Unlocking new opportunitites for Australia's burgeoning STEM skill problem

Overview

This document outlines the objectives and key findings of research from Samsung Electronics Australia and University of Canberra's STEM Education Research Centre (SERC). The findings are based on two separate research programs; firstly investigating practical methods for increasing mathematics education results in primary students and secondly, developing student-led STEM inquiry projects at high school. In addition to serving as a summary of the key takeaways from the program, this document also outlines proven teaching methods for improving STEM skill development.

"We find this project challenging but rewarding. It's not like anything else we do in class." Erin, Year 9, St Clare's College

What is spatial reasoning?

Spatial abilities are an overarching set of skills that allow us to represent, navigate, and interpret the world around us. The capacity to locate, orientate, and visualise objects; navigate paths; decode information graphics; as well as use and draw diagrams, are critical to success in Science, Technology, Engineering and Mathematics (STEM).

These skills are also essential in many other areas of life such as the design-thinking and the problem-solving processes involved in reading a map; coding a website; understanding basic finances; or even understanding complex recipe methods.

What do we already know

Spatial thinking plays an important role in early STEM learning. It is an adaptive set of skills which can be developed through intentional teaching[1].

Improving spatial reasoning also improves STEM skill competence. Even when factors such as mathematics and verbal skills are held constant, spatial skills have a significant influence on STEM success[2].

What did we want to find out?

The primary school component was designed to determine the impact of spatial-reasoning activities on students' visualisation skills and mathematics competence. The project incorporated a teaching and learning program with digital app integration, utilising Samsung technology.

The secondary school component focused on demonstrating the benefits of incorporating technology into investigative and experiential STEM learning activities. The project involved student-led STEM enquiry projects whereby Samsung technology served as a data logger, as well as a data analysis and story-telling tool through video documentation.

[1]Lowrie, T., Logan, T., & Ramful, A. (2016). Spatial reasoning influences students'performance on mathematics tasks. 2016. In Opening up mathematics education research (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia. Adelaide: MERGA.

[2]Wai, J., Lubinski, D., & Benbow, C. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative knowledge solidifies its importance. Journal of Educational Psychology, 101, 817-835.

Samsung-SERC Spatial Reasoning Resarch Program

Primary schoool context

Spatial reasoning program

to promote mathematics literacy

Secondary school context

Real world learning

technology driven
hands-on learning

spatial reasoning activities and assessment tools

Digital pedagogical practices

STEM community focused learning

student led enquiry research projects

The process

The participants

Students in Year 5 and 6 from 20 schools in the Catholic Education Archdiocese of Canberra & Goulbourn were involved in the primary school program. Students in Year 7 to 11 from St Francis Xavier College and St Clare's College were involved in the secondary program.

Both programs involved a diverse population of students from low-SES backgrounds, rural and remote areas and as Aboriginal communities.

Primary School

1. Students' mathematics and spatial reasoning competences were tested.

2. For one group of students (intervention), regular mathematics classes were replaced with digital and hands-on activities. Another group of students (control) continued with normal classes.

3. After three weeks, the mathematics and spatial reasoning competences of all students from both groups were re-tested.

Secondary School

1. Students developed STEM inquiry projects using.

2. Students used Samsung phones to conduct 'in the wild' STEM investigations. This included investigating the growth of crystals; the speed of sound; and the physics involved in a rollercoaster ride.

3. Using Samsung devices, students logged, analysed and presented the data to creatively demonstrate the thinking behind their projects and the findings.

What did we find?

Primary School

The results pointed to an effect size of 0.5, which means students' mathematics skills improved to the level typically achieved in one year, in just three weeks. The intervention group increased their spatial reasoning score by 12 per cent while also recording an improvement in the mathematics test with an increase of 20 per cent.

Secondary School

The key outcomes saw an increase in design-process thinking and inquiry-based learning among the students. This demonstrated that the integration of technology in classroom activities supports real-world STEM investigations, which students enjoy. Teachers noted the way in which their role had shifted towards acting as a facilitator, guide and advisor, rather than just delivering the lessons.

The tools and resources

The use of applications on Samsung devices promoted high levels of student engagement and supported the teachers' content knowledge for both the primary school and the secondary school programs. Students also drew on the range of sensors built into the Samsung phones, such as the Accelerometer, Barometer, and GPS to capture data, analyse the information and then develop video to creatively highlight their findings.

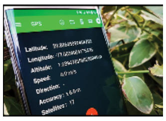
Primary School

Mandalar is based on pattern blocks which encourage investigation of relationships among shapes and other mathematical concepts. Students used this app to create complex symmetrical patterns.

Geogebra is a dynamic mathematics tool that allows students to visualise and manipulate 2D and 3D mathematical models. Students used this app to visualise the cross sections of 3D shapes.

Origami paper cutting is an open-ended paper engineering app. Students worked collaboratively to create complex designs for their partner to solve, encouraging visualisation.

Secondary School



Physics Toolbox Apps provide lesson ideas that require minimal resources, and are relevant to introductory physics in high school. Students from St Clare's College used this app on a rollercoaster ride to capture and analyse the accelerometer data for the trip.

PhoneLabs provides a range of free web apps to help students capture and analyse data with their phones. Year 11 students from St Francis Xavier College used this app to measure the speed of sound in air.

Phonelabs 60X enables students to turn their phone into a microscope and explore everything around them in greater detail. Year 7 students at St Francis Xavier College used this app to investigate the structure of different crystals.

"I think this project has really leant itself to an inquiry-based model of learning, whereby the students pose the problem or question, and then go out of their way to critically explore and understand the answers to their questions. They have stopped taking the world for granted and this project is helping them to understand real-world experiences beyond the classroom."

Graham Stock, Physics Teacher, Saint Francis Xavier College

What can parents do?

Spatial reasoning can be enhanced through a range of out-of-school activities:

- Block play;
- Use and creation of maps;
- Following and giving directions;
- Tangrams and jigsaw puzzles;
- Using photography to explore different perspectives and angles;
- Everyday tasks such as packing the dishwasher or making the bed.

Language is one of the most important aspects of learning to think spatially:

- For children aged 3 to 7 years old, use spatial language such as 'on top', 'under', 'between' or 'rotate';
- For older children, aged 8 and older, use more precise language such as '360° turn' and 'visualise'.

What can education leaders do?

Think:

To achieve sustainability and a broader impact, teachers across all levels of education can consider how to put clearer focus on spatial thinking.

Do:

Providing students opportunities to visualise and represent problem scenarios or tasks prior to solution will greatly advantage student understanding and retention.

Think:

How are your colleagues adding strong visual and digital elements to help convey complex concepts?

Do:

Implement these techniques into classrooms and note how students respond.

"My role as a high school teacher has really transformed from traditional perceptions of teaching, whereby I am just the facilitator and the girls are really hands-on and leading their own learning."

Juliette Major, ICT Curriculum Coordinator, St Clare's College

What can policy makers do?

Existing policy documents[i] acknowledge that spatial visualisation is critical for understanding mathematics ideas and concepts. It is understood that learning opportunities enhance spatial visualisation through the exploration of geometry-based tasks, including the composition and decomposition of shapes, and net and paper-folding activities. Activities that highlight the role of spatial reasoning in number sense and the decoding of graphs are also widely documented. Such documents need to be further developed and championed in Australia. Consider how teaching might improve with a multimodal communication focus. What can be done to support teachers adapt to use spatial and visualisation communication to support their teaching?

"The St Clare's girls are so excited about what they are doing with the Samsung devices. They have been extremely engaged, particularly in the way that they are using design-process thinking to plan out their projects."

Juliette Major, ICT Curriculum Coordinator, St Clare's College

[i] Ontario Ministry of Education's (2014) Paying Attention to Spatial Reasoning

Find out more about the STEM Education Research Centre

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Find out more about Samsung's commitment to Australian communities

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