

## International Science Education

Thomas K. Karikari<sup>1,2,3\*</sup>, Miriam Segura-Totten<sup>4</sup>, Esperanza C. Cabrera<sup>5</sup>, Diana E. Waturangi<sup>6</sup>, Erin E. Barding<sup>4</sup>, and Tatiana Ascencio<sup>7</sup>

<sup>1</sup>Department of Psychiatry and Neurochemistry, Institute of Neuroscience and Physiology, The Sahlgrenska Academy at the University of Gothenburg, SE 43180, Mölndal, Sweden; <sup>2</sup>School of Life Sciences, University of Warwick, Coventry CV4 7AL, UK; <sup>3</sup>Midlands Integrative Biosciences Training Partnership, University of Warwick, Coventry CV4 7AL, UK; <sup>4</sup>Department of Biology, University of North Georgia, Dahlonega, GA 30597; <sup>5</sup>Department of Biology, De La Salle University, Manila, Philippines; <sup>6</sup>Faculty of Biotechnology, Atma Jaya Catholic University, Jenderal Sudirman 51, Jakarta, Indonesia; <sup>7</sup>Department of Microbiology, School of Medicine, Dr. José Matías Delgado University, San Salvador, El Salvador

The importance of STEM crosses geographical boundaries: research advances continue to help improve the quality of our lives and our environment worldwide (1). Scientific breakthroughs benefit us all—from improved healthcare to healthy living, environmentally friendly transportation and agricultural systems, more efficient manufacturing processes, accessible information technology, and beyond.

It is therefore of the utmost importance to support the global dissemination of successful STEM education practices. Worldwide access to evidence-based STEM pedagogy will facilitate the training of professionals to lead the next generation of inventions and discoveries and their applications. Several strategies that have become popular in North America and Europe have yielded impressive results in terms of improving learning gains, student participation, and engagement. For example, teaching methods such as active learning, inquiry-based learning, and the inverted or “flipped” classroom have been repeatedly shown to be more effective than traditional methods across disciplines, institutions, grades, and countries (2–6). However, several vital questions remain unanswered. For example, are these new pedagogical approaches compatible with the diverse educational and cultural systems that exist worldwide? Are the facilities, training, and systems necessary to support the introduction of such teaching methods available? Are there other novel instructional approaches used outside North America and Europe that are not widely reported in the literature? We currently know little about STEM education

in countries beyond the few that heavily dominate the pedagogical literature. However, as the world becomes increasingly connected, the full benefit of STEM education can be realized only if we understand global educational systems and develop mechanisms to strengthen and standardize instructional provisions where possible.

This themed issue of the *Journal of Microbiology and Biology Education (JMBE)* provides insight into STEM education trends, practices, challenges, and progress on the international front. The 16 manuscripts accepted for publication cover a broad range of topics categorized into three main sections: teaching and curriculum resources, international collaborative education, and learning within a cultural context. To extend the reach of these international articles, the abstract of each article appears in English as well as a major language in the country where the activity took place or where one of the authors comes from.

### Teaching and curriculum resources

The articles in this section describe the design, implementation, and evaluation of new curricula and other novel teaching resources proven to deepen students' engagement, inquiry, and participation. Morel and colleagues describe an innovative approach developed in Uruguay but adaptable to a variety of settings that uses a comic book to teach students about the benefits of microorganisms. Smith-Keiling and Hyun demonstrate how to use software, available in several languages, to monitor trends and progress in students' linguistic development. Sumranwanich and colleagues describe an inquiry-based curriculum strategy first implemented in Thailand that promotes student engagement in a zoology laboratory course. Oliveira and colleagues introduce a science communication initiative developed for young scientists in Brazil that combines face-to-face training with online engagement and can easily be adapted

\*Corresponding author. Mailing address: Department of Psychiatry and Neurochemistry, Institute of Neuroscience and Physiology, The Sahlgrenska Academy at the University of Gothenburg, SE 43180, Mölndal, Sweden. Phone: +46 736317880.

E-mail: [Thomas.Karikari@gu.se](mailto:Thomas.Karikari@gu.se).

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to promote communication within or between countries. The trend of using technology to augment learning is also evident in the case study by Aishat, which uses Nigeria as an example to argue that institutions lacking advanced microbiology teaching resources can take advantage of virtual laboratories and other open-access resources to provide their students with up-to-date training. Training of professional students is highlighted by Carrero, who performed an extensive comparative analysis of immunology curricula for veterinary students in two dozen universities across Latin America. She reports on similarities and differences in course content and delivery, which may be important for the design of new curricula and the review of existing ones. Mangayarkarasi and colleagues also focus on professional education, by describing a problem-based teaching and learning strategy to train medical students in India in a World Health Organization–recommended program to detect and treat tuberculosis.

### International collaborative education

International educational partnerships provide students with a platform to build cultural awareness, widen social and professional networks, and benefit from the expertise and guidance of educators at multiple sites. The articles in this section detail the steps taken and lessons learned from establishing collaborative educational programs, describing the benefits and limitations of such partnerships. Ballen and Holmegaard discuss the need to appreciate the limits and potential biases associated with big data analysis whilst exploring its advantages. They caution against drawing conclusions solely based on data trends without looking for possible unobvious reasons behind these trends. The remaining articles in this section focus on fruitful collaborations between institutions in the United States, India, or Europe. Gray and Eisen describe a collaborative exchange program between Emory University in the United States and Tibetan Buddhists in India. Myer and colleagues show that a short-term U.S.-based study-abroad program for Honduran agricultural bioscience students improves their scientific knowledge, confidence, and communication skills. Vrentas shares her personal experience and lessons learned teaching microbiology in India as part of a cross-continental exchange program supported by the American Society for Microbiology (ASM). Finally, Meštrović and colleagues describe a collaborative initiative between the ASM and the European Society of Clinical Microbiology and Infectious Diseases to address challenges in microbiology education, support career growth, and foster cross-continental networking and collaboration among young scientists and between novice and senior scientists.

### Learning within a cultural context

A better understanding of culture and its influence on educational access, participation, and outcomes is important

in our quest to promote inclusive and equitable education. In this section, the engagement of different populations through the culturally relevant use of food is front and center. For example, the active learning program that Yoshiyama and colleagues describe can serve as a model for inquiry-based learning within the cultural context of a local food. Meléndez reports on a teaching strategy that helps students appreciate real-life applications of microbiology concepts by learning about food-making practices that utilize such concepts in specific cultures. Finally, Agustinah and colleagues use yogurt making as an outreach strategy to engage community participants and help them understand fermentation and its application in food production. The section concludes with a guided toolkit provided by Smith-Keiling for international visiting faculty to support them by improving their intercultural competency, enabling them to introduce new teaching methods within culturally appropriate contexts.

### CONCLUSION

Internationalization of STEM education has received limited attention until now. With this themed issue, we are beginning to understand how international collaborations, improved understanding of culture, and the development of context-specific teaching resources can improve learning gains. The articles in this issue provide important resources for educators and learners alike as they navigate the world of global education. In a time when so many countries are increasingly looking inwards and away from international efforts, we are proud to have published a collection of manuscripts that will help to facilitate the global transfer of information. Finally, we would like to thank Dr. Samantha Elliot, the outgoing Editor-in-Chief of *JMBE*, for conceiving of the special issue, the ASM for supporting it, and the *JMBE* publishing staff and reviewers for their dedicated services.

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