Science Teacher Training for the 21st Century: How to Integrate Cultural Ideas to Cultivate Educators with a Global Perspective

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Abstract: Educational systems that are capable of supporting and including all diverse cultures is crucial in the modern era of sustainable globalisation. Our main objective is to examine science teacher training for the 21st century and how to integrate cultural ideas to cultivate educators with a global perspective. Our study designed professional development program grounded in culturally relevant pedagogy that was conducted from January 2022 to January 2024 at Shanghai High School involving 150 teachers. The findings showed significant positive impacts on both student learning outcomes and teacher self-efficacy. Paired-samples t-tests showed a substantial increase in student science test scores following the program ($p < 0.001$), with a moderate effect size (Cohen's $d = 0.47$). Furthermore, linear regression analysis indicated a positive association between teacher self-efficacy at baseline and student test score gains, suggesting that teachers with higher initial confidence in CREST strategies fostered greater student learning improvements. The program also yielded positive effects on teacher self-efficacy in CREST strategies over time. ANOVA demonstrated statistically significant increases ($p < 0.05$) in all four CREST areas (Content Readiness, Equity Readiness, Information Analysis, and Use of ICT) from baseline to both 1 year and 2 years post-program.
Keywords: Culture, Science Teacher, Global, Pedagogy, Professional Development Program

1. INTRODUCTION

The recent growth and advancement in technology has led to transnational migration, information and sharing of knowledge that has increased the interrelationships and connections among individuals and regions. The emergence of globalisation challenges brought by seamless interconnections and relationships among individuals such as the need for an integrated and knowledge-driven economy, increased transnational migrations, rural-urban migrations and growth of inequalities. Although Beck (2012) postulated that the diversity and differences in the linguistics, race and culture among the Canadian schools constitute a salient feature due to the consistent increase and rapid rise in the immigrant families, internal migration patterns and growth of the Aboriginal individuals. Moreover, previous studies (Guo, 2013) have suggested that the increased

changes in the educational landscape have led to increased demand on culturally and pedagogically experienced and competent teachers who are knowledgeable about addressing the challenges and emerging issues of globalisation, social justice and race. According to Parsons and Carlone (2013) culture can be interpreted as a contextual and time-dependent feature that exists in several levels of local, global, macro and micro. The essence of culture has been defined in several literature, and individual views that indicate a variation in time and space from a viewpoint that highlights the interconnections between human development and behaviour from the past to the present and capturing all the dynamics of the present and future. Culture allows people to obtain meaning of events that occur in the present moment and plan for what is expected in the future. Culture can be interpreted from the perspectives of psychology (system of beliefs and values that affects how individuals interact and perceive with the world), and anthropology perspective (patterns of ways of life that are unique and defines a social group that is passed from one generation to another). Educational systems that are capable of supporting and including all diverse cultures is crucial in the modern era of sustainable globalisation. The development of a distinct form of education allows individuals to coexist in peace and harmony to create a sense of well-being and sustainable development (PISA, 2018). The formulation and reshaping of educational policies in several parts of the world has been championed by organisations such as the UNESCO who presented the Four Pillars of Learning (Learning to know, learning to do, learning to be and learning to live together) (Tawil & Cougoureux, 2013). A fifth pillar was added by UNESCO consisting of learning to address the special challenges associated with sustainability and transforming oneself and the society (Holst, 2023; Lai & Peng, 2019). According to Tawil and Cougoureux (2013) these five pillars were regarded as an integral vision for education of the future and has been adapted in the conceptualisation of learning and education for the world.

The implementation of these education policies over the last 40 years have been effective and led to the establishment of effective models, tools of educational assessment, educational continuums and frameworks. The emergence of ideas such as pluralism, diversity (Stanley, 1996), intercultural learning (Sorrells, 2020), multicultural teaching (Harrison et al., 2010), global citizenship (Larsen, 2014), and the global competencies of democratic culture. The teacher education in China has lasted for more than a century and constitutes a significant component of the education system (Guo et al., 2019). In the last 5 decades of teacher development and

training since the founding of higher education in China, there has been an emphasis on the focus of hiring and caring for teachers. Chinese teacher education system is distinct and geared towards attaining the types and different levels of basic education (Lee, 2019). At the 5th National Meeting in 1996, teacher education was deemed as a strategy priority for the educational development in China. The focus on teacher education and its significance in global development constitutes the basis for the myriad of societal benefits and advancement. The teaching education system in China offers the largest support to basic education worldwide. Reforms in the Chinese education system must contribute heavily to the quality of the nation. The training and teacher education in China consists of two elements of pre-service education and in-service training. There are four-year teacher training education systems involving universities while 3-year education systems that are offered in colleges (Gong & Wang, 2017). Secondary school teachers must undergo a pre-service education training. Due to the significant lags and delays in the development of science teacher training and development in China, there has been insufficient and inadequate preparation of science teachers. In the last 3 decades in China, a higher proportion of Chinese science teachers underwent training in normal universities. However, at the present, China operates more than 100 universities involved in training of 4-year Bachelor of Science and 3-year graduate students and few with masters and doctoral programs. Global citizenship is a 21st century strategy to life where the principles of accountability and responsibility are applied in addressing the local activities and complicated global issues (Leite, 2022; Sharma, 2020). Students and teachers in the 21st century require the elements of global citizenship to increase their empowerments with values and key skills of taking actions and addressing all the issues and realities of the 21st century. Several literatures have reported that the philosophy of global citizenship possess certain features such as respect for fellow humans, appreciating diversity and several perspectives, encouraging sustainable patterns and striving for conflict resolution. The idea of civic and citizenship education is not common among the Chinese literature and educational policies; however, there are related ideologies in the Chinese context such as education on values, moral education and political education based on different levels depending on historical periods (Feng, 2014). The Chinese have a renowned history of moral education that dates back to the Confucius period that is based on educating young people with Confucian principles of loyalty to the state, obedience and morality. In 1949 after the founding of the People's Republic of China, education of citizens was

based on cultivating national identity, loyalty to the communist party and state and collectivism (Wing-Wah, 2013). Educational practices and programs performed on the basis of global citizenship should seek towards preparing students in achieving and becoming global citizens. The main objective of global citizenship education is to establish and create a sense of belonging based on the shared principles of humanity, solidarity, responsibility and identity. Several studies (Desveaus & Guo, 2011; Goddard, 2013) have proposed that new teachers often start their careers with lack of sufficient and deep knowledge and skills to adequately manage and interact with learners from different parts of the globe. The training of teacher candidates in the preparation of education training programs, several candidates have been not adequately prepared and supplied with sufficient theoretical understanding and the professionality of allowing students to become global citizens (Weber et al., 2013). Chai et al. (2019) suggested that the 21st century quality of learning should focus on the enhancement and modelling of teachers with the efficiency, effectiveness and beliefs about the pedagogical content of technological skills and knowledge. Technological pedagogical content knowledge forms a significant perspective and a powerful technique of unravelling the skills and knowledge of teachers to effectively design and implement science lessons for the 21st century classrooms. Although, recent studies have reported contradicting findings on the utilisation of technological pedagogical content knowledge has failed to transform the existing state of technology and integration in classrooms (Heitink et al., 2017; Pringle et al., 2015; Tondeur, 2020; Tondeur et al., 2017). Quantitative studies have focused on the validation of the seven-factor model (Mishra & Koehler, 2006) and the utilisation of validated models to examine the growth and development of teachers based on their teaching efficacy before and after undertaking information and communication technology teaching courses (Chai & Koh, 2017). There has been significant success from previous studies in validating the seven-factor model (Chai et al., 2016), however, it has often faced challenges in the conception of the technological pedagogical content of technological skills (Jang & Tsai, 2013; Lee & Tsai, 2010; Yeh et al., 2014). Culture and education form a significant and dominant culture when combined together and can often be deployed as a tool for control or colonialism. Practices of a particular culture consists of patterns of beliefs, norms and values of the scientific culture. Scientific knowledge in the 21st century has been cross-examined and monitored to ensure equitable instructions and offer learners with suitable opportunities in the global and democratic world. Learning of science can be based on

cultural border-crossings of either enculturation and assimilation, hybridization and cultural flexibility. We believe that learning science requires strong cultural influence of schools, teaching and engagement in several cultural processes. Effective and efficient instructional techniques and approaches to learning and teaching of science should be supported by pedagogical frameworks and enhanced by cultural congruent and responsible instructions. Our main objective is to examine science teacher training for the 21st century and how to integrate cultural ideas to cultivate educators with a global perspective

2. METHODS

2.1 Professional Development Program

Our program involves a teacher professional development program grounded in culturally relevant pedagogy that was conducted from January 2022 to January 2024. The program investigated the link between the theoretical framework, its implementation, and the impact on both teaching practices and student test score gains. Culturally relevant pedagogy serves as the foundation for the program's design, informing the intervention's core assumptions. Culturally responsive models play a crucial role in identifying topics relevant to specific tribal communities. Furthermore, culturally congruent instruction guides the development of program activities. This is achieved by strategically matching tribal cultural elements and practices with the science content being taught. The program itself is a collaborative effort, bringing together tribal advisory teams, faculty from institutions of higher education, and the participating teachers themselves.

2.2 Characteristics of the Professional Development Program

Our study presents a professional development program designed to cultivate science educators in Shanghai high schools. The program was grounded in the theoretical framework of Culturally Responsive Science Teaching (CREST) aimed to equip teachers with the ability to integrate cultural ideas into their classrooms and foster global perspectives in science education. The program was delivered through a blended learning approach over five weeks of 30-hour intensive workshop targeted in-service science teachers. The program unfolded in five modules each building upon the previous one. The initial module introduced CREST while module two prompted teachers to reflect on their own cultural

backgrounds and their potential influence on science instruction. Module three focused on cultural perspectives in scientific inquiry through case studies examining historical and contemporary discoveries. Module four equipped teachers with the tools for implementation by introducing various CREST teaching strategies and adoption of ICT. The final module focused on implementation and reflection, with teachers developing plans to integrate CREST strategies and sharing best practices and challenges during initial implementation. The program concluded with a discussion on strategies for ongoing reflection and assessment of CREST's impact on student learning.

2.3 Participant Characteristics

Our cohort study (N = 150) for in-service science teachers in Shanghai High Schools. The cohort consisted of teachers from Shanghai high schools where the science program was rated as "high quality" by 43% of the teachers based on a 5-point scale (3 to 5). These schools typically had self-contained science classrooms in 75% of cases, with an average class size of 20-26 students (45%) or 27-31 students (10%). Students in these classrooms were approximately 15-16 years old (Grade 10) or 17-18 years old (Grade 12).

2.4 Data Collection

Two pre- and post-program surveys, each containing approximately 30-35 questions, were administered online using a secure platform to evaluate the effectiveness of the program. These surveys utilized a combination of question formats: Likert scale questions assessed teacher self-efficacy in integrating CREST strategies, multiple-choice questions gauged baseline science content knowledge of students, and open-ended questions captured additional insights on teacher experiences and perceived student learning gains. Each survey took teachers an estimated 15-20 minutes to complete.

2.5 Data Analysis

Quantitative analyses were performed in GraphPad Prism version 9.5.1 at a statistical significance of 5%. Descriptive statistics were presented as mean (standard deviation) while frequencies were presented as percentages. Changes in student science test scores, measured pre- and post-program, were analysed using paired-samples t-tests to assess the program's immediate impact on knowledge acquisition. To explore the influence of

teacher self-efficacy on student learning, linear regression analysis was conducted, examining the relationship between teacher self-efficacy scores (measured at baseline) and student test score gains.

3. RESULTS

3.1 Demographic Profile of Science Teachers Involved in the Study

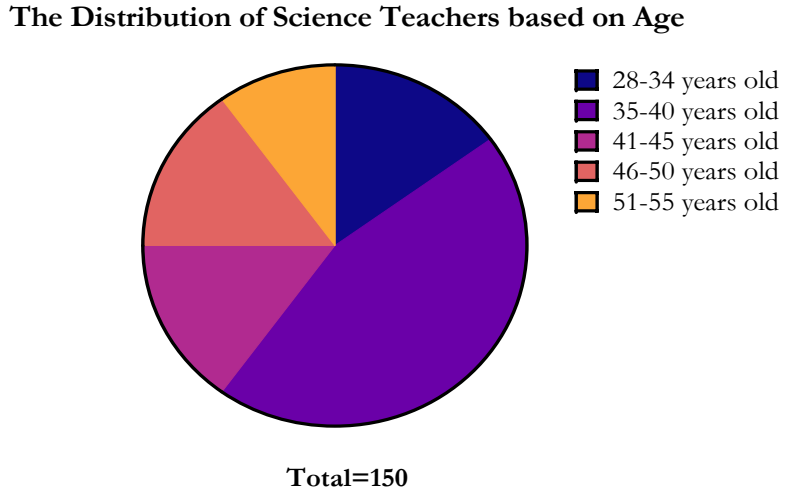

Figure 1: A Pie Chart Showing the Demographic Distribution of Participants based on Age.

In Figure 1, A total of 150 science teachers participated in the study. The age range spanned from 28 to 55 years old. Among the participants, 22.5 (15%) fell within the 28-34 age range, with the largest group (67.5 teachers, 45%) being between 35-40 years old. The remaining participants were fairly evenly distributed across the 41-45 (22.5 teachers, 15%), 46-50 (22.5 teachers, 15%), and 51-55 (15 teachers, 10%) age ranges.

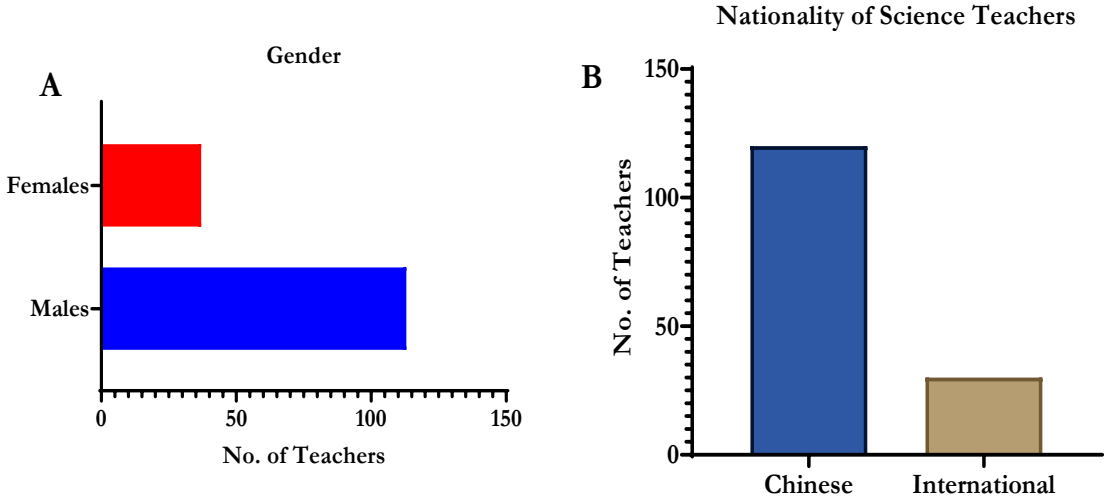

Figure 2: Column Charts Showing the Proportion of Science Teachers Based on Gender (A) and Nationality (B).

The program attracted a diverse group of science teachers from Shanghai high schools who received a stipend for their involvement. The program included approximately 20% international teachers and 80% Chinese teachers with 75% male teachers and 70% having a Bachelor's degree (B.S. or B.A.) in Science Education or a related field while 30% had a Master's degree (M.S.) or higher (see Figure 2). Teacher certification primarily focused on secondary education. Over 80% of all teachers held certification for teaching science in high school. Multiple certifications (covering both elementary and high school levels) were present in approximately 15% of participants (see Figure 3). The largest category consisted of those with 10-15 years of experience.

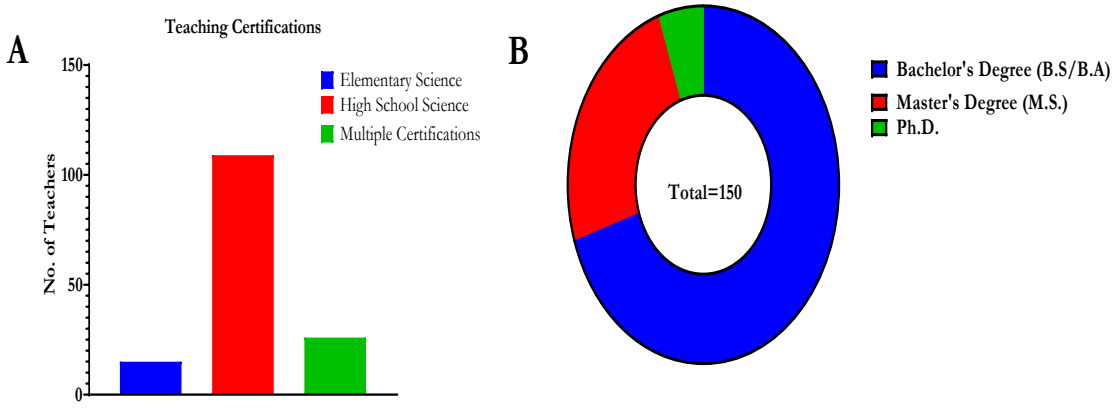

Figure 3: A Doughnut Plot and a Column Chart Showing the Teaching Certifications and Educational Qualifications of Science Teachers.

Table 1: Paired-Samples t-Test for Changes in Student Science Test Scores

Variable	Mean (Pre)	Mean (Post)	SD (Pre)	SD (Post)	T-Value	P-Value	Cohen's D
Student Science Test Scores	68.5	83.2	5.2	3.8	4.12	0.001	0.47

Note: SD = Standard Deviation.

In table 1, student science test scores showed a significant improvement ($p = 0.001$) following the program. Mean scores increased from 68.5 (SD = 5.2) pre-program to 83.2 (SD = 3.8) post-program, representing a moderate effect size (Cohen's $d = 0.47$).

Table 2: Linear Regression Analysis for Teacher Self-Efficacy and Student Test Score Gains

Variable	Coefficient (B)	Standard Error (SE B)	Beta	T-Value	P-Value
Teacher Self-Efficacy-Student Test Scores	3.2	0.8	0.38	4.02	0.001

In Table 2, teacher self-efficacy at baseline significantly predicted student science test score gains (p-value = 0.001). There was a positive relationship, with a one-unit increase in teacher self-efficacy (measured by the survey) associated with a 3.2-point increase in student test score gains, on average. The effect size was moderate, with a beta coefficient of 0.38.

Table 3: Mean (SD) of Teacher Self-Efficacy in CREST Strategies (Baseline, 1 Year, 2 Years)

Variable	Baseline (Mean, SD)	1 Year (Mean, SD)	2 Years (Mean, SD)	Sig. (P-Value)
Content Readiness	(3.8, 0.7)	(4.2, 0.6)	(4.1, 0.5)	0.002
Equity Readiness	(3.5, 0.8)	(4.0, 0.7)	(3.9, 0.6)	0.001
Information Analysis	(3.2, 0.9)	(3.7, 0.8)	(3.6, 0.7)	0.003
Use of ICT	(2.8, 0.9)	(3.4, 0.8)	(3.3, 0.7)	0.041

In Table 3, teacher self-efficacy in CREST strategies increased significantly over time ($p < 0.05$) across all areas measured. Mean scores for Content Readiness rose from 3.8 (SD = 0.7) at baseline to 4.2 (SD = 0.6) at 1 year and 4.1 (SD = 0.5) at 2 years post-program. Similarly, Equity Readiness increased from 3.5 (SD = 0.8) at baseline to 4.0 (SD = 0.7) at 1 year and 3.9 (SD = 0.6) at 2 years. Information Analysis followed the same trend, with scores rising from 3.2 (SD = 0.9) at baseline to 3.7 (SD = 0.8) at 1 year and 3.6 (SD = 0.7) at 2 years. Use of ICT showed improvement as well, although with a weaker significance level (p-value = 0.041), increasing from 2.8 (SD = 0.9) at baseline to 3.4 (SD = 0.8) at 1 year and 3.3 (SD = 0.7) at 2 years.

4. DISCUSSION

Our study proposed significant positive impacts on both student learning outcomes and teacher self-efficacy. Paired-samples t-tests showed a substantial increase in student science test scores following the program ($p < 0.001$), with a moderate effect size (Cohen's d = 0.47). Furthermore, linear regression analysis indicated a positive association between teacher self-efficacy at baseline and student test score gains, suggesting that teachers with higher initial confidence in CREST strategies fostered greater student learning improvements. We suggest that the program's positive impact on student science scores may be attributed to increased teacher implementation of equitable instruction and fostered student connections

between scientific topics, real-world applications, and hands-on activities. This aligns with the principles of instructional congruence presented in previous studies (Lee, 2004; Lee & Fradd, 1998) which emphasizes the importance of bridging cultural expectations, classroom norms, academic content, and students' lived experiences (Lee, 2004). The independent contributions of teacher self-efficacy in equitable instruction and student connection-building suggest that both elements contribute to improved student learning outcomes. The preparation of teachers for educating in the era of global citizenship in China must involve two components. Initially, the Chinese classrooms must become more diverse and incorporate individuals of different cultures, linguistics and ethnicities due to the increased number of immigrants and international students, internal migrations and refugees. Thus, this environment requires that teachers should be competent in managing different cultures and addressing the issues of diversity and inclusivity in educational practices. Secondly, the increased interrelationships and connections among countries, particularly, in the areas of peace, culture and economic security must involve teachers who are effective and competent in pedagogy to assist students on intellectual and moral basis for navigating the complex issues and problems of globalisation.

Global citizenship education ensures students are modelled into globally responsible citizens that are striving towards sustainable development of international and local communities and encouraging a holistic school of thought and cross-cultural understanding. Graduating students nowadays are involved in an interconnected world compared to previous decades. Thus, citizens and students of the 21st century should be responsive and aware of the several complicated issues of global and local concerns in various aspects of health, economy and peace (Guo, 2014). In the last decades, the education of teachers is a critical challenge in preparing teachers for the increased heterogeneity and altering demographic profile of participants across the globe. In the US, demographic changes in classrooms have led to the increased focusing on the linguistic and cultural issues emerging in classrooms across the country. The commonly used response involves the division of education into compartments through unique and targeted teacher targeted programs based on their levels of specialisation and categorised based on the language background, ethnic backgrounds and learning capacity. In the last 3 decades, 21st century learning has constituted a significant component of educational discourse (Griffin et al., 2012) with educationalists and institutions proposing that the educational curricula should be structured to emphasize the higher

order cognitive activities of critical thinking, innovation and creativity. Moreover, there is a significant emphasis on interpersonal skills of communication and collaboration. The educational frameworks of the 21st century should consist of skills such as teamwork, social learning, peer assessment and sharing of knowledge. Previous studies have suggested that changes in the labour market in developed countries have led to significant shifts in the job requirements from structured knowledge to the mastery of learning skills and tools (Griffin et al., 2012). The education of the 21st century makes teachers to have the difficult task of preparing students to become responsible citizens and workers. The recent focus has been on what students are capable of doing with knowledge rather than the number of learning units acquired in contemporary education. Our findings were analogous to a study by Abualrob (2019) on the role of science teachers in developing the 21st century skills for elementary school students found that there was a significant advancement of science teachers towards eight major categories of critical thinking, collaboration, communication, innovation, self-direction, global connections, local connections and increased utilisation of technology. We propose that 21st century skills and knowledge are required worldwide and teachers must play a critical role in equipping learners with these skills to ensure effective participation in the society and cultural development. Learners should be allowed more time to practice these skills by transitioning from teacher led classrooms to student led classrooms. Kim et al. (2019) suggested that the training of science teachers for the 21st century involves key skills that increases the instructional quality of teachers. Although, there are significant challenges in the achievement of these skills and professional competencies among teachers such as lack of a specific focus on the teaching practices and significant ways of increasing teacher development.

Our study was similar to Grimberg and Gummer (2013) who conducted a study to evaluate the effects of teaching science from a cultural viewpoint of intersection by analysing a professionally developed program for science teachers in Montana. They designed a program based on culturally relevant premise of pedagogy through instructional techniques and content based on intersection of three cultures of tribalism, science and teaching of science. Their findings indicated that after 24 months of participation, teachers changed their beliefs and teaching practices about science and advocated for an equitable implementation of teaching techniques that positively impacted the performance of students. Similarly, a study by Avraamidou (2020) found that intersectionality and cultural differences in

the study of science is significant in ensuring that classroom inequalities are addressed and alleviates systems of oppression such as sexism or racism that have existed in science. The utilisation of science as an identity is crucial in contributing to the comprehension of how science identity serves in ensuring its learning is purposeful and has an impact to the society. Science identity can be viewed from an ontological perspective of learning and address all the variations and diversity encountered in the learning of science. Drake and Reid (2018) postulated that there is a global consensus on the significance of incorporating 21st century skills into the education curricula. An integrated curriculum would be an effective and efficient way of addressing all challenges of the 21st century through rich learning environments. We highlight that education in the 21st century is mainly affected by globalisation and technology with consistent increase in skills such as creativity, communication and critical thinking. However, there is little development of professional teachers on how to teach these skills because they are mainly focused on teaching mathematics or humanities without a focus on innovative teaching techniques. A recent study by Wang et al. (2018) suggested that in China and Finland, there has been increased incorporation of 21st century skills and competencies into the education curricula based on specific subjects. The National Primary Science curricula of Finland and China has been modified to involve aims aligned with science education. Although, the science competencies of the 21st century are more robust in Finland compared to China. The Chinese curriculum have a distinct cultural and theoretical perspective from the Finnish due to the alignment and focus on the Anglo-American traditions while the Finnish are more closely related to the German *Bildung-Didaktik* tradition. Thus, in addressing this heterogeneity in the training and development of science teachers for the 21st century, the curriculum should be changed in a manner that is specific to particular subjects of interest that would create global citizens in a holistic manner with target skills and knowledge. Our program also yielded positive effects on teacher self-efficacy in CREST strategies over time. Repeated-measures ANOVAs demonstrated statistically significant increases (p-value < 0.05) in all four CREST areas (Content Readiness, Equity Readiness, Information Analysis, and Use of ICT) from baseline to both 1 year and 2 years post-program. These findings highlight the program's effectiveness not only in boosting student achievement but also in equipping teachers with long-lasting pedagogical skills aligned with CREST principles. Sang et al. (2018) found that in

helping students to build a 21st century of key essential skills, the teachers must be trained and have correct perceptions about the learning processes and skills. The Chinese perception of competencies of the 21st century learning involves collaborative learning, self-paced learning, correct utilisation of technology and information, solving problems and creative thinking. Their findings showed significant gaps and deficits between perceptions of preferred learning and actual learning with teachers lacking correct utilisation of information technology for positive learning outcomes. Similarly, Ferguson-Patrick et al. (2018) proposed that despite the widely support for different approaches to learning and teaching practices, there are no sufficient implementation of the proposed changes to global education systems. The teaching of integrated curriculum for global education is often faced with several challenges of the 21st century and its pedagogy. Our study was aligned with Liesa-Orús et al. (2020) who suggested that in the 21st century quality teaching of learning processes in science and teaching can be improved through the use of technology due to a significant impact in increasing the abilities and skills of the 21st century teachers and students. The perceptions of adopting technology in the 21st century teaching techniques and methods is influenced by the increased utilisation of these technologies by teachers. Utilisation of technology in learning is a significant outcome of positive effects in learning and development of global citizens.

González-Pérez and Ramírez-Montoya (2022) alluded that education 4.0 must have components related to the 21st century skills to ensure an inclusive, equitable and quality driven education in promoting opportunities for lifelong opportunities. In their systematic review, their found significant opportunities for creating and improving 21st century skills through frameworks of education 4.0 for developing future skills. They observed lack of these frameworks for schools and teachers with most of them focused on students and developing competencies for suitable strategies of active learning, character and meta-learning. Therefore, the incorporation of innovative and creative educational practices and core components of education 4.0 with a reflection on the creation and development of educational models to create complicated-reasoning competencies and an auto-systemic thought patterns of solving problems and social requirements. Our study's success in integrating International and Chinese culture aligns with existing research on culturally responsive science teaching. The program's focus on "cultural points of

intersection" expands the concept of a "hybrid space" (Barton et al., 2008; Seiler, 2011) by incorporating these intersections into the cycle of knowledge creation within a community. By aligning cultural practices with core scientific concepts, the program fostered the development of "hybrid content," effectively bridging the gap between school science and the lived experiences of students. This suggests that science education can be enriched by not only school culture and pedagogical approaches but also by the vibrant cultural practices of the surrounding community. Similar to Chinn (2007) findings, the program enhanced teacher appreciation for the local culture and its role in science education. Furthermore, the program aligns with Johnson (2011) work on culturally relevant pedagogy, promoting shifts towards practices that benefit diverse students. Beare and Slaughter (2021) suggested that education for the 21st century emanates from a common and deep-seated concerns about the ways of young individuals and how they think about their future and relatively simple forms of education. Several schools, institutions, teachers, curriculum, and schooling patterns have been criticised for failure to solve problems in education due to unsatisfactory or no long-lasting solutions. Beare and Slaughter (2021) have suggested that schools in the 21st century do not require fine-tuning but changing and revising the fundamental assumptions of schooling to exist in the present and future. Llopart and Esteban-Guitart (2018) highlighted those inclusive educational practices in the 21st century should ensure availability of funds of knowledge because it offers a cutting-edge approach to education that overcomes the existing challenges such as deficits in the perspective of education in the 21st century. A case study for dialogic pedagogy by Teo (2019) on teaching for the 21st century found that over the last two decades there has been a significant emphasis and advocation for the students and global citizens of the 21st century. Science teachers should ensure that students are equipped with the holistic education and focus on key life skills of communication, critical thoughts and cross-cultural collaboration. Recently, there has been interest in dialogic pedagogy in a basic approach to increase and facilitate the construction of knowledge among students through negotiating ideas, interrogation and integration of knowledge in a respectful manner. The dialogic teaching and 21st century goals are aligned on a common perspective and have a single objective of empowering learners with key competencies and skills that transcends the limits of knowledge and information from conventional and local based teaching practices to the

intersection of critical thinking, collaboration and communication. According to Myers (2016) the analysis and interpretations of global citizenship education by the public and scholars have shaped its perspectives and conceptualisation. In the context of the Chinese, there are different proportions and views about global citizenship based on education, sociology and politics. Chinese scholars have placed significant emphasis on the basic status and significance of national identity while expending into the global domains (Pan, 2011; Wing-Wah, 2013). According to Bell et al. (2013), the rapid and consistent growth in science and digital technology has changed the ways of communication and flow of information around the world. Several individuals who are experts in science education and policy making have postulated the need for restructuring the education of science and technology. The desire to incorporate competencies of the 21st century skills in science education has been driven by the Next Generation Science Standards that emphasizes on the need for problem solving, critical thinking, information literacy and collaboration. These new requirements in science education requires significant changes in the education and preparation of teachers from teacher centred and lecture-based teaching to student-based teaching techniques. In certain cases, it has been reported that effective implementation of new science teaching practices has been limited by lack of motivation from science teachers, inadequate resources of learning materials, time and computing (Bell et al., 2013).

5. CONCLUSION

Our single-cohort study provides encouraging evidence for the program's ability to improve student science learning and enhance teacher self-efficacy in CREST strategies. The observed increases in student test scores and sustained positive changes in teacher self-efficacy suggest the program's potential to contribute meaningfully to science education. Further research with larger and more diverse samples could explore the program's generalizability and long-term impact on student achievement and teacher practice across various contexts.

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