Professional Development of STEM Teachers Using the DECODE Model in India and Taiwan

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Abstract: This study will explore the impact of the DECODE model for STEM teacher professional development, drawing on empirical evidence from a year-long India–Taiwan collaborative project. The DECODE framework integrates structured teacher learning cycles where Demonstration (DE) provides model practices, Co-training/Co-design (CO) engages teachers collaboratively in lesson design and peer learning, and Debriefing (DE) offers reflection and feedback for continuous improvement. Together, these components integrate technology, pedagogy, and content knowledge to prepare teachers for rapidly evolving educational contexts, particularly in AI-supported scientific inquiry and technology integration. Workshops conducted with pre-service and in-service teachers in India, alongside field visits and collaborative research in Taiwan, revealed significant improvements in teachers' competencies, confidence, and ability to integrate innovative tools such as CloudClassRoom (CCR) and AI platforms into STEM curricula. The research findings compare professional development models from India and Taiwan, and present strategies for designing adaptable, cross-cultural training programs. The study recommendations for policymakers, educators, and researchers interested in scaling hybrid teacher training models for global STEM education needs.

Keywords: STEM education; STEM teacher professional development; online training model; DECODE

1. Introduction

The DECODE model for STEM teacher professional development combines Demonstration (DE), Collaborative co-design/training (CO), and Debriefing/feedback (DE) cycles to foster technological pedagogical content knowledge (TPACK). In 2024–25, a joint India–Taiwan project applied this model to enhance pre-service and in-service teacher competencies in integrating innovative technologies such as AI-Supported Scientific Inquiry (AISI) and CloudClassRoom (CCR).STEM-TPD is designed to engage teachers in active learning and focus on teachers' needs to STEM teaching successfully. When teachers learn actively in quality PD, teachers would increase their self-efficacy in STEM teaching, gain STEM experiences (Thibaut et al., 2018), and realise the relevance of teachers' professional lives (Cavlazoglu & Stuessy, 2017). Integrated STEM teaching advocates that active learning is an essential environment for students to construct new ideas for authentic problem-solving and designing(Heba et al., 2017; Nadelson et al., 2013). Teachers perhaps need to become active learners in the quality PD opportunities before implementing STEM education that requires an active learning environment. Researchers sustained that the rationale for organizing STEM-TPDs is to improve teacher practices by enhancing superior knowledge needed for the betterment of STEM implementations. The authentic and up-to-date content knowledge was transformed in TPDs, such as earthquakes or nanotechnology (Fore et al., 2015).STEM-TPD aims to transform instructional models such as inquiry-based teaching, how to teach social scientific issues (SSIs) or engineering challenges (Macalalag et al., 2020; Nadelson et al., 2012), and how to integrate technology in STEM classrooms to facilitate awareness of STEM careers (Parker et al., 2015).

1.1 ***Workshop Description***

The workshops conducted under the DECODE professional development framework have been intentionally designed as purely online programs, enabling teachers to participate regardless of geographical or institutional constraints. The virtual nature of these workshops ensures accessibility and inclusivity, allowing educators from rural, urban, and international contexts to engage with the same training quality.

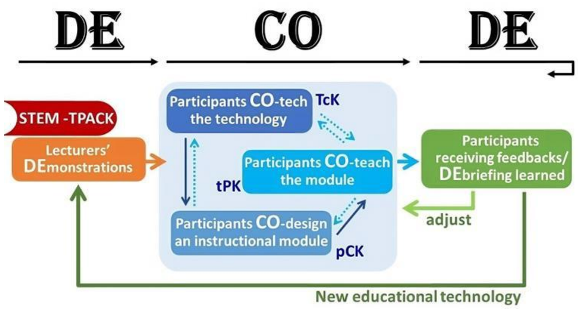

Fig-1: DECODE model (Adopted from Cheng et al.,2022)

1.1.1 Demonstration-DE (Session 1)

Taiwanese experts introduced and demonstrated the AISI and CCR platforms, highlighting the importance of scientific inquiry and artificial intelligence in education. Participants explored the platforms to understand their features. (Rajasekaran et al., 2024)

1.1.2 CO-teach&CO-train (Sessions 2, 3, and 4)

Participants were divided into groups based on subjects in these sessions, ensuring diverse contributions. Facilitated by the Indian research team, these offline sessions involved exploring the platforms, topic selection, and collaborative planning. Groups finalised topics with research team consultations, prepared lesson plans incorporating AISI and CCR, and selected group leaders to coordinate tasks.

1.1.3 DEbrief-DE (Session 5)

Participants presented their topics in a hybrid mode to a large audience, including Taiwanese experts, institution teachers and students, and the research team. Feedback from Taiwanese experts aimed to improve presentations and assess the professional development of Pre-Service teachers post-workshop.

1.2 *Literature Review*

Information technology capacity is a prerequisite in the 21st century with the continuous development of science and technology. All experts need to use information technology in their work from doctors or scientists. Teachers are also one of them. Teachers need to use information technology to integrate into their lessons, especially during the Covid-19 epidemic. Technology is a tool in teachers' lessons and becomes the goal of classes. Technology plays an even more essential role in STEM lessons. Technology (T) is a critical element in STEM lessons. Consequently, the technological pedagogical and content knowledge (TPACK) framework was advocated as the framework to examine the technology, pedagogy and content that the current STEM-TPD is targeting (Chai, 2019). Teachers utilized instructional practices to access students achieve such valuable STEM competencies. For example, the 6E instructional model, project-based learning (PjBL), problem-based learning (PBL), and engineering design process (EDP) (Wahono et al., 2020). Teachers dynamically choose any instructional model to implement STEM education successfully.

Thibaut et al. (2018) reviewed 23 STEM interventional papers in terms of instructional practices to synthesize five principles in STEM teaching. Such five principles are rooted in the social constructivist view of learning theory with student-centred pedagogies. STEM teaching could be successful when teachers could adapt pedagogical approaches based on the social constructivist view, inquiry and engineering design.

Vrasidas and Zembylas (2004) agreed with the effectiveness of technology integration in TPD but note the lack of research-based frameworks to develop and evaluate TPD. In addition, there is a dilemma in balancing between philosophical and pragmatic focusing on TPD in Science Education (Mundry & Loucks-Horsley, 1999) because of the Nature of Science. The rapid developments of science and technology call for innovative teaching to educate individuals well-equipped with academic knowledge as well as 21st-century skills. Integrate Science is advocated as a promising place for better education such as science with engineering integrated. Antink-Meyer and Meyer (2016) indicated Science teachers' misconceptions of Science and Engineering distinctions in online TPD.

The ultimate of STEM-TPDs positively increase students' learning outcomes once TPDs would directly improve teachers' both perceptions and practice (Han et al.,2015; Nadelson et al., 2013). Besides, teachers' specific professional knowledge such as pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPCK) should be activated and developed for successful STEM implementation (Awad et al., 2019; Chai, 2019). In the following paragraphs, we identified key features of effective STEM- TPD in response to the STEM assessment, STEM teaching, and the global trend. Based on our research, the Technological Content Knowledge in response to technological advancement, such as teaching techniques, and assessment technology, but not including learning management system.

DECODE model (Figure 1) can facilitate teachers' critical reexamination of the affordances of the innovative technologies for their teaching practices from the views of subject matter selection, motivation empowerment, information presentation, activity design, and pedagogy transition. It was also found that the DECODE model can facilitate teachers' TPACK towards a more connected model that addresses accessible technologies, pedagogy, and subject matter jointly (Cheng et al., 2022). The DECODE model includes three stages: (1)DE: teacher's DEmonstrations, (2)CO: students CO-train the use of CloudClassRoom, students CO design an educational technology-integrated course, (3)DE: students CO-teach, eventually students receive feedbacks and DEbrief what they have learned through the stages mentioned above. For every type of technology, we will run through DECODE once. The length of time determined for running through the DECODE will be based on the type and characteristics of the technology. In each DECODE, at least two rounds of DE-CO-DE- CO-DE will be conducted to promote and strengthen teachers' familiarity and mastery of the technology used in STEM education.

The study conducted a comparative analysis of STEM teacher training models in India and Taiwan, focusing on professional development programs designed to equip educators with the skills required to teach in rapidly evolving scientific and technological landscapes. The study's objectives are twofold: (1) to identify the existing professional development frameworks and approaches utilized for STEM teachers in both countries and (2) to evaluate the effectiveness of these models in preparing educators to address current and future educational demands. With an increasing emphasis on STEM education globally, this analysis highlights each country's approach to integrating recent advancements, such as Artificial Intelligence, Internet of Things (IoT), and interdisciplinary STEAM strategies, into professional training.

2. Abstracts of Individual Panelists' Presentation

2.1 International Collaboration and Cross-Cultural Framework Adaptation (Chun-Yen CHANG)

This presentation highlight the role of international collaboration in adapting the DECODE framework to diverse cultural and educational contexts. Drawing on Taiwan's expertise in competency-based STEM education and AI-enhanced learning environments, the talk will outline how tools such as CloudClassRoom (CCR) and AI-supported Inquiry (AISI) can be localized for effective integration in India. Prof. Chang will also share lessons from field visits and collaborative workshops, emphasizing how cross-national partnerships strengthen professional development models and promote scalable, globally relevant practices in STEM education.

2.2 Applying the DECODE Model in Pre-Service Teacher Training (P. S. SREEDEVI)

This presentation focus on empirical evidence gathered from training 187 pre-service teachers across Kerala and Tamil Nadu using the DECODE model. The sessions integrated CCR and AI platforms, enabling participants to engage in collaborative lesson design, active inquiry, and technology-enhanced pedagogy. The findings reveal substantial improvements in teacher confidence, digital literacy, and capacity to design STEM lessons responsive to real-world contexts. Prof. Sreedevi will discuss the challenges and opportunities of implementing the DECODE model in Indian teacher education institutions, offering insights for adapting it in developing-country contexts.

2.3 Technology Integration and Curriculum Innovation in STEM Education (Dr. Marison Sudianto Manalu)

This presentation address how technology integration and teacher professional development can be enhanced through the DECODE model. Drawing from postdoctoral research at National Taiwan Normal University, Dr. Manalu will explore how CloudClassRoom (CCR) and AI-supported Inquiry (AISI) as online collaborative environments facilitate authentic scientific inquiry in STEM classrooms. Case studies from Indonesia will illustrate how the integration of the technology enhances teacher professional development, ensuring the sustainability and adaptability of the model across varied institutional settings.

2.4 Instructional Design and Teacher Training through DECODE (Mr.P. Rajasekaran)

This presentation examine the instructional design dimension of the DECODE framework, focusing on how structured cycles of demonstration, co-design, and debriefing foster deeper professional growth among teachers. Based on research with pre-service and in-service teachers, Mr. Rajasekaran will present data on how collaborative workshops enhanced reflective practices and peer-supported learning. The presentation will also address the scalability of DECODE-based training through online and hybrid delivery models, emphasizing its potential to overcome geographical and institutional barriers in teacher professional development.

3. Discussion

Data collected quantitatively and qualitatively from teachers in order to understand the effects of the DECODER TPD on teachers' technological competencies, as well as perceptions and practice of technology integration in their science teaching. The research team conducted three workshops in preservice teacher education institutions (B.Ed, Special B.Ed & D.El.Ed), in two states (Kerala and Tamil Nadu) for 187 Preservice teachers with the DECODE Model. The professional development was measured through a rating scale constructed based on five stages of professional development.

The results indicated significant improvements in their professional skills. The preservice teachers gained skills like incorporating Artificial intelligence, scientific inquiry, and cloud classrooms in their regular classrooms. This study highlights the significant impact of professional development for pre- service teachers and suggests the DECODE model of Professional development training for teachers in India.

About the comparative analysis of STEM teacher training models in India and Taiwan, we focus on professional development programs designed to equip educators with the skills required to teach in rapidly evolving scientific and technological landscapes. Data gathered from a series of focus group discussions and qualitative surveys reveal the structure, accessibility, and content diversity within each model, showcasing how different educational contexts influence program design. Findings underscore the strengths and limitations of each country's training model, offering insights into the adaptability of these approaches across cultural and educational settings. Recommendations are proposed for cross-collaborative training initiatives between India and Taiwan to enhance STEM education through shared expertise and resources. This study contributes to the global discourse on professional development in STEM education, emphasizing the need for adaptable, accessible, and forward-looking training programs for teachers. In addition, the research team also had a field visit & observation of professional development Training for STEM Teachers in Taiwan in the first year and continued to plan future cooperation.

4. Conclusion

The panel underscores the effectiveness of the DECODE model as a transformative framework for STEM teacher professional development across diverse cultural and institutional contexts. By combining structured cycles of demonstration, co-design, and debriefing, DECODE not only strengthens teachers' technological pedagogical content knowledge (TPACK) but also fosters collaboration, reflection, and innovation in teaching practice. Evidence from India and Taiwan demonstrates that pre-service and in-service teachers gained significant improvements in confidence, digital integration, and inquiry-based pedagogy. Moreover, the cross-national partnership highlights the adaptability of the model to varying educational systems and resource settings. Looking ahead, the panel advocates for scaling DECODE as a hybrid, accessible, and sustainable professional development approach capable of preparing educators for AI-rich, globally connected STEM classrooms. The insights generated will serve as actionable recommendations for policymakers, teacher educators, and researchers committed to building resilient and future-ready teacher training ecosystems.

Acknowledgements

This work was financially supported by the National Science Council of Taiwan under contracts the MOST 111-2410 H003-032-MY3, and the NSTC 111-2423-H-003-004 and the "Institute for Research Excellence in Learning Sciences" of National Taiwan Normal University (NTNU) from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan and 113-2923-H-003 -001 -MY2.
Professional Development of STEM Teachers Uisng the DECODE in India and Taiwan & Joint Research project under ICSSR(India) NSTC(Taiwan)/JRP4/2024-25/IC).

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