel concept termed "complementary assessment," aimed at integrating these fundamental skills into teacher and school leadership training. This approach marks a significant step towards developing a model that enhances the assessment and cultivation of these critical competencies within educational leadership programs, thereby contributing to the preparation of educators equipped to meet the demands of contemporary education effectively [27].

This classroom action research aimed to enhance collaborative problem-solving competencies through STEM-based learning in dietary plan lessons, involving 77 twelfth-grade students in a public school's science-technology program. The study utilized ten biomolecule lesson plans and various data collection tools, including observation sheets, learning reflections, and informal interviews, analyzed using frequencies, percentages, and content analysis. The findings revealed significant improvements in three key competencies: "Establishing and Maintaining Shared Understanding," where students transitioned from relying on a dominant member to engaging in collective problem-solving and communication; "Taking Appropriate Action to Solve the Problem," with improved role assignments based on individual strengths leading to more effective problem-solving; and "Establishing and Maintaining Team Organization," where students learned to provide constructive feedback and enhance group efficiency. A notable challenge was time management, highlighting the need for continuous, well-structured collaborative activities. These activities proved effective in both STEM-based and project-based learning approaches, suggesting broader applicability for enhancing teamwork skills. [28].

Table 3

The data coding scheme

The Collaborative Problem-Solving (CPS) Competencies	Opinions and behaviors					
	Before the lesson			After the lesson		
	Always/ Regularly	Often/ Sometimes	Occasionally/ Seldom	Always/ Regularly	Often/ Sometimes	Occasionally/ Seldom
1. Establishing and maintaining shared understanding 1.1 Understanding the problem and the task. 1.2 Maintaining rules of engagement while solving the problem during tasks without getting off track.						
2. Taking appropriate action to solve the problem 2.1 Considering the strengths and weaknesses of the member when assigning roles. 2.2 Enacting the plan based on the assigned task and role. 2.3 Communicating with team members while performing the task for successful completion.						
3. Establishing and maintaining team organization 3.1 Adapting the team organization or roles when facing an unexpected situation. 3.2 Monitoring and providing feedback about the group successes.						

Note. The rating scale: 3 = always/usually (80-100%); 2 = often/sometimes (50-79%); 1 = occasionally/seldom (below 50%).

The table outlines competencies in collaborative problem-solving (CPS) and assesses their frequency before and after a lesson. It categorizes CPS competencies into three sections: establishing and maintaining shared understanding, taking appropriate action to solve the problem, and establishing and maintaining team organization. Each section includes specific skills such as understanding the problem, maintaining rules of engagement, considering team members' strengths and weaknesses, enacting plans, communicating effectively, adapting to unexpected situations, and providing feedback. The table uses a rating scale where 3 indicates behaviors demonstrated 80-100% of the time (always/regularly), 2 for 50-79% (often/sometimes), and 1 for below 50% (occasionally/seldom). It compares these frequencies before and after the lesson to evaluate any improvements in these competencies.

5.3 Theme 3: Digitalization and Technology Integration in Education

This study examines how school leaders in Sweden perceive digitalization and the digital competencies required for effective leadership. Utilizing reflective learning journals (n=32) and interviews (n=8) with school leaders, the research delves into their understanding of digitalization as a multifaceted concept that includes technical, pedagogical, administrative, and organizational challenges across all school levels. The findings highlight the added complexity digitalization brings

to the role of school leaders, emphasizing the need for sufficient time, resources, and professional development to support leadership efforts in enhancing teachers' and students' digital learning experiences. This research provides valuable insights for school leaders and educational administrators aiming to navigate and promote digitalization within school settings, highlighting its strategic significance among other organizational priorities [29].

This study examines the role of Information and Communication Technologies (ICT) in school leadership and management, with a specific focus on German school principals in comparison to their international counterparts. Using data from the International Computer and Information Literacy Study (ICILS) 2018, the research investigates the frequency and patterns of ICT usage among principals across 12 countries. Quantitative analysis reveals that German principals generally employ ICT for leadership and management activities at levels similar to their international peers, with notable emphasis on communication with education authorities but less frequent use for representative tasks like presentations or maintaining a school homepage. Latent class analysis identifies distinct clusters among German principals based on their ICT usage patterns. Qualitative findings highlight barriers such as insufficient competencies and support hindering more effective ICT integration for leadership and school improvement. This study contributes novel insights into the comparative ICT practices of school leaders internationally and provides valuable perspectives on enhancing ICT utilization in educational leadership and management [30].

This study explores the progression of ICT integration in Israeli elementary schools through the lens of school leaders tasked with technology integration. It specifically analyzes shifts in the school ICT culture over the third and fourth years of the National ICT program. Data were gathered using an online questionnaire administered to school principals and ICT facilitators in elementary schools located in the Northern District, achieving a robust response rate of 91.2%. The research aimed to identify predictors that influence the overall ICT culture in schools and examined how these factors evolve over time. Findings reveal several significant predictors of school ICT culture, including the frequency of ICT use by teachers, the integration of technology to enhance pedagogy, teachers' digital competence, utilization of digital content created by teachers, updates to class websites and school portals, intra-school e-communication practices, and teacher-parent e-communication. These factors collectively account for 63% of the variability in the overall school ICT culture. Furthermore, the study illustrates ongoing significant changes in the school ICT culture and its elements during the third and fourth years of ICT integration. This research offers valuable insights into the dynamics of sustained ICT integration in educational settings, emphasizing critical predictors essential for nurturing a supportive ICT culture and underscoring the continuous adaptations needed for effective implementation of educational technology [31].

This qualitative study explores the implementation of competency-based medical education (CBME) across the transition from undergraduate medical education (UME) to graduate medical education (GME). Through in-depth, semi-structured interviews with leaders in UME and GME engaged in CBME, the research investigates their experiences and perspectives regarding the use of CBME assessments during this crucial educational transition. Nine interviewees, predominantly from internal medicine backgrounds and holding key leadership roles in UME and GME, participated in the study. Thematic analysis of the interviews revealed four central themes: mistrust between UME and GME stakeholders, misalignment of goals particularly evident in the residency selection process, inadequate communication concerning competence assessment, and inflexible training timeframes that do not accommodate individual learners' competency trajectories. These findings underscore significant challenges hindering the seamless adoption of CBME across the educational continuum. Addressing these themes is crucial for enhancing collaboration and facilitating effective CBME

implementation, potentially leading to improved educational outcomes for medical learners transitioning from UME to GME [13].

This article examines ICT professional development across schools located in close proximity, focusing on the role of communities and networks. Conducted over a two-year action research project, the study focuses on a lead teacher community spanning five schools. By analyzing interviews with participants, including lead teachers and school leaders, the research underscores the pivotal role of various communities and networks—both within individual schools and across them—in shaping ICT professional development. The findings reveal that effective professional development in ICT is intricately linked to the dynamic interaction among these communities and networks, which facilitate learning in both anticipated and unforeseen ways. The study highlights the necessity for tailored approaches that address the diverse and evolving needs of teachers, advocating against a standardized, one-size-fits-all approach to professional development. This research contributes insights into optimizing ICT professional development strategies across educational contexts characterized by close physical proximity, offering practical implications for fostering collaborative learning environments conducive to sustained professional growth [32].
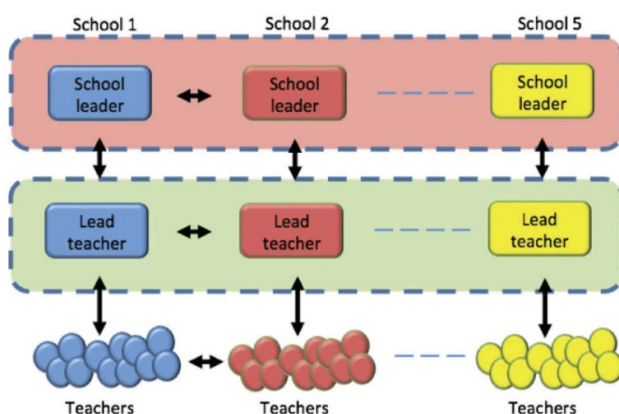

Fig. 2. School leader community, lead teacher community and teacher and five collaborating schools

The figure illustrates the hierarchical and collaborative network among school leaders, lead teachers, and teachers across five schools. At the top level, each school has a "School leader" who interacts with "Lead teachers" directly below them, and these school leaders also communicate with their counterparts in other schools. At the middle level, each lead teacher supervises a group of teachers within their school and collaborates with lead teachers from other schools. At the bottom level, teachers interact primarily with their lead teacher and also engage with teachers from other schools. The figure underscores the importance of collaboration, leadership, and community building within and between schools, highlighting the structured interactions that promote professional development and resource sharing among educational staff. This visualization is crucial for understanding leadership dynamics and inter-school cooperation in educational research.

6. Discussion and Conclusion
6.1 Theoretical Framework and Integration

The findings from this systematic review reveal three interconnected themes that can be understood through established educational theories and frameworks. This theoretical integration provides deeper insights into how communication competency, STEM professional development, and digital integration interact within educational leadership.

The emergence of communication competency as crucial for effective teaching and leadership aligns with Bass and Avolio's Transformational Leadership Theory (1994). This theory emphasizes how leaders inspire and motivate followers through effective communication and role modeling.

Our findings regarding principals' communication behaviors, particularly in high-performing schools, demonstrate the four components of transformational leadership: idealized influence through transparent and student-centered communication, inspirational motivation via regular face-to-face interactions, intellectual stimulation through collaborative decision-making processes, and individualized consideration evidenced by personalized mentoring approaches.

The findings on STEM and professional development align with Vygotsky's Social Constructivist Theory and Lave and Wenger's Communities of Practice framework. The identified need for multifaceted approaches, including cultural competence and collaborative problem-solving, reflects how knowledge is socially constructed through interaction and professional learning occurs within communities of practice. This theoretical alignment suggests that effective STEM professional development requires creating social learning environments that facilitate both technical and cultural competence development.

The challenges and opportunities in digitalization and technology integration can be understood through Davis's Technology Acceptance Model (TAM) and Rogers's Diffusion of Innovation Theory. Our findings about school leaders' roles in technology integration reflect the importance of perceived usefulness and ease of use in technology adoption, the significance of change management in technology implementation, and the need for systematic professional development to support innovation diffusion.

These theoretical frameworks collectively suggest that effective educational leadership requires an integrated approach that applies transformational leadership principles to communication strategies, creates social learning environments for professional development, and considers both technical and human factors in technology integration. This theoretical understanding has practical implications for leadership development programs, professional development design, technology implementation strategies and policy development.

6.2 Conclusion

The studies highlight the importance of communication skills in improving the effectiveness of school leaders and teachers. Good communication builds trust, encourages teamwork, and improves the learning environment, ultimately benefiting students. Leaders who focus on clear, honest, and student-centered communication can create stronger relationships with teachers and foster better decision-making. Practices like frequent face-to-face conversations, listening carefully, and involving teachers in decisions help build trust and improve collaboration. These skills are essential for creating a supportive and productive school culture.

However, traditional leadership training often does not provide enough focus on communication. To address this, mentoring programs, postgraduate education, and targeted training are crucial. Teachers also need to be trained in communication strategies to strengthen partnerships with families and communities, which play a key role in student success. Policymakers and schools must make communication training a priority. Adding these skills to teacher and leader development programs, offering mentoring opportunities, and creating supportive policies can help school leaders communicate more effectively.

In summary, strong communication skills are essential for school leaders and teachers. Investing in these skills will lead to better teamwork, stronger schools, and improved outcomes for students.

The studies emphasize the importance of leadership competencies and innovative teaching strategies in fostering professional development and preparing students for future challenges. Effective school leadership plays a crucial role in supporting teacher growth, with key skills such as communication, accountability, digital literacy, and subject-matter expertise emerging as essential. Providing targeted training and resources for school leaders, as recommended in the Namibian study, can greatly enhance professional development outcomes. Leadership training should also address cultural competencies, as shown in the study abroad program. Participants gained valuable insights into cultural awareness, diversity, and relationship-building, which are vital for inclusive and effective educational leadership. These findings highlight the need for comprehensive programs that prepare leaders to navigate diverse educational settings confidently.

In the classroom, STEM-based approaches have proven to be effective in improving collaborative problem-solving skills. Students demonstrated significant growth in understanding tasks, working together, and organizing team efforts. This underscores the value of integrating STEM activities into the curriculum to enhance critical thinking and teamwork. However, challenges like time management highlight the need for well-structured and continuous activities to sustain these improvements.

Overall, the findings suggest that both school leadership and classroom practices must evolve to meet modern educational demands. Policymakers and educators should prioritize professional development initiatives, integrate cultural and collaborative competencies into training programs, and adopt innovative STEM-based methods. By doing so, education systems can equip both leaders and students with the skills needed for success in a rapidly changing world.

The studies collectively highlight the transformative impact of digitalization and technology integration on educational leadership and school culture. Digitalization is not only a technical shift but also a complex process that influences pedagogy, administration, and communication. School leaders play a central role in navigating these changes by fostering digital competencies among staff and embedding technology into school practices. Research shows that effective digital leadership requires targeted professional development, sufficient resources, and a supportive organizational culture. For instance, Swedish school leaders identified the need for time and training to manage the complexities of digitalization. Similarly, German principals' ICT practices revealed barriers such as insufficient competencies and support, emphasizing the importance of tailored professional development strategies.

The progression of ICT integration in Israeli schools demonstrated how consistent efforts in technology use and communication practices can reshape school culture. Predictors such as teacher digital competence, interactive e-communication, and the integration of digital content highlight the need for sustained and adaptive approaches to technology adoption. Collaboration and networking also emerged as vital elements for successful ICT professional development. Communities of lead teachers and school leaders across multiple schools illustrate how shared learning environments can enhance the effectiveness of technology training. This underscores the importance of moving beyond standardized approaches to embrace dynamic and collaborative models that address diverse needs.

In conclusion, digitalization offers vast opportunities for educational improvement, but its success relies on strong leadership, effective training, and a culture of collaboration.

Policymakers and educators must invest in professional development programs, build supportive networks, and provide resources that empower schools to integrate technology effectively. By doing so, schools can harness the potential of digital tools to enrich teaching, learning, and leadership practices.

Acknowledgement

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