Editorial: Cultivating a Future-Ready Workforce – Reimagining STEM Education

Mohamad Termizi Borhan[1], Lee Tien Tien[2], Mohd Mokhzani Ibrahim[2], Nur Hamiza Adenan[3]

[1] Biology Department, Faculty of Science and Mathematics, Sultan Idris Education University, Malaysia
[2] Chemistry Department, Faculty of Science and Mathematics, Sultan Idris Education University, Malaysia
[3] Mathematics Department, Faculty of Science and Mathematics, Sultan Idris Education University, Malaysia

As Guest Editors and passionate advocates of STEM education, we—Mohamad Termizi Borhan, Lee Tien Tien, Mohd Mokhzani Ibrahim, and Nur Hamiza Adenan—firmly believe that quality STEM education is no longer a luxury, but a necessity. In a world grappling with constant technological transformation and global challenges, it is essential that we reimagine how STEM can serve as a vehicle for equity, innovation, and sustainability. This Special Issue represents our collective effort to spotlight how STEM education can cultivate a workforce that is adaptable, creative and future-ready.

STEM education must continuously adapt to equip learners with future-ready competencies. The *International Journal on Maths, Science and Technology Education* proudly presents this Special Issue titled *Cultivating a Future-Ready Workforce: Reimagining STEM Education*. This issue gathers 18 diverse and impactful articles that respond to five critical focus areas: STEM teacher development, innovative pedagogies, digital and inclusive practices, workforce readiness and forward-looking trends in STEM education. We are delighted to introduce the following scholarly contributions that reflect both regional insights and global perspectives.

STEM Teacher Training and Professional Development

Several articles examine how teacher confidence, preparation, and pedagogical identity shape effective STEM education:

- *"Self-efficacy, attitudes, knowledge, and school support as predictors of STEM teachers' pedagogical approach to sustainable development"* reveals how Malaysian teachers' self-efficacy, supported by attitudes and institutional backing, strongly predicts their use of SDG-aligned pedagogies.

- "*Gender differences in preservice mathematics and science teachers' professional identities*" explores the influence of gender on STEM teaching identity, uncovering important implications for equitable teacher education.
- "*Teachers' challenges in teaching integrated STEM: In the light of PCK as an analytical lens*" presents real-world insights from Denmark, highlighting how pedagogical content knowledge and cross-disciplinary collaboration challenges shape i-STEM teaching practices.

Innovative Strategies for Enhancing Student Engagement and Learning Outcomes

This theme is enriched by multiple studies showcasing practical approaches that improve student learning:

- "*Effects of online heutagogy approach in learning science via Telegram*" shows how learner-centred heutagogical models can foster science process and creative thinking skills among primary pupils.
- "*STEM in chemistry: Cultivating problem-solving skills via blended problem-based learning Socratics module*" highlights how blended learning and Socratic inquiry improve conceptual mastery in chemistry.
- "*Enhancing physics problem-solving skills through guided discovery and scaffolding strategies*" from Saudi Arabia illustrates the power of structured discovery learning in developing technical students' higher-order skills.
- "*Addressing mathematics learning challenges through concept-based instruction*" shares how deeper conceptual teaching strategies can uplift struggling learners in South Africa.
- "*Impact of Arduino-Based STEM Education on Cognitive Domain Level of Mechanics and Scientific Creativity*" examines the benefits of hands-on microcontroller-based learning in enhancing both mechanics understanding and scientific creativity.
- "*Reconstruction of the Engineering Design Project (EDPj) Learning Model based on Ethno-ESD*" introduces an Ethno-STEM framework that successfully boosts environmental literacy in university students.

Role of Technology, Collaboration, and Equity in STEM

Technology integration and inclusive design are critical in shaping future-ready STEM classrooms:

- *"Impact of digitalization for students with disabilities: A comprehensive structured review"* explores digital inclusivity, highlighting the challenges and opportunities in supporting students with disabilities.
- *"Development and impact of histoguide application towards drawing and labelling in microscopic practical"* demonstrates the effectiveness of mobile virtual microscopy in improving lab skills and motivation.
- *"Development and usability of a traditional game simulation module with augmented reality technology (AR-SiGaSTEM)"* presents an innovative AR module based on traditional games, promoting online STEM learning aligned with Industry 5.0 goals.
- *"Implementation of IoT-based STEM-Contextual learning with the MQTT protocol on the digital literacy skills of pre-service science teachers"* reveals how IoT-based learning enhances digital literacy among future teachers through a STEM-contextual approach.

STEM Education's Impact on Workforce Readiness and National Development

The link between classroom learning and workplace preparation is a core theme:

- *"Addressing complexity for educating the future-ready workforce in STEM fields: MINTco@NRW from a mathematics educational perspective"* presents the German MINTco@NRW initiative, addressing STEM complexity through research-informed teacher mentoring and performance assessments.
- *"Expanding the STEM integration model introducing the learning environment"* proposes a fifth dimension to STEM integration—learning environment—which redefines how STEM activities interact with local contexts and facilities to build meaningful experiences.

Emerging STEM Trends, Initiatives, and Beyond

Finally, this issue includes studies that broaden our understanding of STEM development across contexts:

- *"Examining STEM attitudes for Chinese senior pupils in primary school"* provides important data on how attitudes towards STEM subjects and careers are shaped by demographic and experiential variables.
- *"Exploring the implementation of STEM education through mathematical modelling activities in schools: A bibliometric analysis"* tracks global trends in integrating mathematical modelling into STEM, spotlighting productivity patterns and research gaps.

- *"A comprehensive synthesis of differentiated instruction approaches in mathematics"* analyses a variety of different teaching approaches in mathematics, emphasizing the importance of adapting teaching methods to students' learning needs to improve teaching effectiveness.

Each article in this Special Issue contributes a unique lens on how STEM education can rise to the challenge of shaping not only future professionals but also informed, critical, and collaborative citizens. The diversity of *methodologies*, geographical contexts and educational settings *underscores the global relevance and depth* of STEM educational research. Looking ahead, it is vital to continue investing in teacher capacity building, technology-enhanced pedagogy, and inclusive education policies. Future research must also address equity gaps and foster deeper collaboration across borders, sectors, and disciplines. We envision STEM education not merely as a field of study, but as a transformative force that shapes how we understand, engage with, and improve our world.

We extend our sincere appreciation to the contributing authors, peer reviewers and editorial staff who helped shape this special issue. We hope that the insights and innovations shared here inspire ongoing dialogue and action towards a more future-ready and inclusive STEM education ecosystem.

Warm regards,

Dr. Mohamad Termizi Borhan

On behalf of Guest Editors:

Assoc. Prof Dr Lee Tien Tien, Dr Mohd Mokhzani Ibrahim, and Dr Nur Hamiza Adenan