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Professional Development Training for STEM teachers–A comparison between India and Taiwan

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Abstract

This comparative study analyzes the professional development training programs of STEM teachers of India and Taiwan. Both Indian and Taiwan teachers in focus group discussions conducted with 112 subjects inform that a professional development program which is consistent with national policy is found in both countries, but it is not at par with the level of accessibility and quality that one would expect. Taiwanese teachers were reported to have better access to resources and technological support, while Indian teachers had problems due to the rural urban divide and the inequalities that exist between government and private schools. It demonstrates that there is a need to formulate professional development programs that address the problems confronting teachers in both countries.

Keywords: teacher development, STEM education, teacher instruction, comparative research, special need education

INTRODUCTION

The growing importance of high quality STEM education across the world is due to the advancement of technology and the growing need for skilled labor (English, 2016). Bibliometric evidence further shows a sharp global increase in research on science teacher professional development, especially after 2018 (Pham & Pham, 2023). Teachers are required to have sound understanding of subject matter, be able to use technology, promote inclusion, as well as teach and cultivate critical thinking and problem solving (Johnson et al., 2020). Therefore, professional-development training is crucial for teachers' skill and competence development and effective teaching (Johnson et al., 2020).

With regard to the systematic investment channels, both India and Taiwan have invested heavily in professional development courses for STEM teachers over the years. Training teachers is a necessary step towards improving student performance (Kaur, 2025). However, significant hurdles remain with respect to ensuring that every teacher is able to take advantage of quality professional development programs.

This research seeks to identify what professional development training for STEM teachers exists across India and Taiwan, their influence on the teachers' professional development, and the results of the training as put into practice by the teachers in the classrooms.

In the context of these two countries, the study identify best practices, common challenges, and areas for improvement in professional development training for STEM educators. The results of the study will benefit those who make policies, manage education, and train teachers in order to improve the quality and effectiveness of professional development programs for STEM teachers.

REVIEW OF RELATED LITERATURE

Across the globe, training and development of professional STEM teachers is a key component of

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Contribution to the literature

- This study contributes evidences offering ground-level insights into professional development practices through Focus Group Discussions with STEM teachers in India and Taiwan.
- It depicts how policies influence the design and implementation of professional development training programs of India and Taiwan.
- It highlights inclusive education challenges in STEM teacher development like rural–urban gaps, public–private differences, limited training in special needs and inclusive teaching strategies.

education to which various countries have put in a range of efforts aimed at improving teacher performance. A recent scoping review of 178 studies further highlights emerging trends and research gaps in professional teacher learning (McChesney et al., 2024). It has been established that professional development programs stem from differing theories of how students learn and differing theories of how teachers learn (Kennedy, 2016). Postholm (2012) explains that both teachers' individual and organizational factors help to shape teachers' learning. Systematic reviews also emphasize the importance of continuous and differentiated professional development across career stages (Salmerón Aroca et al., 2022). The study stresses the necessity of having a good school culture, adequate teacher collaboration, and external resource people as critical for teacher professional development (Postholm, 2012).

Currently, STEM education is a growing area of interest for many countries which are adopting new methods for teaching science, technology, engineering, and mathematics as how researched show that STEM education can gain from the use of different disciplines in instruction and learning (English, 2016). Martin-Páez et al. (2019) stressed the need to understand how STEM education is practiced in different settings.

Comparative studies on STEM teachers' professional development training procedures by different countries can contribute to best practices and areas for improvement. Recent Scopus-based analyses also indicate an increasing global focus on professional learning communities in teacher development (Nguyen et al., 2024). Bibliometric analyses of science teacher professional development further reveal increasing global attention to STEM-focused teacher training policies and research trends over the past two decades (Pham & Pham, 2023). Recent systematic literature reviews highlight the growing emphasis on digital competence and pedagogical content knowledge in teacher professional development, particularly in response to contemporary educational reforms (Ibda et al., 2023). Studies report that professional development training for STEM teachers is confronted with many obstacles such as lack of training on special needs and inclusive education strategies. Implementation challenges in design and technology teacher training programs have also been systematically documented (Ramli et al., 2024). Recent scoping reviews emphasize the need for holistic, system-level approaches that integrate policy, school culture, and teacher collaboration in professional development frameworks (McChesney et al., 2024).

This document review indicates a significant professional development training for STEM teachers with specific focus on India and Taiwan. Focused on building a review, professional development strategies and structures such as appropriate school culture, teacher cooperation, and external resource persons have been attempted. However these will need to be formulated in further detail. Also, all these will not be able to be achieved without proper comparative studies. The review also highlights the challenges of implementing professional development training for STEM teachers, including inadequate training on special needs strategies and inclusive education. Recent systematic reviews also stress the importance of digital competence and pedagogical content knowledge in the digital era (Ibda et al., 2023). Recent research in Taiwan also highlights the evolution of national teacher professional standards and post-12-year basic education reforms, emphasizing the need for systematic quality enhancement and policy-aligned teacher education frameworks (Wang & Shih, 2022). Recent Indian studies further emphasize that teacher professional development significantly influences student achievement and instructional effectiveness, particularly when aligned with the transformative vision of NEP 2020 and competency-based digital integration (Kaur, 2025; Panda, 2025).

OBJECTIVES OF THE STUDY

1. To identify professional development training available for STEM teachers in India and Taiwan.
2. To explore the impact of these trainings among the In-Service STEM teachers in enhancing their professional development.
3. To enlist the challenges faced by the STEM teachers in implementing these training outcomes inside the classroom.

METHODOLOGY OF THE STUDY

A comparative study was done by the researcher, who traveled to primary and secondary schools in

Taiwan and India. The primary data collection tool was focus group discussions (FGDs) intended to study the training of STEM teachers' professional development trajectory. There were 78 Indian teachers and 34 Taiwan teachers who participated in the FGDs, which were conducted in different sessions.

In India, the sample of teachers was drawn randomly from Tamil Nadu and Kerala so as to get varied perspectives from different educational backgrounds. In Taiwan, teachers from different schools participated in the FGDs and provided their perspectives on professional development (Onyumba et al., 2018). The FGDs followed a semi-structured format with the help of a tool that contained 17 questions that were not closed-ended. These questions were meant to provide the needed details for teacher professional development, the application of educational technology, practice of inclusive education, and the practice of STEM education. Other issues such as the school and how the community were involved and general teacher development were also discussed. The gathered data was subjected to qualitative analysis to ascertain the themes and identify the trends and divergences in the professional development initiatives in the two countries.

DATA ANALYSIS AND FINDINGS

Analysis of FGD With Secondary School Teachers of Dindigul District, Tamil Nadu

The FGD held in Ottanchathiram DIET with 40 secondary school teachers of Dindigul District, Tamil Nadu offered unique perspectives about the professional development, and its constraints, more specifically in the rural setting. The findings emphasized a persistent level of urban-rural gap in professional development opportunities, particularly in high end technology training such as Internet of things (IoT) and artificial intelligence (AI) (Zhang, 2017). Teachers in cities have adequate interaction, while rural teachers face a deficit in availability of resources and infrastructure (Van Maarseveen, 2020).

Government schoolteachers claim that professionals development training programs in Tamil Nadu touch base on critical areas like mentoring, inclusive education, information and communication technology (ICT), AI, new assessment techniques, and other areas which are mostly in conformity with NEP 2020 (Ministry of Education, 2020). However, rural teachers lacked professional development training which made them incapable of using technology in classroom pedagogy (Teece, 1986). It was also noted that the government supervision of these at the implementation level was erratic especially in rural areas, thus trimming down their effectiveness and sustainability factors (Fan et al., 2000). There are many challenges to engage in professional development programs. Some teachers claimed that in order to overcome these challenges, offering incentives, recognition, and flexible working hours would be a way out, bearing in mind the context of rural schools.

There were also disparities between private and government schoolteachers, with rural private school teachers being almost 40% less likely to have access to professional development.

Training strategies related to teaching children with special needs was limited, and there was a scarcity of trained services and special educators in both rural and urban areas (Peter, 2013). Professional development programs have been designed to cultivate more equitable learning environments but are difficult to operationalize, especially given resource limitations in rural schools (Neill et al., 2018). Teachers have also observed that while these programs most often touch on professional challenges, it appears that personal issues that can impact their overall efficacy is subtracted (Bell & Gilbert, 1994). Teacher networking was identified as a resource for peer learning, albeit networks were not as organized as those in neighboring states (e.g., Kerala) (Horn et al., 2020).

The authorities were seen as not being present with rural teachers not feeling included in future training and resource allocation. The challenges involved in inclusive education implementation were associated with a shortage of trained special educators and insufficient resource and were compounded by minimal participation from parents and communities in creating better learning environments (Pivik et al., 2002).

Prior literature also highlighted differences in infrastructure and technological resources, with better equipped urban schools (Opoku-Asare & Siaw, 2015). With these challenges, teachers seemed to have better self-confidence and digital skills as reported after being exposed to professional development programs.

Yet the limited resource availability often prevents these new strategies from being enforced with the desired efficiency. Specifically, STEAM-based strategies were identified as addressing the demand for critical thinking skills and improving classroom practice.

While some teachers reported successfully incorporating STEAM concepts, the widespread adoption of STEAM remains limited due to training and resource gaps (Park et al., 2016). They highlighted the need for further training on cost-effective STEAM solutions and the incorporation of local contexts into the curriculum, which would be especially useful in multicultural classes.

Overall, the FGD highlighted the urgent need for targeted professional development programs that cater to the specific needs of rural educators in Tamil Nadu. Improving instruction and closing the urban-rural gap need solid support by authorities, well-functioning teacher networks and equitable access to resources.

FGD Analysis With Kottayam District Elementary and Secondary School Teachers, Kerala

At Kerala Kottayam DIET, an FGD was held with 38 primary and secondary school teachers from Kottayam district of Kerala. From the discussion it emerged that teachers within Kerala are well positioned to promote professional development in IoT and new technologies, with programs such as DIKSHA and PM eVidya. Such programs equip them with the skills necessary for effective integration of technology in teaching, a phenomenon widely reported in literature concerning the importance of TPACK in teachers (Ibda et al., 2023).

Some of the first issues addressed within the program include implementation of mentoring, inclusive education, ICT, AI, teaching and learning materials, and assessment which is in tandem with NEP 2020 (Ministry of Education, 2020). From the discussion it is clear that there are well developed frameworks for monitoring in Kerala, with evaluations and regular follow up being important deliverers of the professional development programs. Every teacher is encouraged to participate due to the strict discipline, monitoring, awards and incentives provided as well as the more relaxed schedules (Borko, 2004). Teachers in government schools in Kerala tend to be in a far better position to access professional development programs than private school teachers, in particular those in the rural areas (Opfer & Pedder, 2010). Though special educators are lacking, training on particular needs strategies is slowly increasing (Donohue & Bornman, 2014). Gender and inclusiveness has been mentioned in professional development programs, however there are still technological constraints in rural regions that hinder progress (Holmqvist & Lelinge, 2020). As in many other places, and in Kerala, teachers' networks are organized around subjects and districts, which facilitates networking and strategizing (Carmichael et al., 2006). The discussion also accentuated the challenges teachers encounter while adopting STEAM strategies, such as the lack of sufficient resources and infrastructure, insufficient empowerment programs, and limited time (Park & Cho, 2022). These problems are usually tackled by teachers through collaboration and peer learning.

Taiwanese Teachers' Elementary and Secondary FGD Analysis

To overcome some of these difficulties, an FGD was executed involving thirty-four elementary and high school teachers in Taiwan in order to learn more from their professional development practice and hindering factors. It was found during the debate that teachers are required to participate in IoT, AI, and other new industry-related professionalism enhancement activities, which among others improve their professional competency through the application of modern tools in teaching (UNESCO, 2021).

Key areas of focus for these exemplary programs includes AI technology, digital pedagogy, steam education, teaching methods, strategies for inclusiveness, collaboration, and resource management, which ensures teachers area able to keep pace with changing technologies and methodologies in education. The controls exercised by government on these programs are wanting because more comprehensive assessments, feedback mechanisms, and incorporation of teachers' recommendations are required to improve program outcomes (McChesney et al., 2024).

The discussion pointed out the necessity of teacher engagement in these programs, which can be achieved through program attaching or linked attendance incentives, compulsory attendance, and flexible working hours. But there is inequality in the availability of these programs whereby teachers in private schools have to rely on the policies of the school management whereas teachers in public schools have access to them.

The inability of these programs to have a large impact without strengthening practice, multicultural education focuses more on technology and academic differentiation (Kennedy, 2016). It seeks to foster a more equitable learning environment. Teachers need more pragmatics and practical approaches in dealing with day-to-day work-life balance.

Participating in professional development programs through networking and group activities contribute to the exchange of knowledge, strategies, and best practices needed for professional development (Carmichael et al., 2006).

RESULTS AND DISCUSSION

India and Taiwan offer a comparative analysis with similarities and differences in the professional development trainings for STEM teachers.

In India, as well as in Taiwan professional development programs are offered on the recent trends and emerging technologies like IoT, AI, and STEAM education. These programs have a relevance to the national education policies and frameworks like NEP 2020 in India (Ministry of Education, 2020). The trainings are reported to be useful to STEM teachers professional development because teachers who underwent the training were more confident, enhanced digital teaching skills, and technology integration into teaching and learning.

On the other hand, there are still some gaps in the access and quality of these programs. Teachers professional development opportunities in Taiwan are more systematic and compulsory, while in India many of these programs are optional, and of variable quality (Wang & Shih, 2022). Leadership competency has also been identified as a key factor influencing the success of continuous professional development programs (Ambon et al., 2024). Taiwanese teachers also reported being better equipped with resources, infrastructure, and technology.

Lack of training in special needs and inclusive education seems to be a problem that both countries face. However, Indian teachers will have to emphasis the divides India's rural-urban separates, as well as how public and private schools differ since it presents significant barriers to professional development (Van Maarseveen, 2020). While in Taiwan, there is a better opportunity for equitable distribution of resources and opportunities.

This is an area that India can learn from Taiwan's perspective of teachers seeking global and collaborative networking. Conversely, Taiwan can learn from India and give more attention to inclusive education and special needs strategies and policies. Addressing the needs and specific barriers of each country's educators is how access to professional development can be broadened in teachers' best practices. International collaboration and networking should be prioritized as best practice toward teacher development and professional growth (Calvó-Armengol et al., 2008).

Future Directions

1. Design longitudinal studies to assess the failures and successes of instructional STEM programs for teachers.
2. Identify and invest in comparative studies with other nations while identifying STEM teachers professional development programs effective practice techniques.
2. Encourage STEM teachers' multi-contact collaboration through the internet, workshops, and conferences.
3. Focus on proper resourcing of professional development programs such as funding, infrastructure, and technological support.
4. Put in place effective monitoring and evaluation systems to determine the success of the professional development program and provide recommendations for enhancements in the future.

Recommendations

1. There is a need to put in place professional development courses for STEM instructors with b emphasis on new technologies and distinct pedagogy techniques.
2. Create context specific STEM oriented professional development programs to meet the challenges of teaching in different areas.
3. Foster partnerships and networking among STEM teachers through social media, workshops, and conferences.
2. Allocate enough resources to allow for professional development like appropriate funding, infrastructure and technological support.
3. Establish strong monitoring and evaluation frameworks to measure the effectiveness of professional development of the participants and use this for enhancement.

CONCLUSION

To sum up, it can be concluded that the study is a comparative one and focuses on professional development STEM training in India and Taiwan. Both countries try to put training programs in place from their sides, but it seems that tailored approaches are needed for teachers from both countries to be able to effectively develop. India needs to understand the systematic and compulsory aspects of professional development in Taiwan whereas Taiwan needs to learn more about the management of multicultural and special education from India. In addition, both countries need to work towards improving the access level to relevant professional development training, overcoming the challenges including the cultural ones, and to improve collaboration and contacts between teachers in practice to share experiences and best practices.

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AI statement: The authors stated that AI tools were used only for language editing and clarity improvement of the manuscript. It was not used for data collection and analysis purpose.

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