# Excellence in mathematics education: Influences on the effective use of technology in primary classrooms

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The current COVID-19 pandemic has highlighted the many variances in technology-infused mathematics teaching due to influences such as school context, community support, school commitment to technology use, and school culture. These elements have a significant impact on how teachers plan to use technology in mathematics classrooms. In this brief paper I provide a snapshot of findings from a larger study to highlight some of the variances found in four case studies across three different primary schools.

While we continually strive for excellence in mathematics education, we also continue to face challenges. The forced school shutdowns experienced by many countries during 2020 caused by the COVID-19 pandemic forced many teachers to shift to more technology-infused practices. This highlighted the critical role that technology plays in contemporary mathematics education and the need to understand more about the influence of school context, culture, community, and commitment on technology use in classroom practice. In this brief paper I share some insights from four case studies conducted in primary classrooms within three Australian schools to illustrate the abovementioned influences on technology integration in mathematics classrooms. I do this through the lens of a holistic model of technology integration, the *Technology Integration Pyramid (Mathematics)* (TIP(M)). The TIP(M) emerged from a larger study conducted across 10 Australian classrooms ranging from early childhood through to senior secondary (Attard & Holmes, 2020a, 2020b). The TIP(M) considers the influences on technology integration at a school level, along with the critical considerations for effective technology use within mathematics classrooms. In this paper I provide a snapshot of the complex influences across four case studies in relation to the teachers' effective implementation of technology-infused mathematics lessons.

## A Model for Technology Use in Primary Mathematics Classrooms

There are several frameworks that attempt to describe the types of knowledge required to integrate technology into teaching and learning. For example, the widely cited TPACK framework (Koehler & Mishra, 2009) provides a model of a professional knowledge construct, and according to Krauskopf et al. (2018), potentially provides a richness to teaching conversations, providing a theoretical vocabulary to help understand the required pedagogical considerations of technology integration (Koh, 2018). However, there are limitations to the TPACK framework. Although it is helpful in identifying specific knowledge domains for technology integration, TPACK is regarded as a pedagogically neutral model (Bower, 2017). The framework makes no suggestions about specific technologies and pedagogies that would be appropriate for mathematics, nor does it consider the importance of student engagement, which is a particular concern within the discipline of mathematics education. While TPACK provides an acknowledgement of school contexts, it does not provide insight into the complex contextual elements that may influence task design, teacher practice and student learning, and does not consider the variety of barriers and dilemmas that are typical to technology integration, such as a lack of technical support

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or issues of access. Arguably, these issues influence how technology-infused teaching plays out in individual classrooms.

The *Technology Integration Pyramid (Mathematics)* (TIP(M)) (Figure 1) (Attard & Holmes, 2020b) emerged from existing frameworks and the findings of the broader study from which this paper is drawn. TIP(M) is conceptualised as a three-dimensional model to illustrate the connections and inter-related elements within it that teachers should consider when planning for the use of any technology, regardless of device, software, access and school context. The purpose of TIP(M) is to assist in future-proofing technology-infused teaching and learning as new technologies continue to emerge. It presents a holistic means of understanding the parameters within which teachers operate and a recognition that student engagement with mathematics is a critical element for learning to occur in contemporary classrooms. In this paper, a sample of findings from four case studies of teachers considered to be effective users of technology in mathematics education is used to illustrate the variances and complexities that influence technology-infused mathematics teaching across different schools.

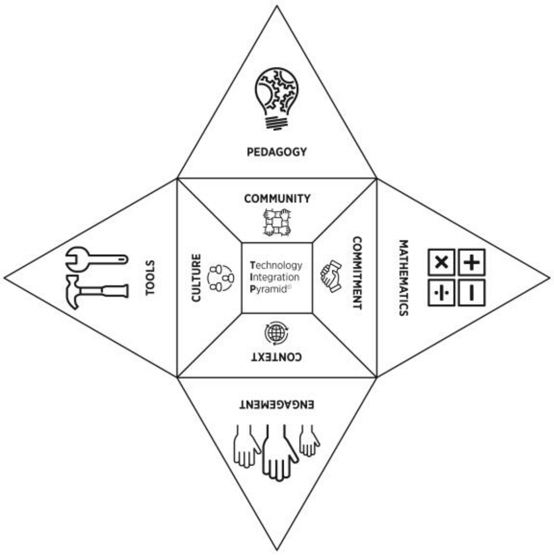

*Figure 1.* Technology Integration Pyramid (Mathematics) (Attard & Holmes, 2020b)

## Methodology

To assist in understanding how the influences described on the base of the TIP(M) evolved, a brief overview of the methodology employed in the larger study is provided. A qualitative multiple case study approach was utilised. Each case consisted of a classroom teacher, one member of the school leadership team, and a focus group of five or six students. Cases were identified through a process of purposive sampling. The case studies were conducted in a mixture of public and private schools and represented a range of socio-economic and geographic areas.

### *Participants*

Case study teachers were identified through professional networks as teachers who are considered by their peers as effective and innovative users of technology. While the three schools (two case study teachers taught at the same school) were located in metropolitan areas, they differed significantly in terms of size, socio-economic status, access to technology, and school support for technology integration. School leaders were identified as those who had a formal leadership role. Students participating in focus groups were selected by their teachers as a representative sample of the case study teachers' students. Where possible, students were chosen to represent a mixture of gender, ability, and attitudes towards mathematics. Students below Grade 3 did not participate in focus groups.

### *Data Collection and Analysis*

Data collected from the case study teacher included classroom observations, lesson plans, and interviews. Students participated in a focus group discussion and the nominated school leader participated in an interview. Data drawn from interviews and focus group discussions were audio recorded and transcribed verbatim. Observations were video recorded. Data analysis was conducted in alignment with the components of the TIP(M). To do this, all relevant data from interviews and focus group discussions from each of the case studies were collated to provide collective responses to the research question. Field notes and observations were used to support further analysis. For a more detailed description of the larger study, its methodology and findings, see Attard and Holmes (2020a, 2020b).

## The Influences on Effective Technology Use

The three school settings examined in this paper varied in context with two being government schools and the other a very well-resourced independent school. The independent school (Case A) utilised a whole-school approach to technology integration, ensuring a one-to-one iPad ratio and providing professional development for teachers, largely in-situ, allowing for a highly contextualised approach. The teachers were expected to consistently reflect on the proposed purpose when thinking about using a new technological tool or app. Teachers in this school were actively encouraged to limit the number of apps used during teaching, only adding new ones when there was a clear pedagogical purpose for doing so.

In contrast, the government school in two cases (B and C) had a different approach for the early years (K-2) and the primary years (3-6). All students in Years 3 to 6 were required to have their own iPad which the school facilitated through an Apple purchase plan. Students in the lower years had a small number of iPads to share in the classroom, but the teachers of these years were perceived as being more sceptical about the value of technology for learning. Rather than taking a whole-school approach, the technology divide in this school between older and younger students was quite embedded and unlikely to change with current teaching staff. In Case D, a whole school approach was not yet in place due to the school being new, yet there was still an ethos of encouragement of technology use, albeit through a "trial and error" method, rather than through an agreed systematic approach.When the Bring Your Own Device (BYOD) iPad plan was introduced for Years 3 to 6, the school in Cases B and C faced considerable backlash from parents, concerned about how the technology might change the teaching and learning practices. The school then increased communication with parents to ensure that support for the technology was present at home as well as at school. Interestingly such concerns were not raised at the independent school where even very young learners were expected to have their own devices.

Despite significant differences in levels of support and access, the teachers at all schools saw the benefit of using technology in the mathematics classroom to shift the focus from learning content to developing conceptual understanding and mathematical reasoning. They recognised increased opportunities for students to explore mathematics content and to communicate their mathematical understanding in a variety of modes using digital cameras, audio and video recording, and screen capture. In Cases A, B, and C, *Google Sheets* was used for learning about data and *Beebots* and/or *Spheros* were used to enhance spatial reasoning through basic programming. Cases A, B and C used a learning management system (*OneNote*, *SeeSaw*) as a means of tracking student progress and to share student work with parents. *Kahoot* was employed in all schools to check on student progress both from the teachers' perspectives and as a means for students to gain immediate feedback on their understanding.

In all observed lessons there was evidence of high levels of student engagement because of how teachers utilised the tools at hand. The technology was used seamlessly with few technical difficulties, regardless of constraints posed by some school contexts and communities. While the influences at each school varied, each teacher was able to find ways of using the available technologies in effective and meaningful ways.

Arguably, some of the influences such as system policies, school funding, and provision of professional development are beyond the individual teachers' control. Others, such as individual teacher beliefs about technology, their willingness to innovate and the depth of their pedagogical content knowledge can be somewhat controlled and influenced by the teacher. An understanding the four categories of influence (context, culture, community and commitment) within a teacher's school will help to understand the possibilities for effective technology-infused mathematics education within each unique and individual context. Further, clarity regarding contextual affordances and constraints will assist teachers in the planning of mathematics teaching and learning and contribute to the pursuit of excellence in mathematics education.

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