Available online at: http://proceeding.rsfpress.com/index.php/mess/index
Proceeding on Management, Education and Social Science (MESS)
Volume 2 Number 1 (2022): 40-47

International Comparison of STEM Teacher Education

Zhaohao Nian
Department of Education and Social Studies, Faculty of Education, Palacky University

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 use 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. Through the comparative analysis of this study to provide international experience for STEM teacher education for other countries.

Keywords: *STEM education ,teacher education,comparative research.*

INTRODUCTION

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. (Martín-Páez & Aguilera, 2019).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 (Yanbing, 2014). 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: STEM education is an interdisciplinary learning method that students can use to apply science, technology, engineering, and mathematics

Corresponding author
zhaohao.nian02@upol.cz
DOI: -to be assigned-

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 (Davis & Francis, 2019).With the development of science and technology in society, more and more counties have launched the exploration of STEM education,as well as the STEM teacher education has also been placed in an important position.This research combines the reasons and policy backgrounds of STEM teacher education between United States,United Kingdom and Australia,comprehensively collects and analyzes their characteristics based on the comparative research model, and to figure out their similarities and differences to provide the experience references in STEM teacher education for other countries.

LITERATURE REVIEW

Radloff and Guzey(2016)explored the extent to which pre-service STEM teachers visualize STEM education through visual images and found that STEM education is highly variable in terms of textual and visual perceptions. Erdogan and Ciftci(2017)explored preservice science teachers' perceptions of STEM educational practices by providing them with STEM activities, and their findings indicated that preservice science teachers generally had positive attitudes toward STEM educational practices. They believed that STEM educational practices helped to improve their overall competence. Chiyaka and Kibirige(2017)explored the factors that influence professional development engagement of teachers in STEM and non-STEM disciplines, and there were some differences in the factors that they expressed as barriers to engagement. Teachers in STEM disciplines reported that work schedules, family responsibilities, and lack of motivation to engage in professional development were barriers to engagement.Nagdi and Leammukda(2018)explored the changing identities of STEM teachers in emerging STEM schools. Findings suggest that STEM teacher identity can be viewed as a dynamic, evolving process that stems from the interaction of personal and professional identities in new educational experiences. Keiler(2018)examined the difficulties teachers face in their changing roles and identities as they shift to student-centered instruction. By engaging teachers in a peer support restructuring classroom project, teachers' self-perceptions as educators changed significantly compared to traditional classrooms.Bartels and Rupe(2019)used a systematic STEM curriculum model to construct preservice STEM teachers' understanding of STEM concepts, showing that in a relatively short period of time, participating preservice teachers improved their understanding of STEM concepts and how to teach them. HallmanThrasher and Connor(2019)found that teachers with strong knowledge of STEM subjects were able to focus on teaching, provide different explanations for students' questions, and expand on the curriculum. Czajka and McConnell(2019) investigated the impact of new student-centered materials on STEM teachers' professional development by showing that the use of new materials was more effective in promoting teachers' professional development compared to traditional materials.Akiri and Dori(2021)found that experienced STEM teachers perceive novice STEM teachers' efficacy as lower than that perceived by the novice teachers,and they identified gaps between the mentoring factors described by novice STEM and experienced STEM teachers and a strong correlation between the growth dimensions.

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

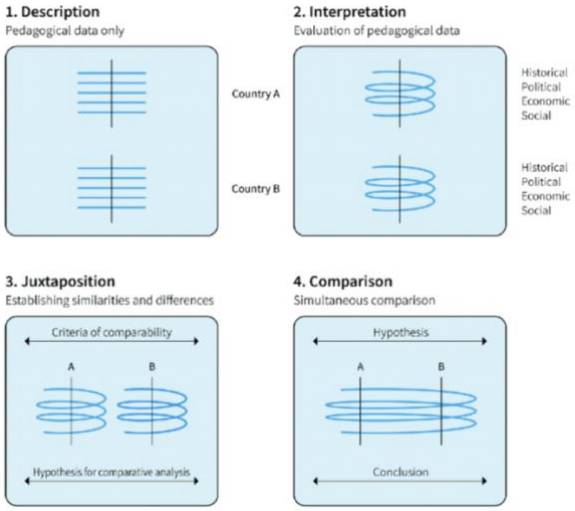
development, teacher perceptions, teacher efficacy, and teacher identity,etc. Few studies have examined the overall teacher education preparation model as well as international comparative perspectives. Future research should strengthen research on STEM teacher education that integrates and references international experiences, so this study attempts to deepen research in this area from international comparative and integrative perspectives.

RESEARCH METHODOLOGY

This research collects information about STEM teacher education in the United States, the United Kingdom, and Australia from official documents and references. It combines the reasons for STEM teacher education in these three countries and the educational policy background and cooperates with the case. The purpose of the research is to The similarities and differences of national STEM teacher education are studied internationally. Therefore, this study mainly adopts Bereday's comparative research model, documentary analysis, and case analysis research methods. In this study, literature on STEM teacher education-related topics in the United States, the United Kingdom, and Australia was collected from the Internet and in the literature database. At the same time, the researcher downloaded the official STEM teacher education-related topics from the official website of the national government department, documents, and access to library materials, combined with scholars' literature for sorting and analysis.Additional, the researcher collected from the literature about different educational projects in the three countries of the United States, the United Kingdom, and Australia in the practice of promoting STEM teacher education. In order to further deepen the understanding of STEM teacher education in the three countries, the representative examples of STEM teacher education in the three countries are selected for the supplementary explanation. Finally,Bereday's comparative approach provides a sophisticated model for this total analysis as described above, and it can be summarised as：

Diagram 1

Comparative Model：



Bereday's comparative model is placed in this research for data analysis and divided into the following four steps: First, systematically collect official texts and data on STEM teacher education in the three selected countries (the United States, the United Kingdom, and Australia). Second, explain the collected information and data based on social factors and educational policies. Third, through the previous step, determine the dimensions of comparative analysis and summarize their respective characteristics; fourth, based on the previous step, summarize the characteristics of STEM teacher education in the three countries, analyze and compare the similarities and differences.

RESULTS

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 (President's Council of Advisors on Science). and technology, 2010). 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 (Committee on STEM Education National Science and Technology Council, 2013). 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 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 (Johnson & Mohr-Schroeder, 2020). 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. 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 (Marder, 2005). The third type is multi-party teacher education projects. For example, the 100Kin10 project (2011). 100Kin10 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 100Kin10 project 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.

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. (Matthew Harrison, 2012) The United Kingdom

is mainly through expanding the recruitment channels of STEM teachers and adopting incentive measures to attract outstanding talents into the field of STEM teaching (Department for Education, 2019). The British STEM, teacher education model combines teacher training schools and teaching institutions to form a national teaching network. 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 (The Royal Society, 2014). 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 (Department for Education, 2017). 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, after the course, you can get a training certificate and qualified teacher qualifications (Surrey South Farnham SCITT, 2019).

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 (Office of the Chief Scientist, 2014). 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. According to the Australian Council for Educational Research (2016): 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. 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 before 2019, 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 teacher professional 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. (The Council of Australian Governments, 2018). For

example: STEM Teachers' Training College at the University of Sydney. It provides STEM professional education courses in two directions for STEM teachers. The first type: the primary school project, which aims to provide STEM teachers with tutoring, online forums, newsletters, seminars, and other activities, establish a 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.

Diagram 2
Comparison of STEM teacher education:

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.

CONCLUSION AND FURTHER RESEARCH

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.

REFERENCES

Martín-Páez, T, Aguilera, D. (2019). What are we talking about when we talk about STEM education? Science Education, 103, 799-822.

Yanbing Li.（2014）.Essential reflections and practical issues of the "Science,

Technology, Engineering and Mathematics". educational movement: A dialogue with Professor Nashon from the University of British Columbia in Canada. Global Education Outlook,11: 4-5.

Davis, B., Francis, K. (2019). STEM Education by Design,Opening Horizons of Possibility (1st ed.). Routledge.

Denzin, N. K. (2006). Qualitative Methodology. In C. D. Bryant & D. L. Peck (Eds.).21St Century Sociology: A Reference Handbook, pp. 98–107. SAGE Publications.

Akiri, E., & Dori, Y. J. (2021). Professional Growth of Novice and Experienced STEM Teachers. Journal of Science Education and Technology, 31(1), 129–142.

Selina L. Bartels, Kathryn M. Rupe (2019) Shaping Preservice Teachers' Understandings of STEM: A Collaborative Math and Science Methods Approach, Journal of Science Teacher Education, 30:6, 666-680.

Hallman Thrasher, A., Connor, J., & Sturgill, D. (2019). Strong Discipline Knowledge Cuts Both Ways for Novice Mathematics and Science Teachers. International Journal of Science and Mathematics Education, 17, 253-272.

Chiyaka, E., Kibirige, J. (2017). Comparative Analysis of Participation of Teachers of STEM and Non-STEM Subjects in Professional Development. Journal of Education and Training Studies, 5(9), 18-26.

Charles Doug Czajka & David McConnell (2019) The adoption of student-centered teaching materials as a professional development experience for college faculty, International Journal of Science Education, 41:5,693-711.

Radloff J, Guzey S.(2016)Investigating Preservice STEM Teacher Conceptions of STEM Education.Journal of Science Education and Technology,25（5）:759- 774.

Erdogan I, Ciftci A.(2017)Investigating the Views of Pre-Service Science Teachers on STEM Education Practices.International Journal of Environmental and Science Education,12（5）:1055-1065.

El Nagdi, M., Leammukda, F.(2018). Developing identities of STEM teachers at emerging STEM schools. International journal of STEM education, 5(1), 36.

Keiler L. S. (2018). Teachers' roles and identities in student-centered classrooms. International journal of STEM education, 5(1), 34.

Beredy, G. Z. F. (1964). Comparative method in education. New York: Holt, Rinehart and Winston, Inc, 28.

President's Council of Advisors on Science and Technology (2010). Prepare and inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's future.https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf.

Committee on STEM Education National Science and Technology Council （2013).Federal Science,Technology,Engineering,and Mathematics(STEM)5-Year Strategic Plan. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf.

Johnson, C.C, Mohr-Schroeder, M.J. (2020). Handbook of Research on STEM Education (1st ed.). Routledge. https://doi.org/10.4324/9780429021381.

Marder, M. (2005). UTeach: Teacher preparation at The University of Texas at Austin. Bulletin of

the American Physical Society.

100Kin10(2011).100Kin10 is answering the nations call. 100Kin10. Retrieved May 05, 2021,https://100kin10.org/about.

Matthew Harrison .(2012)Jobs and Growth:the Importance of Engineering Skills to the UK Economy.Royal Academy of Engineering .www.raeng.org.uk/jobsandgrowth.

Department for education (2019),Recruit a qualified maths or physics teacher from. abroad.Fenews.https://www.fenews.co.uk/press-releases/28805-detailed-guide-rec ruit-a-qualified-maths-or-physics-teacher-from-abroad.

The Royal Society.（2014）.Vision for science, mathematics and computing education. The Royal Society Science Policy Center.https://royalsociety.org/~/media/education/policy/vision/reports/vision-full-repor t-20140625.pdf.

Department for Education.(2017).School Direct: guidance for schools. Govuk.

Https：//www.gov.uk/guidance/school-direct-guidance-for-lead-schools.

Surrey South Farnham SCITT.(2019).School Direct Tuition Fee ,https://www.ssfscitt.org.uk/page/?title=School+Direct+Tuition+Fee+QTS &pid=11.

Office of the Chief Scientist.(2014).Benchmarking Australian Science, Technology,Engineering & Mathematics.Australian Government.https://www.chiefscientist.gov.au/2014/12/benchmarking-australian-science-technology-engineering-mathematics.

Australian Council for Educational Research.(2016).Impact Case Study: STEM education.(2016).Teach For Australian. https://teachforaustralia.org/impact-case-study-model-improving-quality-stem-educ ation/

The Council of Australian Governments.(2018). Optimising STEM Industry-School Partnerships: Inspiring Australia's Next Generation.VOCED. https://www.voced.edu.au/content/ngv%3A79571