International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 19, No. 3, 2025

Challenges Faced by Novice Australian Teachers in Early Childhood STEM Education

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Abstract: The global demand for STEM professionals has increased, and countries around the world have increased their emphasis on STEM education. This extends to the initiation of STEM education in early childhood. However, studies have indicated that novice early childhood teachers encounter a range of challenges in their professional practice, particularly in the area of STEM education.This study combines Self-Determination Theory and Ecological Systems Theory as the research framework to explore the specific challenges encountered by novice Australian early childhood teachers in STEM education, focusing on their professional development context. It aims to understand the challenges they face when transitioning from learning to work experiences, analyse how these challenges fit into the ecosystem of their career pathways, and identify areas where novice teachers need support in implementing STEM education. This study identified the overall challenges faced by novice teachers in implementing STEM education focus on the Individual, Microsystem and Mesosystem environments. Therefore, in the discussion section, I made three suggestions: Novice teachers should be autonomous and reflective in professional development; Give children exploratory time and observe children; Build good cooperative relationships with colleagues, to promote novice early childhood teachers to have a greater sense of self-efficacy in the process of STEM education, and to promote more effective STEM education for children.

Keywords: Early Childhood STEM Education, Novice Early Childhood Teachers, Self-efficacy of Teachers, Professional Development.

1. Introduction

The 21st century is an era of rapid development of science and technology, and the global demand for science and technology innovation is growing, while the contradiction of relative shortage of STEM-related talents has become a key factor restricting the development of science and technology and economic growth of various countries [1]. In this context, many countries around the world have recognised the importance of STEM education and have paid attention to it at the policy level.

In 2006, the U.S. released the American Competitiveness Plan, which proposed that the cultivation of professional talents with STEM literacy is an essential factor in enhancing national strength and global competitiveness [2]. In 2014, the Royal Society in the United Kingdom published Vision for Science and Mathematics Education, proposing a lasting and stable educational reform to strengthen interdisciplinary connections and emphasize integration across disciplines, aiming to foster learners' STEM awareness and competencies [3]. United Nations Educational, Scientific and Cultural Organization, during its 42nd General Conference, approved the establishment of an International STEM Education Institute in China, underscoring the global recognition of STEM education's importance and its core position in the global educational agenda [4][5].

Amidst this global trend, the Australian education sector reviewed its own STEM education situation and recognised a crisis in academic performance and the number of qualified STEM teachers [6]. In response to the challenge of declining PISA assessment scores, Australia implemented the National STEM School Education Strategy 2016-2026 to enhance the quality and effectiveness of STEM education[7]. This strategy includes extending the STEM education model to the early childhood education stage [8]. In 2020, the Australian Department of Education released the STEM program evaluations in the early years of schooling, which systematically evaluate the implementation and effectiveness of STEM education-focused programs and set out future directions for the development of STEM education in Australia [9].

However, for novice early childhood teachers, there is not enough self-efficacy to carry out relevant teaching activities [10]. Bandura's self-efficacy theory describes an individual's beliefs about the degree of success in completing a particular task, and this belief affects the self-growth and professional development of novice teachers [11]. According to Saçkes et al., novice teachers in STEM education often feel uncertain about their pedagogical abilities, especially when designing and implementing maths and science activities [12]. Similarly, On the other hand, research by Stephenson et al. indicated that gamified teaching methods can help pre-service teachers regain confidence in STEM teaching [13].

Therefore, this study will explore the challenges novice teachers face in the overall process of STEM education, laying the groundwork for identifying practical solutions.

2. Theoretical Framework

This study used Self-Determination Theory and Ecosystem Theory for theoretical analysis. Both theories are middle-level theories and have direct guidance in practical research.

2.1. Self-Determination Theory

Self-determination theory focuses on the autonomy and intrinsic motivation of individual behaviour, as well as how external factors influence motivation and psychological well-being [14] [15]. It proposes three basic human needs: autonomy, competence, and relatedness, which significantly

impact motivation and emotions in individual actions [14].

Firstly, teachers may feel that their choices in implementing STEM education are limited due to the centre-based curriculum and pressure from parents and leaders of the centre, which may affect their enthusiasm and commitment to teaching [16]. Secondly, STEM fields often involve complex concepts and skills, and novice teachers are very likely to feel "overwhelmed" when attempting to integrate theory and practice, a feeling that can lead to a decrease in novice teachers' confidence in education, which in turn can affect teaching effectiveness [17]. Furthermore, establishing relevance in interdisciplinary education is challenging. Novice teachers face challenges in interdisciplinary education in a multicultural and multidisciplinary integrated STEM environment [18]. Novice teachers struggle with the flexibility of interdisciplinary education in the four areas of STEM when they first join the profession [19].

2.2. Ecological Systems Theory

Ecological systems theory focuses on the interaction between individuals and their environments, examining how environmental factors influence individual development [20]. By placing novice teachers as learners at the centre of the ecological systems theory model, educational practice can be understood as an embedded system that analyses the complex relationships between novice teachers and their social environments [21].

According to the model proposed by Baker, the Microsystem refers to the most influential environment in which novice teachers are directly involved by their classrooms [21]. Extending outward, the Mesosystem encompasses the broader context of the school, educational institutions, and interactions with parents and fellow educators. The Exosystem includes settings in which the practitioner is not directly involved but which nonetheless exert significant influence, such as educational policies, curriculum standards, and community resources. The Macrosystem comprises wider cultural and societal structures, explaining cultural values, ideologies, and the socio-political context that shapes the experiences of early childhood educators. Finally, the Chronosystem represents the temporal dimension, incorporating both individual developmental trajectories and broader historical and environmental shifts.

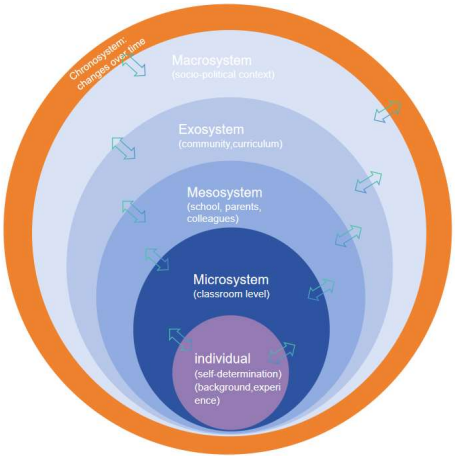

Figure 1. Theoretical Framework

By drawing on both ecosystem theory and self-determination theory, this research provides a logical framework to explore the various challenges faced by early childhood STEM educators, beginning with their immediate environment and extending to wider contextual influences. Figure 1 presents an analytical diagram based on the theoretical framework of this study, illustrating the dynamic interaction between the individual educator and their surrounding environment.

3. Methodology

This study used a qualitative research approach to analyse the challenges faced by early childhood teachers when implementing STEM education. This approach allowed researchers to gain a nuanced understanding of teachers' thoughts and beliefs, thus providing rich insights into the complex factors that influence teachers' self-efficacy [22][23].

3.1. Participants

In order to compare the challenges encountered by novice teachers of young children in implementing STEM education across different age groups, I interviewed two teachers of young children, (pseudonyms Winter and Sophia are used in this study for the privacy of both participants). They worked in the Knider room for 3-4 year olds and 4-5 year olds, respectively. Both teachers were from China and had obtained their Master of teaching (Early Childhood Education) degrees in Australia and had been working there for no more than two years. They work in a chain of early childhood education centres in the south-east area of Melbourne. The centre consists of two kinder rooms and is open from 6:15 a.m. to 6:30 p.m. Full-time teachers usually work eight hours a day, five days a week. Interviews were arranged on weekends in a Melbourne coffee shop, allowing plenty of time as well as a quiet environment to conduct the interviews.

3.2. Semi-structured interviews

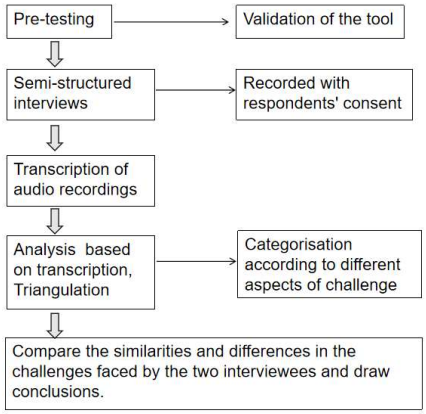

Figure 2. Data generation.

Figure 2 demonstrates the data generation process, which began with a pre-test of the interview outline to verify its validity and clarity through an initial interview with an educator who was not involved in the main study prior to the formal interviews. Necessary changes were made based on feedback. Next, the semi-structured interviews were formally started and audio-recorded with the consent of the interviewees. After these recordings were transcribed, two educators' lesson plans, training materials, and feedback from other educators in the park were collected to triangulate the data to ensure reliability and validity [24]. By analysing the responses of the two interviewees, this study aimed to identify the challenges that novice teachers encounter in STEM

education in order to provide a comprehensive and nuanced understanding of the issues.

In analysing the interview data, I followed the seven phases of thematic analysis outlined by Braun and Clarke: transcription, reading and re-reading, coding, generating themes, reviewing themes, defining and naming themes, and producing the report [25]. Following each interview, I transcribed the data verbatim and engaged in repeated readings to reflect on the factors that early childhood educators identified as influencing their self-efficacy in implementing STEM education. During this process, I annotated the text and used MAXQDA for systematic coding. As my familiarity with the data deepened, I identified several overarching categories informed by the integrated use of self-efficacy theory and ecological systems theory: Individual, Microsystem, Mesosystem, Exosystem, and Macrosystem (see Figure 3). These categories provided a structured framework for detailed coding and classification of the factors affecting novice teachers' challenges.

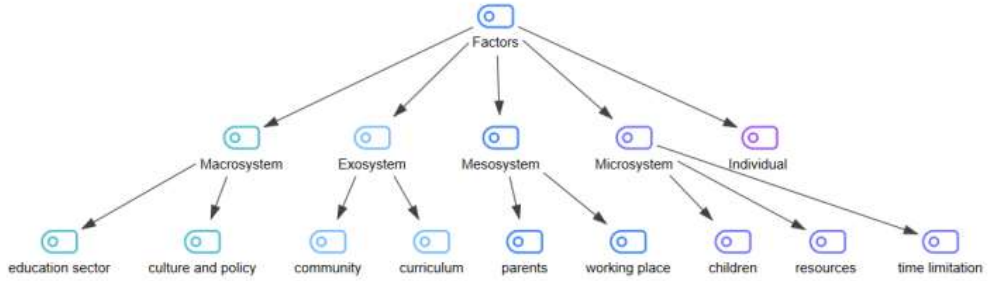

Figure 3. Coding Themes

In terms of ethics, I applied for ethical approval from the Monash University Human Research Ethics Committee (MUHREC) and I honoured the principle of participant voluntarism by allowing participants to withdraw from the study at any time with no disruption to their normal work. As I conduct my research I will use more objective rhetoric in my interviews and design questions to avoid or minimise the intrusion of personal bias making the results of the study as objective and scientific as possible [26].

4. Findings

4.1. Challenge 1: Novice Teachers' Limited Ability to Teach STEM

Self-determination theory suggests that individuals are influenced by intrinsic motivation, extrinsic incentives and self-efficacy when acting [27]. Given that STEM education involves numerous technical terms, educators must carefully consider the language they use when explaining scientific phenomena. Children's interest in STEM is largely driven by their curiosity and desire to explore. However, if educators' explanations fail to make complex terminology and concepts accessible, children may lose interest in STEM.

Winter has highlighted the challenges involved in explaining such concepts to young children:

I find it very challenging to explain concepts to children because they are still very young and are not yet able to understand complex words or ideas. Their vocabulary is limited, and their understanding of abstract concepts is still developing.

In the early stages of education, especially for newly graduated kindergarten teachers, they may feel low self-efficacy due to their shortcomings experience, especially when faced with complex or abstract content.

Winter said:

In my teaching experience, I find that children often ask unexpected questions in STEM education, some of which I may not even know the answer to right away.

Similarly, Sophia also noted:

I think I need to engage in more research to improve my ability to create engaging experiences for children, especially in STEM education.

The process of STEM education requires teachers to have solid knowledge and skills to give accurate answers. This suggests that novice teachers may not have a sufficient knowledge base in STEM and need to continue to learn and deepen their understanding of STEM areas.

4.2. Challenge 2: STEM Education based on the Individual Differences of Children

Children are the most important group in the micro-environment of early childhood teachers' professional development. One of the most important characteristics of early childhood education activities is 'fun' because children's attention span is limited, so how to attract children's attention and make them learn through play is an important issue for early childhood teachers to think about. Through interviews with Winter and Sophia, this study found that because STEM education is inherently rigorous and scientific, stimulating children's interest in STEM is a challenge for novice teachers. The goal of education is to actively encourage children to ask questions and develop critical thinking skills, especially in STEM education, as these disciplines help children think logically and critically.

Winter:

For me, the biggest challenge is how to effectively promote each child's development according to their characteristics and abilities, stimulate all children's interest in STEM, and continue STEM education in children's daily lives and daily play.

Sophia:

When I was planning , I need consider the different levels.

To be specific, in my room, there is a child can count to 50, but also, there is another child who cann't recognise 1-10, so, take the different learning level is quite hard."

From the responses of the two teachers above, it can be seen that novice teachers face significant challenges in both individualised education and the implementation of STEM education in their daily activities. In Tsai's study, it was stated that to get to know children better, teachers should give children enough time and space and that teachers need to consider children's interests and abilities to provide them with the right kind of help that is suitable for them [28]. For novice teachers, who often do not have children of their own and thus lack experience in spending long periods with children, it is difficult to put themselves in the children's shoes and think about how to attract the attention of children to stimulate their interest in STEM education.

4.3. Challenge 3: The Childcare Centre Working Model for STEM Education

Early childhood education centres are not only the daily working environment of early childhood educators but also the Mesosystem for their professional development, where the centre sets the teachers' working schedule and provides educational resources and a training course to support teachers' professional growth. Therefore, the working atmosphere and support system provided by the childcare centre have a decisive impact on the development of novice teachers in the field of STEM education.

Winter mentioned:

When I was conducting STEM education, I found that resources for nature education and maths education were relatively easy to access and apply. Engineering education, however, requires that the early childhood centres provide a variety of educational building materials that are regularly updated to stimulate children's interest and desire to explore the building materials. In our Early Childhood Education Centre, we try to avoid excessive "screen time" for children and rarely use electronic devices as teaching aids.

During the interviews, participants mentioned "limited time" as a major challenge. Since teachers in daycare centres often wear multiple hats - both as disseminators of educational knowledge and as caregivers of children in their daily lives - they have a limited number of hours available to them each day. However, having to prepare and organise STEM education activities within this limited time added to the stress felt by the participants. As Sophia said:

We have to be smarter with our time because when we are working with so many children, we need to keep an eye on their safety, and it is really hard to prepare the relevant resources for the STEM education activities. I have received training on children's social skills and emotions but not on STEM.

For novice teachers, teacher professional development training is critical on the path to becoming a skilled teacher [29]. While educational settings often provide basic training in areas such as early childhood safety, emotional management, and social development, which are essential elements in the development of children, STEM education for children is equally relevant in the long term. As a result, novice teachers want support from the workplace, and the ability of the workplace to provide adequate, ongoing professional development programmes in STEM education also has a significant impact on the STEM education of novice teachers.

5. Discussion

5.1. Be Autonomous and Reflective in Professional Development

Teachers' understanding of subject content and their enthusiasm significantly influence both instructional effectiveness and their sense of self-efficacy [30]. Given the broad scope of STEM education, this study found that even novice teachers with a master's degree in early childhood education sometimes struggle to address children's questions.

Teachers' knowledge of and motivation to teach the content can greatly affect the effectiveness of teaching and also have an impact on teachers' self-efficacy [30].The scope of STEM teaching is very broad, and this study found that even novice teachers with a Master's Degree in Early Childhood Teaching sometimes struggled to answer children's questions.

It has been shown that participating in STEM education activities or showing interest in STEM education can significantly increase teachers' STEM self-efficacy [31]. This boost can be attributed to enhanced affective attitudes and equipping skills. Sophia mentioned in her interview that she felt she needed to learn more about STEM as she had identified her own shortcomings in her teaching practice. New teachers need to gain enough experience in teaching and be interested in what they are teaching, and with a sufficient knowledge base, they will be able to teach the content with ease and have a better sense of self-efficacy in their teaching ability [32]. According to self-determination theory, intrinsic motivation, autonomous behaviour, and the influence of external factors play critical roles in shaping individuals' motivation and psychological well-being [14][15].

Reflective thinking is also vital for Novice early years teachers [33]. For STEM educators, reflection may arise through peer, mentor, or self-evaluation. Learning from outcomes is a cognitive process through which teachers deepen their understanding and self-awareness, thereby improving instructional practices [11].As novice teachers like Winter and Sophia transition from student to practitioner roles, reflective practice enables them to critically examine their teaching from broader perspectives and question the effectiveness of their skills [34].

By fostering interest in STEM and promoting reflective practice, novice teachers can strengthen their professional competencies and instructional effectiveness—benefitting both their development and the quality of early childhood education.

5.2. Give Children Exploratory Time and Observe Children

Combined with Ecological Systems Theory, children are in the microsystem of the professional development environment of novice teachers. Children's attitudes towards STEM subjects, as well as children's level of learning ability, greatly influence the effectiveness of novice teachers' teaching and, thus, their sense of competence[10]. Both participants in this study talked several times in their interviews about challenges related to children, such as how to stimulate interest in STEM and how to develop activities based on children's different levels of development in

different areas. Therefore, this study makes the following two suggestions:

First, providing young children with ample time to explore STEM materials. STEM activities require children to observe, experiment, and record carefully during the inquiry process [35]. However, studies have found that due to the daily schedule of activities and time constraints in daycare centres, teachers often interrupt operations and end activities in a hurry when children's interest is at its peak, which is detrimental to the holistic development of children [36]. So, teachers should maintain an appropriate pace when planning and implementing daily routines to ensure that young children have sufficient opportunities for exploration.

Secondly, during scientific inquiry, novice teachers need to continuously guide young children to think independently and ask questions, while also providing them with more opportunities to express themselves. Early childhood is a period of highly rapid intellectual development. STEM education activities can provide rich stimulation for children's brains and promote the development of a wide range of abilities [37]. In STEM education, teachers need to create rich sensory environments for children to exercise their multiple abilities and guide them to use their brains to promote their overall development actively. For example, by designing hands-on experiments and projects, teachers can observe children's thinking processes and creativity in solving practical problems. Through long-term observation, teachers can gradually discover the unique interests and strengths of each child in STEM activities and then design activities to meet their needs for enquiry.

In conclusion, children are constantly growing and changing, and their interests and abilities are evolving. Therefore, novice teachers should give children time, observe them, and patiently encourage them to implement STEM education so that they can improve their STEM skills in practice.

5.3. Build Good Cooperative Relationships with Colleagues

The professional development environment of novice teachers, as well as the workplace and colleagues in the Mesosystem, have a significant impact on the professional development of teachers. Challenges in the workplace were mentioned several times by two participants in this study, such as insufficient time to prepare STEM educational materials in the workplace, insufficient materials for technology activities. According to the correlations mentioned in the self-determination theory, teachers can receive continuous feedback and support in their teaching practice through the establishment of supportive relationships [38].

Participants mentioned in their interviews that they were aware that they did not have much work experience and wanted to learn from experienced teachers on the job. A supportive team of teachers can help new teachers proliferate and increase their sense of belonging and self-efficacy [39]. STEM education encompasses a wide range of fields, such as science, technology, engineering, and mathematics, and different teachers have their expertise in different areas. Through mutual support and collaboration, teachers can share their ideas and teaching strategies, which not only promotes knowledge growth but also enhances confidence in teaching [40].

The support of leaders and administrators in early education centres is critical to the development of STEM teachers [41]. Leaders and administrators should create an open communication environment that allows teachers to speak up [40]. Novice teachers may face insufficient resources and a lack of developmental opportunities to carry out their activities, which can lead to negative feelings and affect the growth of novice teachers. For this reason, the centres should organise regular workshops and exchange activities, also provide adequate STEM education resources and support, to support novice teachers in carrying out STEM education activities more smoothly.

By organising their working hours and resources, building supportive teams, and obtaining support from school leaders and administrators, novice teachers can make good connections with their surroundings to enhance their STEM self-efficacy in practice. These measures help teachers to better cope with the challenges in STEM education and promote their professional development, thereby improving the quality of STEM education.

6. Conclusion

In conclusion, in terms of the professional development environment of novice teachers, the children in the teacher's classroom and the workplace have a direct impact on the process of novice teachers' STEM education, so micro-environmental attention to the development of novice teachers is indispensable, and the teacher's workplace should provide novice teachers with the necessary support and resources. In this way, novice teachers will be able to build up their self-efficacy in STEM education, provide high-quality STEM education for young children, and lay a solid foundation for young children's lifelong development.

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