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International Comparison of STEM Teacher Education

Zhaohao Nian

Faculty of Education, Palacky University, Olomouc, Czech Republic
Email: zhaohao.nian02@upol.cz

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Abstract

With the development of science and technology in our society, more and more countries have carried out the exploration of STEM education, and at the same time STEM teacher education has been placed in an important position. This study combines the reasons and policy backgrounds of STEM teacher education in the United States, the United Kingdom, and Australia and comprehensively uses qualitative research methods and comparative research models to analyze and finds that the similarities among the three countries mainly include: policies and incentives for STEM teacher education have been introduced from the national level, and all advocate the joint efforts of the community to train STEM teachers; Meanwhile, the differences among the three countries are mainly found to include: the United States has developed a STEM teacher education model with diversified and flexible teachers' choices; the United Kingdom has established a community model of STEM teacher education from government departments, universities, and businesses with a national network of joint training. Australia mainly focuses on improving teachers' STEM subject content and pedagogical knowledge and identifies a STEM teacher education model with professional teacher learning as the core. The comparative analysis of this study to provide international experience for STEM teacher education in other countries.

Subject Areas

Education

Keywords

STEM Education, Teacher Education, Comparative Research

1. Introduction

1.1. STEM Education

STEM education originated in the United States and is an acronym for the four

English words of science, technology, engineering, and mathematics. Most scholars believe that STEM education began in the "Undergraduate Science, Mathematics, and Engineering Education" report issued by the National Science Council in 1986. The report clearly stated for the first time the programmatic nature of "the integration of science, mathematics, engineering, and technology education." Recommendations are regarded as the beginning of STEM education [1]. Some scholars trace the origin of STEM education back to the launch of the Soviet satellite in 1957, making the United States pay more attention to student education. In 1958, the government promulgated the National Defense Education Law, which proposed training talented children and strengthening students' mathematics and science education [2]. Although scholars have different opinions on STEM education, common STEM education should be established in an education system. The concept is necessary. At the beginning of this century, Pennsylvania in the United States proposed a widely supported definition [3]. STEM education is an interdisciplinary learning method that students can use to apply science, technology, engineering, and mathematics to schools, communities, work, and In the environment established among global companies, rigorous academic concepts are combined with real-world courses to promote STEM literacy and the development of competitiveness in the new economy.

1.2. STEM Teacher Education

From the perspective of the purpose and essence of STEM education, STEM teacher education is about training teachers to recognize, apply, and integrate scientific, technical, engineering, and mathematical concepts and understand and innovate ways or solutions to solve complex problems. This is also the difference between STEM teacher training and traditional teacher training: content integration and innovation [4]. Combined with the understanding of STEM education, STEM teacher education can be summarized as training teachers to acquire STEM knowledge and skills, have STEM thinking and ability, master STEM teaching methods and ultimately improve teachers' self-confidence in STEM teaching so that STEM teachers can integrate content and innovate a comprehensive training program for teaching. It includes all stages from preservice education, and induction training to on-the-job training and covers the entire process of the STEM teacher's career [5]. The training of STEM teachers' technical and computational thinking has become an important content of STEM teacher education. The two key features of STEM teacher education are content integration and STEM literacy innovation methods. Content integration is STEM teaching And the core content of STEM teacher education [6]. Teachers with strong STEM subject knowledge can focus on teaching, provide different explanations for students' problems, and expand the curriculum. However, teachers with a STEM subject background will also face the challenge of making students understand knowledge [7]. Therefore, STEM teacher education must train teacher candidates to have strong STEM subject knowledge and train them to have knowledge of teaching content and learn to pay attention to students Thinking.

1.3. The Comparative Pattern

Every comparative inquiry must be rooted in the researcher's expertise in base, process, and aims as the fundamental categories of comparison. The bottom of the comparison is determined by the comparability of the subjects, which have been taken into account, as well as the definition of the common factor enabling comparison [8]. Contrary to the widespread assumption of equality, comparability in scientific comparison is dominated by topics suggesting similarity and diversity. The identification of the final comparison lays the ground for elaborating comparative indicators according to the questions which are to be investigated. The classical pattern has been applied in many comparative studies. In particular, Comparative Research in professional training is still widely dominated by juxtapositional descriptions in tabular form, which is suggested, above all, by the outcomes of analyses [9]. Firstly, it determines the progress and direction of the heuristic operation, whereby explaining and understanding can be considered as the focal variations. Secondly, the aim is rooted in the fundamental question, to which degree the application of comparative methods points the way to the generation of generalizing theories and, moreover, permits predictions or judgments about universal trends of evolution, perhaps even the identification of laws concerning the relations inside the education system as well as between this system and the processes in the society on the whole. In comparative education, this issue has always played an important role. On the other hand, comparative education is regarded as a field of research, and international and intercultural comparison can be utilized as an instrument for testing existing theories or single hypotheses. Within this function, the comparison is theory-bound in the sense that only entirely determined and problem-relevant empirical findings are selectively compared concerning their compatibility with the theory to be tested [10].

Based on previous researchers' major studies and findings, it was found that previous research in the field of STEM teacher education research has focused on teacher professional development, teacher perceptions, teacher efficacy, teacher identity, etc. Few studies have examined the overall teacher education preparation model as well as international comparative perspectives. Future research should strengthen research on STEM teacher education that integrates and references international experiences, so this study attempts to deepen research in this area from international comparative perspectives.

2. Research Methodology

This study mainly uses the documentary analysis method, case analysis method and Bereday's comparative research model. Bereday's comparative model (as shown in **Figure 1**) [11], which is placed in this research for total data analysis and divided into the following four steps: First, systematically collect related texts and data on STEM teacher education in the three selected countries (the United States, the United Kingdom, and Australia). Second, interpret the collected information and data based on social factors and educational policies. Third, through the previous step, summarize their respective characteristics and juxtapose them; fourth, based on the comparison to analyze the similarities and differences and give the conclusion.

3. Analysis and Comparison

3.1. STEM Teacher Education in United States

The future economic development of the United States requires a large number of workers who are proficient and able to use STEM knowledge and skills in their work. The ability to solve social problems and promote economic growth will depend on cultivating future professionals who are proficient in STEM skills [12]. The main measure in the United States is to invest in various STEM teacher education projects through fiscal measures and proposes to increase the number of STEM teachers by 100,000 in the next ten years [13]. With support from the United States, the current STEM teacher education projects in the United States can be divided into three types. The first type: STEM teacher education projects

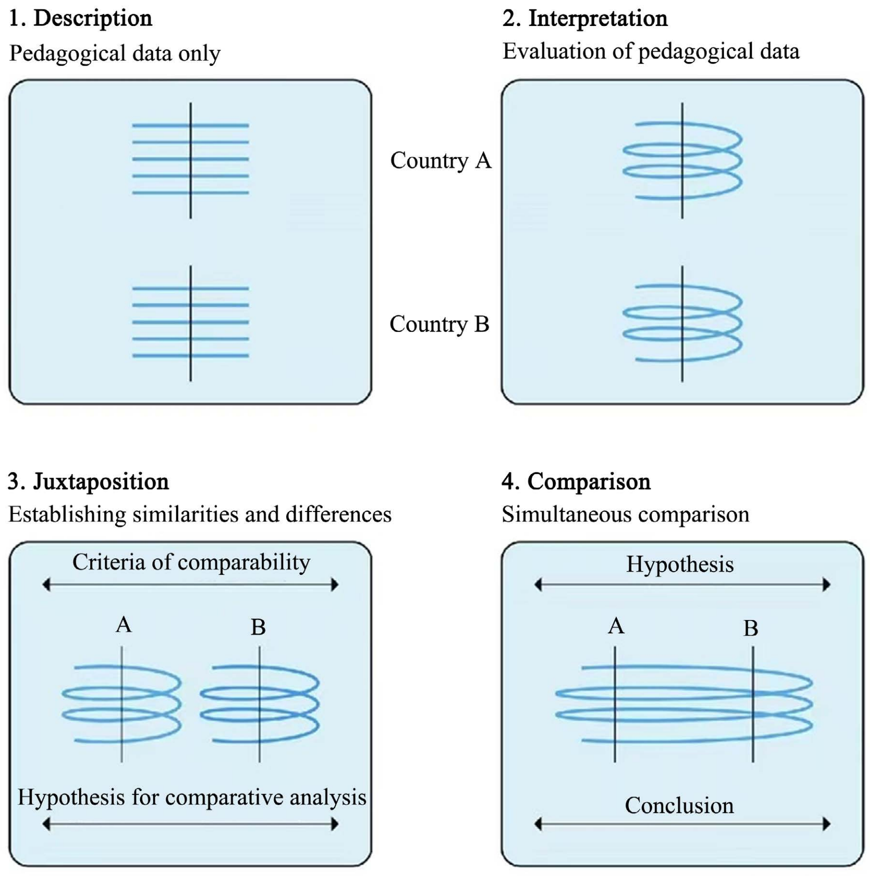

Figure 1. Bereday's comparative model.

led by the Ministry of Education, such as the Teachers for a Competitive Tomorrow project, initiated and funded by the Ministry of Education, and eligible higher education institutions, departments, or schools are responsible for STEM teacher training and qualification certification. The project includes two options: including STEM bachelor's degree programs, funded teacher training institutions provide STEM teacher education programs, and graduates are awarded STEM bachelor's degrees and teacher qualification certificates; STEM master's degree programs are awarded. Funding institutions provide two or three-year master's courses to improve the content knowledge and teaching skills of teacher education. After the course, graduates can obtain a one-year teaching master's degree and teacher qualification certificate [14]. The second type is teacher education projects led by colleges or universities. For example, The UTeach project is a teacher training project initiated by The University of Texas at Austin in 1997 [15]. It is responsible for recruiting and training undergraduates majoring in mathematics and science. Teaching work allows students to obtain STEM professional degrees and qualifications within four years. The project has been regarded as a model for achieving STEM teacher training goals. The third type is multi-party teacher education projects. For example, the 100 K in 10 projects [16], which is not only an alliance but also recruits the right combination of diversified and powerful organizations to expand their capabilities and influence through cooperation, learning, and funding. The 100 K in 10 projects has 28 founding partners, bringing together more than 280 top academic institutions, non-profit organizations, foundations, companies, and government agencies across the country, dedicated to cultivating and retaining excellent STEM teachers.

3.2. STEM Teacher Education in United Kingdom

A report by the British Royal Academy of Engineering pointed out that even if the supply of STEM talents in the United Kingdom increases by about 90,000 people every year, it will result in a shortage of about 10,000 STEM talents every year [17]. The United Kingdom is mainly expanding the recruitment channels of STEM teachers and adopting incentive measures to attract outstanding talents into the field of STEM teaching. The British STEM, teacher education model combines teacher training schools and teaching institutions to form a national teaching network [18]. This networked STEM teacher education model mainly includes two ways: one is a University training school, which is managed by university teachers and provides STEM education training programs. For example, in the physical science education program provided by Imperial College London, students can obtain a degree in physics and a qualified teacher qualification within three years. This is the first such degree in England and Wales. At the end of the three-year course, if students complete the course tasks, they will be awarded a degree in physics certified by the Institute of Physics, and they will be qualified to teach science in schools in England and Wales. Students need to complete a 120-day teaching internship in the third year, followed by a period of teaching practice after the final exam. Another way is the school-led route into initial teacher training, which is a school-led route into initial teacher training, which is a school through train project led by school-led training, which is jointly implemented by an accredited teacher training institution. This project allows schools to recruit directly and train their own teachers. Teacher candidates who complete the course will be qualified as teachers. For example, Surrey South Farnham's school through train project provides three options for different applicants. The first type is a fee-based course for undergraduates. Applicants can pay through student loans and obtain a qualified teacher qualification after the course is over; the second type is a paid training course for in-service teachers, which is an employment-based training course. Based on the program, the government provides subsidies to pay tuition and salaries; the third type is fee-based courses for high-quality graduates; universities provide training and certification, and after the course to get a training certificate and qualified teacher qualifications.

3.3. STEM Teacher Education in Australia

In the comparison of world STEM research output in recent years, Australia ranks tenth, accounting for 2.2% of global STEM research output, while the top two US and China are 20.9% and 9.4%, respectively. In order to improve the international competitiveness of Australian STEM, it is necessary to have a sufficient number of STEM professionals. The Australian government has adopted financial incentives to encourage outstanding STEM students with excellent grades to participate in pre-service STEM teacher education Courses, thereby increasing the number of STEM teachers. Among technology and science teachers, 40% of science teachers and 20% of science teachers have not completed one year of higher education in STEM-related subjects [19]. Therefore, the Australian government proposes to STEM teachers more standardized requirements, including specific subject requirements and teaching requirements. At the same time, it is further required that all graduates of teacher training majors gradually and standardize teachers' professional development, especially STEM subject teachers, must have a major in the professional field of content and teaching knowledge. In order to promote the professional learning of STEM teachers, the Australian government has established a STEM teacher education model with professional teacher learning as the core. The government supports the cooperation of professional teacher associations and universities to cooperate with enterprises and enterprises provide resources or internship opportunities to help STEM teachers connect teaching practice with curriculum theory, for example, STEM Teachers' Training College at the University of Sydney. It provides STEM professional education courses in two directions for STEM teachers [20]. The first type: the primary school project, which aims to provide STEM teachers with tutoring, online forums, newsletters, seminars, and other activities, establish a

Country	Similarities	Differences
United States	Policies and incentives for STEM teacher education have been introduced at the national level; the joint efforts of the community to train STEM teachers are advocated, and emphasis is placed on promoting teacher professional development.	Diversified STEM teacher education projects; Teacher-led and flexible selections of STEM professional development.
United Kingdom		The nationwide networked joint training establish a STEM teacher education community model by government departments, universities, and enterprises.
Australia		Focus on improving teachers' STEM subject knowledge and teaching ability, and determine a STEM professional development plan centered on teachers' professional learning.

Figure 2. Comparison of STEM teacher education.

community of practice for teachers participating in STEM courses, provide continuous support and participation, and provide them at the end of the course certification. The second type is the middle school project, which is mainly hosted by academic experts from the university and is carried out in the form of workshops. Through university academic experts, STEM leaders, and teachers or peer-led conferences, focus on the key knowledge areas in the STEM curriculum, and improve the subject content and teaching knowledge of teachers.

Figure 2 shows the similarities and differences of STEM teacher education in the three countries (United States, United Kingdom and Australia).

4. Conclusion

To sum up, the United States, the United Kingdom, and Australia have all introduced policies and incentives for STEM teacher education at the national level. The three countries all advocate the efforts of all sectors of society to work together to train STEM teachers and attach importance to promoting the professional development of teachers. At the same time, the United States mainly develops diversified STEM teacher education projects; teacher-led, flexible selection of STEM professional development. The major national networked joint training in the United Kingdom has established a STEM teacher education community model for government departments, universities, and enterprises. Australia mainly focuses on improving teachers' STEM subject content and teaching knowledge and determines the STEM professional development plan with professional teacher learning as the core. In summary, the smooth progress and development of STEM teacher education require not only the cooperation of teaching institutions but also the cooperation of STEM subjects. STEM teachers need the joint efforts of various institutions in society, and they also need policy support and protection to increase the attractiveness of being a STEM teacher. In addition, this research is mainly a comparative analysis from the text level, and it could do further and deeper research from a quantitative perspective.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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