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EDITED AND REVIEWED BY
Lianghuo Fan,
University of Macau, Macao SAR, China

*CORRESPONDENCE
Gavin Duffy
gavin.duffy@tudublin.ie

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Editorial: Spatial ability in STEM learning

Gavin Duffy[1]*, Jeffrey Buckley[2] and Sheryl Sorby[3]

[1]School of Electrical and Electronic Engineering, Technological University Dublin, Dublin, Ireland,
[2]Faculty of Engineering and Technology, Technological University of the Shannon, Athlone, Ireland,
[3]The Department of Engineering and Computing Education, University of Cincinnati, Cincinnati, OH, United States

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Editorial on the Research Topic
Spatial ability in STEM learning

Many countries are struggling to make science, technology, engineering, mathematics (STEM) education and careers attractive to young people. Compounding this problem in several regions is a gender gap, with the proportion of men choosing STEM education being much higher than the proportion of women. Increasing female representation in STEM could expand the STEM talent pool and break down the barriers to STEM that women face. The reasons why young people choose not to pursue STEM education, and why women make this choice more frequently than men, range from the affective to the cognitive.

The European Union, under the Horizon 2020 program, recently funded a Doctoral Training Network to focus on the role of spatial ability in and for STEM learning. Spatially Enhanced Learning Linked to STEM (SellSTEM) included 15 PhD students who focused on three themes: (i) developing a better understanding of the cognitive relation between spatial ability and STEM learning, (ii) exploring ways to promote spatial ability development both integrated with and separate to/from STEM learning, and (iii) professional development for educators in formal and informal educational settings to promote greater awareness of and attention to spatial ability development in the classroom. This Research Topic was motivated by the SellSTEM research agenda and includes contributions from this network and beyond.

Spatial ability plays an important role in many aspects of STEM learning. Solving word problems in mathematics (Duffy et al., 2020), developing conceptual understanding in physics (Kozhevnikov et al., 2007), and comprehending molecular structure in chemistry (Bodner, 2015) are just a few of the areas where spatial ability has been shown to be associated with success in STEM tasks. Those who migrate toward STEM tend to have relatively high levels of spatial ability. A gender gap in favor of men in some spatial factors may partially account for gender differences in educational and career choices. More generally, raising levels of spatial ability in children should help prepare them for the cognitive demands that STEM learning may require. What are these cognitive demands and in which subjects and topics are they to be found? Can spatial ability development translate into performance improvements in STEM tasks or be integrated with STEM tasks so that both improve at the same time? How can teachers be prepared to overcome barriers to promoting spatial ability development in the classroom? What should researchers focus on in future work to address these issues? These questions are addressed in the eight contributions to this Research Topic.

The role of spatial ability in STEM learning is addressed by two studies, both of which are related to mathematics but explore concepts more broadly related to STEM. Duffy et al. illustrated how the process of problem-solving has two cognitively distinct phases, with the representation phase being significantly related to spatial ability while the solution phase is not. Mental representation was found to mediate the relationship between spatial ability and problem-solving in engineering students. The importance of math self-concept in shaping STEM preferences was investigated by Lennon-Maslin et al., who found this to be particularly noticeable among girls and tweens. Their study shows that math self-concept serves as a mitigating factor for spatial anxiety and perceived difficulty in spatial tasks and suggests that spatial anxiety may contribute to gender disparities in mathematics and STEM-related domains.

Several papers focused on strategies to promote spatial ability development. Working with kindergarten-grade 1 children, Sonneveld et al. explored how story-based design tasks that combine pretend and construction play can promote spatial ability development. Rather than giving children spatial toys to play with, teachers can integrate spatial ability development into design activities that are more open-ended and develop a broader range of skills. Their findings suggest that design activities may lead to the development of different spatial skills than more traditional analytical puzzles. Garcia-Segarra et al. created a video game to develop spatial reasoning skills through game-based learning, a potentially motivational approach that can be used in informal settings. The game, called the Paper Folding Game, was administered to adults who improved their paper-folding skills and developed strategic knowledge about paper-folding. Spatial reasoning through data physicalization is an innovative idea for integrating spatial ability development with data science. The case study by Zhu et al. offered insights into children's use of spatial reasoning in data physicalization creation and practical implications for situating data physicalization activities in formal and informal learning environments.

One study in this Research Topic directly addressed professional development for educators to teach spatial thinking. Bufasi et al. developed a framework that examines the interrelationships, barriers, and enablers among various educational components, including schools, teachers, students, classrooms, and training programs, that are encountered when teaching spatial ability development. Several recommendations are made concerning curriculum, professional development, assessment, and the use of manipulatives in the classroom.

Finally, two review articles offered ideas for future research. Thom et al. advocated for the use of projective geometry for spatial ability development. With an emphasis on the relationship between 2D and 3D objects, projective geometry offers a meaningful context in which to develop spatial reasoning. The authors present activities for the classroom, demonstrating how this mathematics topic opens up new possibilities to promote spatial reasoning for STEM learning in the elementary grades. Harris concluded this Research Topic with some challenging suggestions for future research: the need for a broader view of research problems and methodologies in spatial reasoning studies and the importance of the application of research to meaningful contexts in pedagogy and learning. She argues that a continued siloed approach is detrimental to the advancement of the field and continues to disadvantage the most vulnerable students.

Author contributions

GD: Writing – review & editing, Writing – original draft. JB: Writing – review & editing. SS: Writing – review & editing.

Conflict of interest

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