The Development of Kindergarten Teachers' Identities as STEM Teachers: A Hong Kong Case Study

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Abstract
This study explores the development of kindergarten teachers' identities as STEM (Science, Technology, Engineering and Mathematics) educators in early childhood education. Six teachers were chosen as case studies, representing diverse experiences and exposure to STEM education. The research found that personal interest, professional development, and supportive environments significantly shape teachers' identities as STEM educators. Teachers with formal training and access to STEM-focused professional development demonstrated more effective integration of STEM concepts into their instructional practices. A classroom environment fostering curiosity, problem-solving, and collaboration is crucial for successfully implementing STEM education. The study suggests continuous and targeted training in STEM education, collaboration among teachers, experts, and researchers, and integrating STEM education into early childhood curricula. However, limitations include a limited sample size and the need for further research on the long-term impact of teachers' identity development on students' STEM learning outcomes.

Keywords: Early Childhood Education, Kindergarten Teachers, Identity Development, Professional Development, STEM Integration

Introduction

STEM (Science, Technology, Engineering, and Mathematics) education has gained significant attention recently due to its role in preparing students for future careers and fostering critical thinking and problem-solving skills (National Research Council, 2011). Early childhood, including the kindergarten stage, is crucial for laying the foundation of STEM (Galanti & Holincheck, 2024). Research has shown that early exposure to STEM concepts and experiences can positively impact students' attitudes and achievement (Boeve-De Pauw et al., 2024; Bybee, 2010).

Kindergarten teachers are pivotal in shaping young children (Bleicher, 2004). Their identities as STEM teachers, encompassing their beliefs, values, and self-perceptions related to STEM education, influence their instructional practices and student interactions (Wan et al., 2021). When kindergarten teachers identify themselves as competent and confident STEM educators, they are more likely to inspire and engage students in STEM activities (Erol & Erol, 2024) . Therefore, understanding the development of kindergarten teachers' identities as STEM teachers is crucial for enhancing STEM education in early childhood settings.

This research aims to explore and understand the development of kindergarten teachers' identities as STEM teachers using a case study methodology. The specific objectives of this study are: a) To examine the factors that influence the development of kindergarten teachers' identities as STEM teachers; b) To investigate the relationship between kindergarten teachers' STEM identities and their instructional practices in the classroom; c) To explore the impact of kindergarten teachers' STEM identities on students' attitudes and engagement in STEM subjects.

Research Questions

The following research questions will guide this investigation:

1. What factors contribute to developing kindergarten teachers' identities as STEM teachers?
2. How do kindergarten teachers' STEM identities influence their instructional practices in the classroom?
3. What is the relationship between kindergarten teachers' STEM identities and students' attitudes and engagement in STEM subjects?

Literature Review

Theoretical Perspectives on Teacher Identity Development

Social identity theory suggests that individuals develop their sense of self and identity based on their membership in social groups (Tajfel et al., 1979). In the context of teacher identity development, this theory posits that kindergarten teachers' identities as STEM teachers may be influenced by their identification with the broader STEM education community.

Self-efficacy theory emphasises teachers' beliefs' role in effectively teaching STEM subjects (Bandura, 1977). Teachers with high self-efficacy in STEM education are likely to engage students and create a positive learning environment.

Theoretical Frameworks Relevant to the Development of Kindergarten Teachers' Identities as STEM Teachers

The TPACK framework emphasises integrating technology, pedagogy, and content knowledge in effective STEM teaching (Mishra & Koehler, 2006). For kindergarten teachers, developing a deep understanding of STEM content knowledge and pedagogical strategies is essential for effective STEM instruction.

Situated learning theory posits that learning occurs in real-life contexts and within communities of practice (Lave & Wenger, 1991). When applied to the development of kindergarten teachers' STEM identities, this theory underscores the significance of creating opportunities for teachers to participate in meaningful and authentic STEM experiences, both within and beyond the confines of the classroom.

Methodology

This study adopts a qualitative case study methodology to explore the development of kindergarten teachers' identities as STEM teachers. Case study research allows for an in-depth examination of a specific phenomenon within its real-life context (Lave & Wenger, 1991). This research aims to comprehensively understand the complex nature of kindergarten teachers' identity development in STEM education by focusing on two cases.

Case study data is utilized to provide an in-depth and comprehensive description of real-life situations (Yin, 2018). This approach allows researchers to explore complex phenomena within their contexts, making it particularly valuable for understanding the nuances of kindergarten teachers' identities as STEM educators. To enhance the reliability and validity of the findings, data collected from case studies was triangulated with information obtained from interviews and open-ended survey questions. This triangulation helps to corroborate findings across different data sources, thereby strengthening the overall conclusions.

The data collection process was conducted in stages, beginning with online surveys to gather initial insights and quantitative data regarding teachers' experiences and perceptions of STEM education. Following this, semi-structured interviews were conducted to obtain more in-depth qualitative information, allowing participants to elaborate on their experiences and views. This two-tiered approach facilitated a richer understanding of the factors influencing teacher identity development in STEM contexts.

Data analysis was carried out according to established protocols for assessing observational data and indicators, as outlined by Braun and Clarke (2006). Thematic analysis was employed to identify, analyze, and report patterns (themes) within the data. This method allowed for a systematic examination of the data, ensuring that key themes related to teachers' identities, professional development, and classroom practices were thoroughly explored and articulated.

By employing a rigorous methodology that combines case study data with qualitative interviews and surveys, this research provides a robust foundation for understanding the complexities of kindergarten teachers' identities as STEM educators.

The selection of cases in this study was guided by purposeful sampling, aiming to identify kindergarten teachers with varying levels of experience, training, and exposure to STEM

education. The rationale for selecting multiple cases is to capture a range of experiences and perspectives, enhancing the findings' validity and generalizability (Merriam & Grenier, 2019).

Semi-structured interviews were conducted with each participating kindergarten teacher to explore their experiences, beliefs, and practices related to STEM education. The interviews were audio-recorded with the participant's consent, transcribed verbatim, and analysed to identify key themes and patterns (Malterud & Guassora, 2016).

The kindergarten teachers' STEM instruction was observed to gain insights into their instructional practices and the integration of STEM concepts in the classroom. Detailed field notes were taken during the observations, capturing essential aspects such as teaching strategies, student engagement, and using materials and resources (Glesne, 2016).

A thorough analysis of relevant documents, such as lesson plans and teaching materials, complemented the interview and observation data. This analysis provided additional insights into the teachers' planning processes, instructional strategies, and the alignment between their intentions and actual practices (Bowen, 2009).

The interview transcripts, observation field notes, and document analysis data will be analysed using a coding and thematic analysis approach. The data will be coded to identify recurring patterns, themes, and categories related to kindergarten teachers' identity development as STEM teachers (Braun & Clarke, 2019). This process will involve iterative coding, constant comparison, and the development of thematic frameworks.

A cross-case analysis will compare and contrast the findings across the different cases. This analysis involves synthesising the themes and patterns identified within each case and exploring similarities and differences between the cases (Merriam & Grenier, 2019). This comparative analysis contributed to a deeper understanding of the factors influencing kindergarten teachers' identities as STEM teachers.

Data Analysis

Inductive and thematic analysis techniques were employed to identify, evaluate, and develop themes that reflect participants' shared experiences (Fereday & Muir-Cochrane, 2006). In the initial stage, each participant's responses were coded using specific keywords to minimize redundancy. To facilitate the coding and categorization process, NVivo 12 software was utilized. This software helped organize data from both surveys and interviews through the use of Nodes and Cases. Thematic maps were created to illustrate the organization of concepts at various levels and to explore potential connections between them. Subsequently, the research team examined both the codes and categories, considering the possibility of merging certain codes for greater efficiency. This inductive approach allowed for the identification of key themes emerging from participants' responses to the research questions (Fereday & Muir-Cochrane, 2006).

Findings

Case Study 1: Kindergarten Teacher A

Kindergarten Teacher A has taught for seven years and participated in three professional development workshops focused on STEM education. She is intensely interested in science and technology and actively seeks opportunities to integrate STEM concepts into her teaching practice.

Her positive experiences influenced teacher A's identity as a STEM teacher in STEM subjects during her education. Additionally, her participation in STEM-focused professional development workshops and interactions with colleagues who shared her passion for STEM education significantly shaped her identity as a STEM teacher.

Teacher A actively incorporates STEM concepts into her lessons through hands-on activities and experiments. She utilises technology tools and resources to enhance student engagement and understanding of STEM subjects. Furthermore, she fosters a classroom environment that encourages curiosity, problem-solving, and collaboration among her students.

> "I believe there is a substantial connection between knowledge and interest for teachers, as it is likely to impact their perception of their STEM identity."… "If you have a certain interest, it is possible that you perceive yourself as having a more distinct identity in that particular domain. If you see a deficiency in knowledge or a lack of interest in a certain subject, it is possible that you may also experience a weakened sense of identity." (Teacher A)

Case Study 2: Kindergarten Teacher B

Kindergarten Teacher B has been teaching for two years and has limited exposure to formal STEM education training. However, she is genuinely interested in STEM subjects and seeks opportunities to enhance her knowledge and skills.

Teacher B's identity as a STEM teacher was influenced by her interest in STEM subjects and her belief in the importance of STEM education for young children. Although she had limited formal training, she actively engaged in self-directed learning and sought resources and support from colleagues to develop her STEM teaching practices.

Teacher B incorporates STEM concepts into her classroom through project-based learning activities and open-ended investigations. She encourages her students to explore and question scientific phenomena and engineering challenges. Despite her limited training, she demonstrates enthusiasm and a willingness to learn alongside her students, fostering a positive classroom environment for STEM exploration.

> "The development of a student's and teacher's identity concerning STEM will occur from their own inquiries and personal research, which is the essence of analytical and critical thinking. If you provide various resources in your classroom and you give weight to those resources." (Teacher B)

Teacher B is just beginning her journey in STEM education. Initially feeling unprepared, her interest in the field has grown through collaboration with more experienced colleagues. She

actively participates in team teaching and observes her peers' STEM lessons to enhance her own practices. This collaborative approach has greatly influenced her identity as a STEM teacher, as she learns to integrate hands-on activities into her classroom. Teacher G encourages her students to work together on projects and share their ideas, creating a sense of community and collaboration. She believes that learning from others is essential for building her confidence and competence in teaching STEM subjects.

> "Working alongside my colleagues has been invaluable. I've learned so much from observing them and participating in team teaching. Collaboration not only enhances my teaching practice, but it also creates a community in the classroom where students feel comfortable sharing their ideas and working together." (Teacher B)

Case Study 3: Kindergarten Teacher C

Teacher C has been teaching for five years and has participated in various workshops and conferences focused on STEM education. With a strong background in environmental science, she is passionate about integrating sustainability into her lessons. Her identity as a STEM educator is closely tied to her commitment to environmental education. In her classroom, she engages students through hands-on activities such as recycling projects and nature walks. By connecting real-world issues to her lessons, she helps students understand important STEM concepts while encouraging them to think critically about their impact on the environment. Teacher C believes that teaching STEM is not just about the subjects themselves; it's about nurturing responsible future citizens who care for the planet.

> "I believe that teaching about sustainability is crucial. When my students engage in projects like recycling, they not only learn about science but also develop a sense of responsibility toward the Earth. My goal is to help them see the connection between what they learn in class and the real world around them." (Teacher C)

Case Study 4: Kindergarten Teacher D

With eight years of teaching experience, Teacher D has a solid foundation in mathematics, having pursued additional coursework in early childhood math education. She firmly believes that developing early math skills is critical for children's future success in STEM fields. Teacher D uses games and interactive activities to promote logical reasoning and problem-solving among her students. By allowing children to explore mathematical concepts through play, she creates a supportive and engaging learning environment. Her goal is to foster a positive attitude toward math, as she knows that instilling confidence in students early on is key to building a strong STEM identity.

> "Math can be intimidating for many kids, but I try to make it fun. By using games and hands-on activities, I help them see that math is all around us. I want them to feel confident in their abilities, because I truly believe that a strong foundation in math can open doors for them in the future." (Teacher D)

Case Study 5: Kindergarten Teacher E

Teacher E has been teaching for four years and initially had limited training in STEM education. However, her deep interest in technology motivated her to take online coding courses on her own. This self-directed learning has significantly shaped her identity as a

STEM educator. In her classroom, she introduces technology through coding games and robotics activities, encouraging students to explore and solve problems collaboratively. Despite her initial lack of formal training, her enthusiasm for technology inspires her students to engage with STEM learning. Teacher E believes that cultivating curiosity and creativity in her students is essential for developing a robust STEM identity.

> "Even though I didn't have much formal training, my love for technology drives me to learn and explore. When my students code or build robots, I see their excitement. It's rewarding to watch them become problem solvers and innovators, and it motivates me to keep learning alongside them." (Teacher E)

Case Study 6: Kindergarten Teacher F

Teacher F has been in the teaching profession for ten years and has extensive experience teaching science. She has participated in numerous professional development workshops focused on inquiry-based learning. Her identity as a STEM teacher is grounded in her belief that inquiry is vital for meaningful education. She designs her lessons around open-ended questions, allowing students to explore scientific phenomena. In her classroom, experimentation is encouraged, and mistakes are seen as valuable learning opportunities. This approach not only deepens her students' understanding of science but also promotes critical thinking and collaboration. Teacher F believes that nurturing an inquisitive mindset is crucial for students to develop a strong identity in STEM fields.

> "I always tell my students that it's okay to make mistakes; that's how we learn! By asking open-ended questions, I encourage them to think critically and explore their curiosity. Inquiry-based learning not only makes science fun but also builds their confidence as young scientists." (Teacher F)

Teacher F is a strong advocate for STEM education in her school. She has led efforts to implement STEM curricula and has organized workshops for her colleagues. Her identity as a STEM educator is shaped by her leadership role and commitment to professional development. Teacher H actively mentors new teachers, sharing her insights and resources to support their growth. She emphasizes the importance of collaborative learning and encourages her students to take on leadership roles in STEM projects. By fostering a culture of inquiry and innovation, she not only enhances her students' STEM learning but also inspires her colleagues to embrace STEM education. Teacher H believes that creating a community of learners is vital for building a strong STEM identity for both students and teachers.

> "Being a leader in STEM education is something I'm passionate about. I love mentoring new teachers and sharing resources. By fostering collaboration among students and teachers, we create an environment where everyone can thrive and develop their STEM identities together." (Teacher F)

Comparison and Synthesis of Findings

A comparison of the findings from the case studies reveals several common themes among the teachers' experiences and identities as STEM educators. Teachers A and B, along with Teachers C, D, E, and F, expressed a strong personal interest in STEM subjects and acknowledged the critical role of STEM education for young children. Each teacher actively

sought out resources to enhance their teaching practices, whether through formal professional development workshops, self-directed learning, or collaboration with colleagues. This proactive approach facilitated the creation of classroom environments that fostered curiosity, problem-solving, and collaboration among students. The emphasis on hands-on activities and real-world applications in their lessons further illustrated a shared commitment to engaging young learners in meaningful STEM experiences.

However, differences also emerged regarding formal training and teaching experience. Teacher A, with her extensive formal training and participation in STEM-focused professional development specific to early childhood education (ECE), demonstrated a heightened level of confidence in her instructional practices. Her structured approach to integrating STEM concepts into her lessons was influenced significantly by her training and prior experiences. In contrast, Teacher B relied more on self-directed learning and informal colleague support to develop her STEM teaching practices. This reliance on informal networks highlights the varying paths teachers take in shaping their identities as STEM educators.

Further distinctions were observed in the experiences of Teachers C and E. Teacher C, with her background in environmental science, utilized her expertise to integrate sustainability into her curriculum, thereby enriching her students' understanding of both STEM concepts and their environmental impact. Meanwhile, Teacher E's enthusiasm for technology led her to explore coding and robotics independently, showcasing her initiative in filling the gaps left by formal training. Teachers F, G, and H also highlighted the importance of mentorship and collaboration. Teacher F's inquiry-based approach was deeply rooted in her belief that experimentation and curiosity drive scientific learning, while Teacher H's leadership role allowed her to foster a culture of inquiry and innovation, not only among her students but also her colleagues.

Overall, the findings underscore the complex nature of kindergarten teachers' identity development as STEM educators. They highlight the significance of personal interest, varying levels of professional development, and collaborative learning environments in shaping instructional practices and confidence in teaching STEM subjects. While some teachers benefitted from structured training and resources, others thrived through informal learning and peer support, illustrating the diverse pathways that contribute to effective STEM teaching. This synthesis emphasizes that nurturing a strong STEM identity among educators is essential for fostering an engaging and impactful learning experience for young students.

Discussion

The findings of this study provide valuable insights into the development of kindergarten teachers' identities as STEM educators. Across all case studies, including Teacher A and Teacher B, the importance of personal interest, professional development, and supportive environments emerged as significant factors shaping teachers' practices. Teachers expressed a genuine passion for STEM subjects, which played a crucial role in their willingness to integrate these concepts into their classrooms. This intrinsic motivation was evident in how they approached lesson planning and student engagement, highlighting the significance of fostering a strong connection between teachers' interests and their instructional methods. Research indicates that teachers' identities are closely linked to their beliefs and attitudes towards STEM, which can significantly influence their teaching practices and student engagement (El Nagdi et al., 2018).

Furthermore, the results suggest that kindergarten teachers with formal training and access to STEM-focused professional development are more likely to integrate STEM concepts seamlessly into their teaching practices. For instance, Teacher A's extensive training and participation in workshops allowed her to confidently implement hands-on STEM activities, while Teacher C's background in environmental science enriched her curriculum with relevant, real-world applications. In contrast, Teacher B and Teacher E, despite their enthusiasm, demonstrated how limited formal training can hinder the effective implementation of STEM education, showing that self-directed learning, while beneficial, may not always fill the gaps left by formal education. Previous studies have shown that teachers who receive targeted professional development in STEM are better equipped to foster student interest and understanding in these subjects (Hachey, 2020).

The findings also emphasize the importance of fostering curiosity, problem-solving, and collaboration among young children. Teachers who created environments that encouraged exploration and inquiry were able to engage students more effectively in STEM learning. Teacher F's inquiry-based approach and Teacher D's interactive math games exemplify how nurturing these qualities can lead to a deeper understanding and appreciation of STEM subjects among young learners. Research supports the notion that early childhood classrooms are critical spaces for identity work, where children begin to form their STEM identities through engaging and meaningful experiences (Galanti, 2024).

Based on these findings, several implications for kindergarten teacher professional development can be drawn:

- *Ongoing and Targeted Professional Development:* Providing opportunities for continuous and focused professional development in STEM education is crucial. This could include workshops, courses, and collaborations with STEM experts, ensuring that teachers are equipped with the latest strategies and resources (Boeve-De Pauw et al., 2024; Fitzpatrick, 2024; Hachey, 2020).
- *Addressing Specific Needs:* Professional development programs should be tailored to the specific needs and interests of kindergarten teachers. Recognizing their prior experiences and varying levels of training will enhance the relevance and effectiveness of these programs (El Nagdi et al., 2018).
- *Mentoring and Peer Support:* Establishing mentoring and peer support networks can be vital in sustaining teachers' motivation and growth in STEM instruction. Such networks enable sharing of best practices, resources, and emotional support, fostering a collaborative culture among educators (Bybee, 2010; Galanti & Holincheck, 2024).

Based on the findings, several recommendations can be made to enhance STEM education in early childhood settings:

- *Prioritizing STEM Integration*: Educational policymakers and administrators should prioritize the integration of STEM into early childhood curricula and standards. This involves providing resources, materials, and learning opportunities that support teachers in implementing developmentally appropriate STEM activities (Hachey, 2020).
- *Encouraging Collaboration:* Collaboration among kindergarten teachers, subject matter experts, and researchers should be encouraged to share best practices, develop innovative instructional strategies, and create a supportive community of practice. This collaboration can lead to more effective teaching methods and a richer learning experience for students (El Nagdi et al., 2018).

- *Emphasizing Family Engagement:* Engaging families in STEM education is essential. Providing resources and workshops that empower parents and caregivers to support STEM learning at home can enhance the educational experience for children and reinforce the value of STEM in everyday life (Fitzpatrick, 2024; Galanti, 2024).

In summary, the findings from this study highlight the multifaceted nature of kindergarten teachers' identities as STEM educators and underscore the need for targeted support and resources. By addressing the identified areas for improvement, stakeholders can enhance the quality of STEM education in early childhood settings, ultimately benefiting both teachers and students.

Conclusion

This study found that personal interest, professional development, and supportive environments are crucial for shaping kindergarten teachers' identities as STEM educators. The data revealed that teachers who possess a strong personal interest in STEM subjects are more likely to seek out professional development opportunities, which in turn enhances their effectiveness in integrating STEM concepts into their classrooms. Furthermore, the study underscored the significance of creating a classroom environment that fosters curiosity, problem-solving, and collaboration among young learners. Such an environment not only engages students but also cultivates a positive attitude towards STEM education.

The findings highlight the importance of tailored professional development and personalized support for teachers, as well as the necessity of integrating STEM education into early childhood curricula. Additionally, involving families in the process of supporting STEM learning plays a vital role in reinforcing the importance of these subjects outside the classroom. Overall, this study emphasizes that a multifaceted approach, combining teacher development, supportive environments, and family engagement, is essential for fostering a strong foundation in STEM education for young children.

Limitations

Despite the valuable insights gained from this study, several limitations should be acknowledged. First, the sample size, while diverse, may not fully represent the broader population of kindergarten teachers across different regions or educational contexts. This could limit the generalizability of the findings. Second, the reliance on self-reported data from surveys and interviews may introduce bias, as teachers might present their practices in a more favorable light. Additionally, the study's cross-sectional design does not allow for the observation of changes in teachers' identities over time, which is crucial for understanding the long-term implications of professional development and support. Finally, while the study highlights the importance of family engagement in STEM education, it did not directly assess the impact of family involvement on student learning outcomes, an area that warrants further investigation.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

In the preparation of this paper, I acknowledge the use of generative AI and AI-assisted technologies to enhance the readability and clarity of the content. These tools were employed to support the writing process, helping to refine and organize ideas effectively. However, the final interpretations and conclusions presented in this work are entirely my own, reflecting my analysis and insights.

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