Title: Primary teachers' self-assessment of their confidence in implementing digital technologies curriculum

Abstract

Technology has significantly impacted our work and leisure spaces. However, education is still working to make links between the technological knowledge and skills required for living now and preparing students for their future use of technology. Although a reduction in the cost of digital technologies has led to increased access and connectivity within schools, where teachers now have a plethora of tools and resources available for them to use in teaching and learning, little has changed in the classrooms. The Digital Technologies subject in the Australian Curriculum has had significant redevelopment. Teachers are attempting to provide effective instruction with and about digital technologies, often with limited knowledge and skills themselves. This study investigated Australian primary teachers' self-assessment of their digital technologies confidence. Through an online survey and interviews, teachers were asked about their access to professional development and their knowledge and skills related to the digital technologies' curriculum. This paper provides an analysis of their self-assessment. Barriers and enablers are identified along with practice implications to be considered.

Keywords: Primary teachers, ICT, self-assessment, confidence, digital technologies, technology curriculum

Introduction

Technology has enabled a world of opportunity, connectivity, discovery and rising global learning. However, there are widespread concerns about potential loss of employment resulting from automation, robotics, and artificial intelligence leading to anxiety and associated mental health issues for those who may be displaced (Wajcman, 2017). Learners are trying to find their place in the world, exploring new ways of learning and knowing in a world disrupted by technology with uncertainty about their future employment prospects. Teachers are trying to provide relevant experiences for students to learn about and with digital technologies as preparation for life. With the advent of the Australian Curriculum: Technologies (ACARA, 2015), there was a great deal of optimism about how technology would be addressed in classrooms, with implications for its enhanced use in daily life and more effective preparation of learners for future employment.

Learners need to understand how the world works and how they can control aspects of it, and much of this will be impacted by technology. This idea formed the foundation for developing the Australian Curriculum: Technologies that was endorsed in 2015 with implementation from 2018, and incorporating two related subjects, Design and Technologies and Digital Technologies. Because the "introduction of Digital Technologies is perhaps the most disruptive curriculum change that Australia has seen in many years, especially in primary [schooling]" (Curran, 2017), teachers need support and ongoing professional learning in order to teach the digital technologies curriculum effectively. Prior to the Australian Curriculum: Technologies, the teaching of content related to computer sciences was left to high school specialist technology teachers or primary school teachers with a personal interest in technologies. With the introduction of the Digital Technologies subject, primary teachers have been tasked with teaching digital technologies concepts, including computational thinking, throughout the primary years (K-6), with a focus on students creating digital solutions.

In recent years, the emphasis of teaching digital technologies has moved from learning to use technology, to using technology to learn, and more recently to transformative learning with technology (International Society for Technology in Education, 2020). That is accompanied by a focus on building an understanding of the underlying knowledge and concepts of computer science to better skill students for their futures in a world dominated by digital technologies. In addition to the specific Digital Technologies subject, the Australian Curriculum includes an ICT (Information and Communication Technology) General Capability through which teachers are tasked with developing student digital literacy across all learning areas.

This paper begins by discussing the push from global influences for developing capabilities with digital technologies. Before introducing the research context of the Digital Technologies subject from the Australian Curriculum and some related challenges and complexities. It then, discusses the research project, including the methods and findings, and concludes with a discussion of the implications, limitations and recommendations for further research. This research was guided by the research question: How ready are Australian teachers to teach the digital technologies curriculum?

Digital technologies expectations in education

Australia is not alone in expecting that digital technologies are taught as part of the school curriculum; there has been a global movement to improve students' capabilities by incorporating digital technologies into primary school curriculum. For example, the United Kingdom (UK) has introduced mandatory computer programming study for all students aged 5-16 years (Berry, 2013). Similarly, Finland introduced coding across subjects for students aged 7-15 years (Sullivan, 2014). The American ISTE standards (2016 & 2018) are standards for the use of technology in teaching and learning to prepare students "to thrive in a constantly evolving technological landscape" (International Society for Technology in Education, 2020). However, there is a lack of research to explore teachers' understandings of the digital technologies curriculum content in the primary school setting.

Along with the need to implement the Digital Technologies subject of the Australian Curriculum, teachers are required as part of the Australian Professional Standards for Teachers to enact a number of expectations related to digital technologies. These standards are not related to the Digital Technologies subject but are related to using ICT as a tool to support learning in all curriculum areas and apply to both initial teacher training and practicing teachers. The relevant standards are:

- Use effective teaching strategies to integrate ICT into learning and teaching programs to make selected content relevant and meaningful;
- Select and/or create and use a range of resources, including ICT, to engage students in their learning;
- Incorporate strategies to promote the safe, responsible and ethical use of ICT in learning and teaching; and
- Use student assessment data to analyse and evaluate. (Australian Institute for Teaching and School Leadership, 2011)

Globally, there is an expectation that teachers and students will learn with and about digital technologies. Along with teacher standards expectations, there is a formal curriculum that drives teachers and students' work related to digital technologies.

TPACK as a conceptual framework

Teaching with technology is a messy and ill-structured process. TPACK presents teachers with a theoretical framework to understand the key constructs of effective technology integration: technology, pedagogy and content knowledge (TPACK). The framework builds on Shulman's (1986) notion of pedagogical content knowledge (PCK), which is "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (p. 8). TPACK "connects technology to curriculum content and specific pedagogical approaches and describes how teachers' understandings of these three knowledge bases can interact with one another to produce effective discipline-based teaching with educational technologies" (Koehler, Shin & Mishra, 2012, p. 17).

The foundation for TPACK is three key bodies of knowledge: content, pedagogy and technology. Adding to the complexity of the framework are the relationships between and amongst the knowledge areas. At the intersections of these three knowledge bases the TPACK construct presents seven types of interrelated knowledge required for effective teaching and learning with technology. The skills and knowledge from these multiple areas represent the multifaceted complexity of teaching in a digital world.

Table 1

Unpacking the sub-elements of TPACK

Element of TPACK	Meaning
Content knowledge (CK)	The subject matter related to the teaching and learning
Pedagogical knowledge (PK)	An understanding of how students learn and are influenced by the values and beliefs of the teacher
Pedagogical Content Knowledge (PCK)	The knowledge of pedagogy related to specific subject matter or content
Technology knowledge (TK)	The evolving body of knowledge related to how to use specific technology hardware, software, and networks
Technology Content Knowledge (TCK)	An understanding of how content and technology constrain and influence each other
Technological Pedagogical Knowledge (TPK)	The leveraging of technology to change teaching and learning opportunities
Technological, Pedagogical Content Knowledge (TPACK)	The intersection between technology, pedagogy and content

TPACK describes the types of knowledges, and the interweaving of the specialised knowledges that teachers need to understand in today's highly complex, dynamic and varied classroom environments. "TPACK as it is applied in practice must draw from each of its interwoven aspects, making it a complex and highly situated educational construct that is not easily learned, taught, or applied" (Harris & Hoffer, 2011, p. 213). TPACK is the foundation for diverse learning experiences afforded by effective digital technology integration.

Research context

This study was situated in the context of the national approach to the Digital Technologies subject across all states and territories in Australia. The digital technologies curriculum is designed to develop the

> capacity of students to generate digital solutions, not only enabl[ing] them to make considered study and career choices that involve many facets of digital technologies … but also build[ing] the capacity of Australia to thrive in an increasingly complex world where the mastery and harness of digital technologies is vital. (Australian Council for Computers in Education, 2015, p. 1)

The Digital Technologies subject in the Australian Curriculum has two interrelated strands. They are Knowledge and Understanding, related to digital systems and data representation; and Processes and Production skills, related to working with digital data and creating digital solutions. Table 2 expands on the content of the strands.

Table 2

Digital Technologies content structure (ACARA, 2015)

Knowledge and understanding	**Processes and production skills**
Digital systems • the components of digital systems: hardware, software and networks and their use Representation of data • how data are represented and structured symbolically	Collecting, managing and analysing data Creating digital solutions by: • investigating and defining • generating and designing • producing and implementing • evaluating • collaborating and managing

The curriculum is not presented as specific expectations by year level, but it is arranged in learning bands: foundation – year 2, years 3 - 4, years 5 - 6. The content within the strands is presented in the form of content descriptions that provides a code for tracking and the description of the required content. For example, for foundation - year 2, students need to *Recognise and explore patterns in data and represent data as pictures, symbols and diagrams* (ACTDIK002) and to *Create and organise ideas and information using information systems independently and with others, and share these with known people in safe online environments* (ACTDIP006). (For more information, see https://www.australiancurriculum.edu.au/f-10-curriculum/technologies/digital-technologies).

"Teachers will be expected to unpack the content descriptions, create authentic learning activities, and assess and moderate students' work" (Sheffield, Blackley & Moro, 2018, p. 1). That process of unpacking is assisted by multiple elaborations provided for each content description, including suggested learning activities. Teachers are encouraged to plan learning activities in which students will create digital solutions by applying processes and production skills and drawing on relevant knowledge and understanding. Students demonstrate their knowledge and understanding of digital technologies through creating solutions using digital technologies.

To support the development of robust curriculum units, the Australian Curriculum: Technologies provides teachers with Work Samples (ACARA, n.d.) aligned to the content descriptions. For example, in foundation - year 2, to *Organise ideas*: students can prepare mind maps with or without images. In this activity, students take digital photos of known places around their school and then prepare a mind map using the images to represent conceptual connections between locations. They can use the mind map to analyse and explore ways to group and display the photos creatively and they can upload their completed mind maps to an online space such as their virtual classroom or class blog (ACARA, n.d.).

The Digital Technologies subject of the Australian Curriculum: Technologies is challenging to teachers and schools because it introduces knowledge and skills that may be unfamiliar to the teachers (Curran, 2017). Even younger teachers may not have encountered most of the Digital Technologies subject's content in their schooling or teacher preparation. Hence, as implementation proceeds, it will be essential to monitor progress and provide teachers with the necessary support in the form of resources and professional learning. This study aimed to investigate teachers' readiness to teach the digital technologies subject, their access to professional learning support, and their early experiences of barriers and enablers to implementation. It provides a self-assessment of the Australian teachers' knowledge and skills related to the Digital Technologies subject.

Method

This study adopted a mixed methodology, using a survey followed by interviews to explore the findings further. An online survey collected data from Australian teachers (n=83). After ethics approval was obtained, the research team distributed the online survey via email and through social media and professional networks. A non-probability sampling method, snowball sampling, was used whereby the research participants were invited to recruit additional participants for the study by sharing the URL of the online (Etikan, Alkassim & Abubakar, 2015). In addition, four (4) teachers who volunteered were interviewed for 30 minutes each to explore their responses about enablers and barriers to teaching the digital technologies curriculum in more detail.

The online survey was presented in four sections and included both open and closed questions. The first section collected simple demographic data and concluded with an item about the year level currently taught by the participant. That response was used to direct participants to a version of the second section that was tailored to the relevant year level. In that section, they responded to items about their confidence, relative to the knowledge and skills required to complete the activities represented in the work samples provided by Australian Curriculum: Technologies for demonstrating achievement standards for the relevant year levels and expanded on these by providing specific examples in the open-ended questions. In the third section, they were asked to self-assess their understanding of relevant content descriptions from the curriculum and provide examples of how they might teach and assess the content descriptions. The final section asked about their access to professional learning related to digital technology and invited them to rate enablers and barriers and to provide a narrative on the enablers and barriers within their teaching contexts.

Quantitative data from the survey were analysed to gain descriptive statistics. The qualitative data from interviews were analysed using the constant comparison method (Wellington, 2000), searching for patterns, themes, contrasts and irregularities. We could not test for relationships between specific variables due to the small sample size (n=83).

Findings and discussion

1. The participants

Most of the survey participants came from Queensland, with 17% male and 86% female. More than two-thirds (69%) of the teachers claimed to be very familiar or somewhat familiar with the digital technologies subject. Sixty-eight per cent of the females were very or somewhat familiar with the curriculum compared with 75% of the males. The majority of the teachers had over 11 years of teaching experience, with 28 of them having more than 20 years of teaching experience. Figure 1 provides a summary of the participants' teaching experiences with ICT.

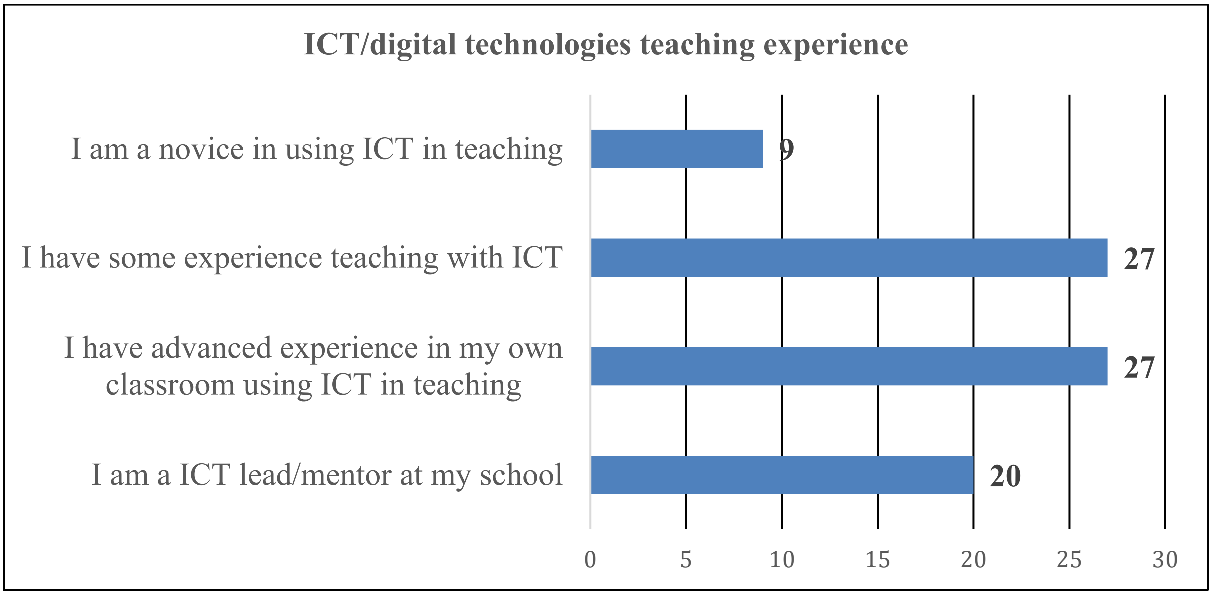


Figure 1. Years of teaching experience using ICTs.

A minority of the respondents classified themselves as novices for using ICT in teaching, probably because most of the research participants had over 10 years of teaching experience, and the expectation of technology use in classrooms was established well before that. Having said that, the curriculum has changed significantly over that time, and the teachers' content knowledge (CK) may not have kept pace with the changes. The same could be said for their technology knowledge (TK), technology content knowledge (TCK) and technological pedagogical knowledge (TPK).

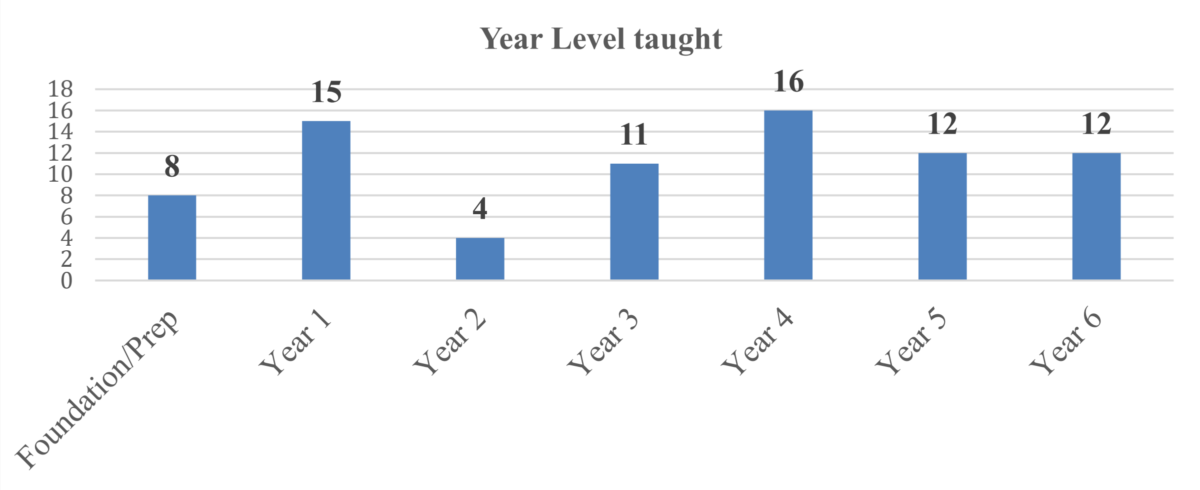


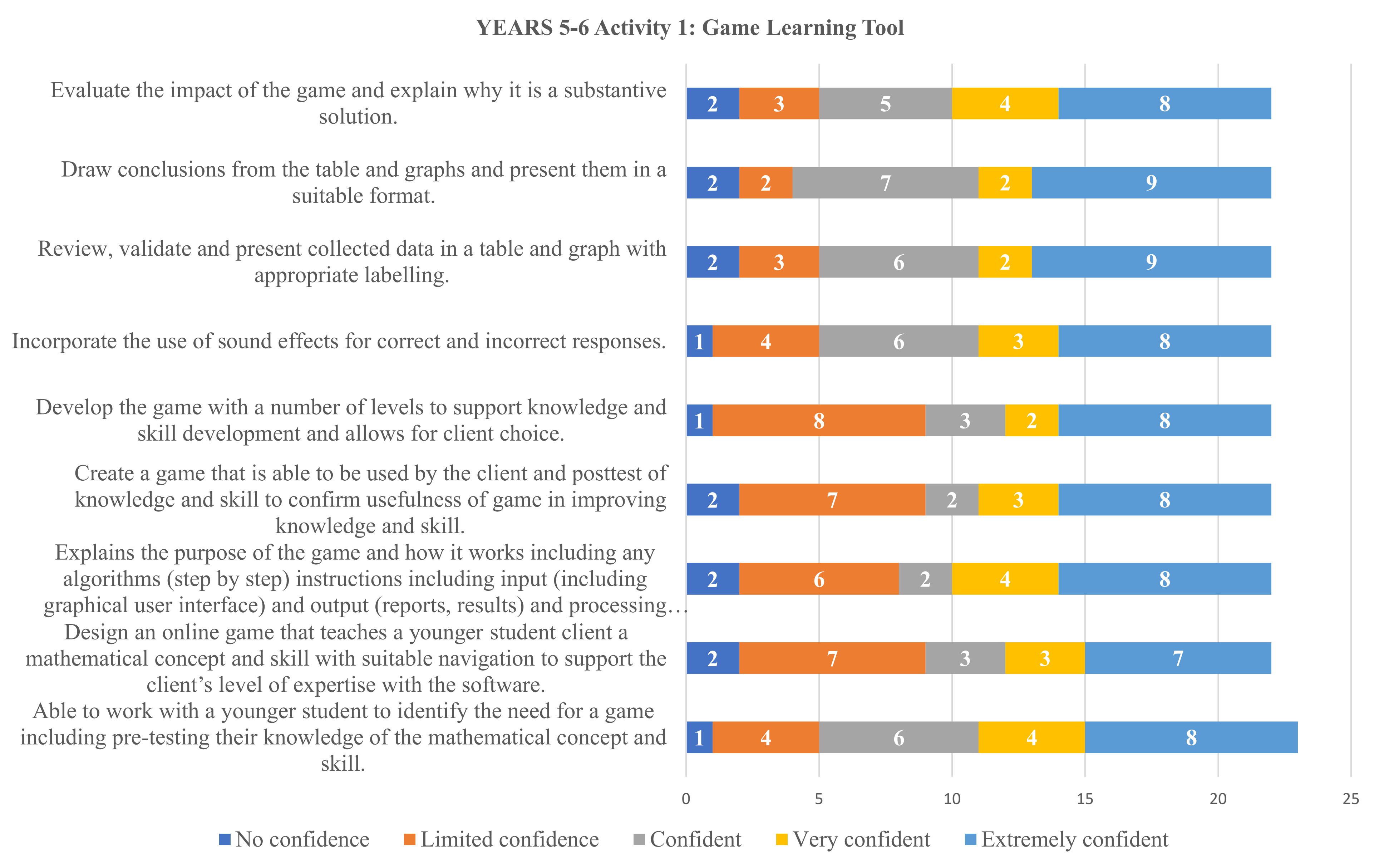
Figure 2. Distribution of current-year levels taught.

Figure 2 represents the distribution of the year levels currently taught by the participants taught. The participants taught across all year level, with each learning band being similarly represented with 27 teachers in foundation – year 2 band, 27 teachers in the years 3- 4 band and 24 teachers in the years 5 -6 band.

2. **Teachers' confidence in digital technology activities**

The participants were asked to rate their confidence concerning the knowledge and skills required to complete the activities in a work sample that was provided on the Australian Curriculum: Technologies website to illustrate achievement standards for the relevant year levels. The task and requirements of the work samples were replicated in the online survey. The following presents the description provided for the years 5-6 version:

> *In a year's 5-6 activity, Game Learning Tool, students can design and create an online game to help younger students to explore, practice and apply a mathematical concept and skill. The game is designed to have multiple levels. To develop the game the students, work with their younger student clients to collect data about what their client already knows using a simple test before and after using the game. Students collect data from a small number of other students/clients and represent the data in graphs. Students then evaluate and draw conclusions about their game and present their results in a spreadsheet. Finally, students prepare a presentation describing the process of game development, their evaluation and their conclusions using presentation software.*



YEARS 5-6 Activity 1: Game Learning Tool
Evaluate the impact of the game and explain why it is a substantive solution.
2 3 5 4 8
Draw conclusions from the table and graphs and present them in a suitable format.
2 2 7 2 9
Review, validate and present collected data in a table and graph with appropriate labelling.
2 3 6 2 9
Incorporate the use of sound effects for correct and incorrect responses.
1 4 6 3 8
Develop the game with a number of levels to support knowledge and skill development and allows for client choice.
1 8 3 2 8
Create a game that is able to be used by the client and posttest of knowledge and skill to confirm usefulness of game in improving knowledge and skill.
2 7 2 3 8
Explains the purpose of the game and how it works including any algorithms (step by step) instructions including input (including graphical user interface) and output (reports, results) and processing…
2 6 2 4 8
Design an online game that teaches a younger student client a mathematical concept and skill with suitable navigation to support the client's level of expertise with the software.
2 7 3 3 7
Able to work with a younger student to identify the need for a game including pre-testing their knowledge of the mathematical concept and skill.
1 4 6 4 8
0 5 10 15 20 25
No confidence
Limited confidence
Confident
Very confident
Extremely confident

Figure 3. Distribution of teachers' confidence ratings for the year 5 - 6 activity.

Figure 3 represents the distribution of respondents' confidence ratings for the years 5 - 6 example. Although the teachers (N=22) were confident overall, there were four areas where one-third of the teachers had no or limited confidence that they possessed the knowledge and skills required to complete the activity. Those four elements were all related to creating the digital game, which is the focus of the activity and the key link to digital technologies and the teachers' technology knowledge (TK).

An analysis of all teachers' ratings of confidence across all year levels and all work samples resulted in a mean of 3.60, with a standard deviation of 1.31. Teachers in the foundation – year 2 group had the highest mean at 3.89. This should not be a surprise given the limited high-level technical requirements for those activities. Overall, teachers were confident that they had the digital technologies knowledge and skills to guide students through the work sample activities. Still, very few of them were very or extremely confident, especially in the high-level tasks. Ertmer (1999, 2006) found that teachers were more likely to use technology for low-level tasks like word processing, PowerPoint or internet research rather than high-level tasks like critical thinking, creativity, or collaboration. Teachers in this sample appear to understand how technology, pedagogy and content can intersect, as identified by the TPACK model.

When comparing these results to ACARA's (2019) digital technologies and teacher self-assessment matrix, it seems that the sample demonstrated over the four different self-assessment levels: 1 uncertain and/or hesitant; 2 willing but dependent; 3 confident and proficient; 4 leading and enabling others. Given the spread of responses, it might be valuable to have teachers complete the student work samples themselves and note through observation which of the four self-assessment levels they select after completing the tasks.

3. Teachers' confidence with the Digital Technology Content Descriptions

Teachers were asked to rate their confidence in the digital technologies content descriptions for the year level/s they taught. Figure 4 summarises the distribution of foundation – year 2 teachers' confidence ratings for the relevant content descriptors. Across all year levels, the mean of their self-assessment was 3.49 with a standard deviation of 1.35.

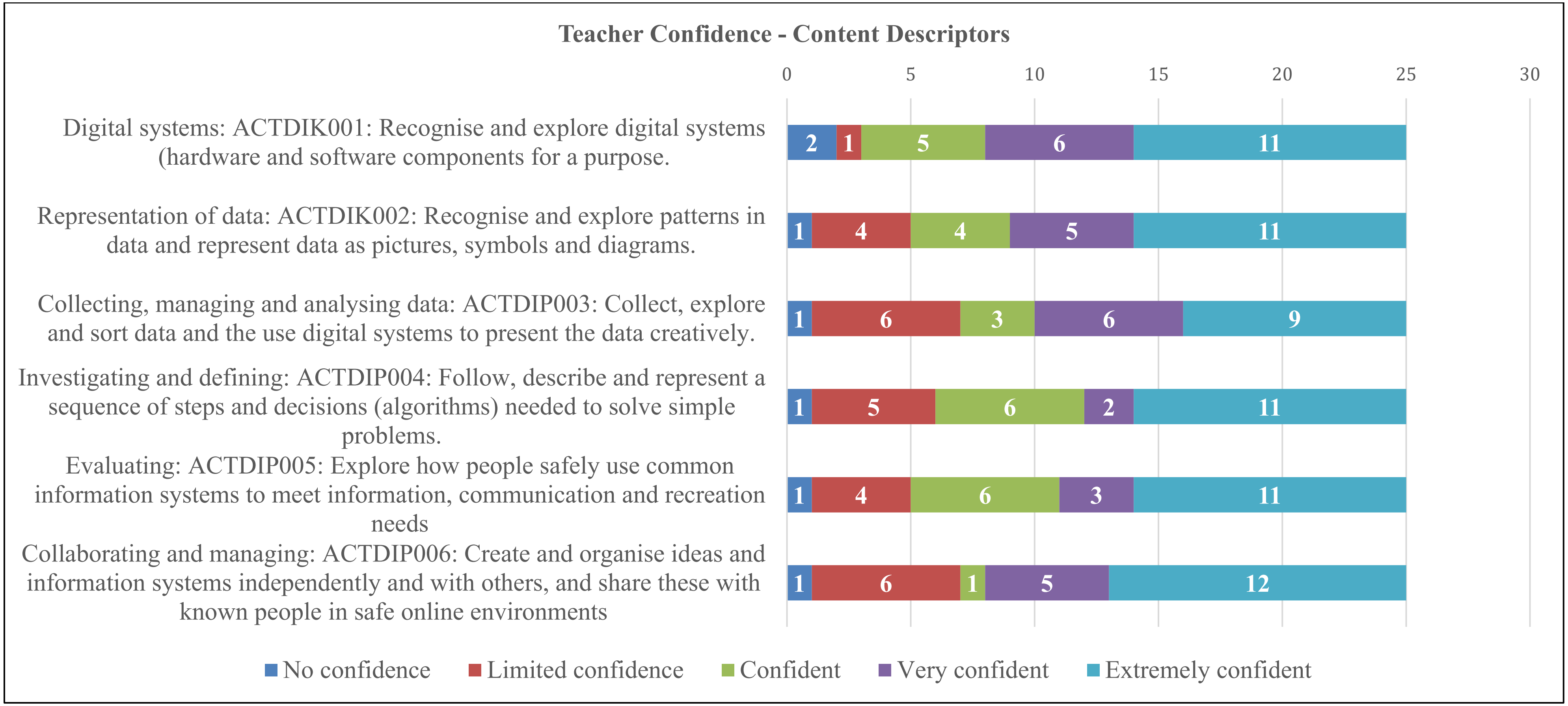


Figure 4. Teachers' self-assessment for the digital technologies content descriptions

Most of the teachers were confident in their understanding of the digital technologies content descriptions. For those who were not, there are implications for using digital technologies and teaching about digital technologies in their classrooms. Teachers' lack of knowledge of the content impacts their ability to effectively teach with and about digital technologies (Kaarakainen, Kivinen, & Vainio, 2018). Those teachers with reduced technology content knowledge (TCK) within the TPACK framework will find it challenging to provide innovative learning experiences within the technology curriculum.

Teachers were also asked to provide examples of their practices and assessment related to the content descriptions. For example, to achieve the foundation - year 2 content description using Bee-Bots: Follow, describe and represent a sequence of steps and decisions (algorithms) needed to solve simple problems, teachers proposed:

- "Using Bee-Bots to determine the shortest path to get the humans away from the chasing bear (Going on a bear hunt simulation)";
- Place "Bee-bots on a map and follow the instructions provided by the teacher"; and
- "The children design a maze and then try to navigate it using the Bee-Bot".

In all year levels, the teachers provided specific examples of hands-on, unplugged, and tool-specific ideas of how they would teach the content descriptions, but few teachers provided assessment ideas. Very few of the ideas provided would be labelled as high level, and they tended to replicate non-ICT activities rather than transform education with ICTs. Although digital technologies provide the opportunity to transform content and teaching processes, teachers need high levels of confidence, knowledge and skill to make effective changes to educational processes (Lawrence & Tar, 2018).

4. Professional learning

Teacher professional development refers to formal activities intended to develop the knowledge and skills necessary to function as a teacher. In recent work, teacher professional development is often contrasted with teacher professional learning, which is more self-directed and less formal (Prestridge & Main, 2018). Although much has been written about professional development for teachers using technology, most of it is written from a deficit model (Niederhauser, Howard, Voogt, Agyei, Laferriere, Tondeur, & Cox, 2018; Voogt, Laferriere, Breuleux, Itow, Hickey, & McKenney, 2015) and explores why professional development has not resulted in long term, sustainable change in teacher knowledge, skills and pedagogical practices nor in significant differences in learners' outcomes. More recently, it has been argued that rapid changes in digital technologies and shifting societal expectations pose challenges for professional development arranged by central authorities. Instead, a recognition of teachers' agency as professionals responsible for their professional learning, including selected formal offerings, may be more effective for addressing changes in context (Albion & Tondeur, 2018).

Previously the focus of professional development has been on generic ICT competence, but in the digital technologies curriculum, teachers are expected to go well beyond that level of knowledge and skill. In this study, the participants were asked to indicate the types of professional learning about digital technologies they had engaged in during the previous two years.

Figure 5 presents the distribution of responses and indicates that the most common professional learning activities undertaken by teachers in the last two years were talking with peers, attending workshops or seminars and reading educational publications. Voogt et al. (2015) also found that collaborative professional learning offered support and stimulus for ongoing learning, including learning that focuses on both ICT skills and pedagogical approaches (Voogt, Westbroek, Handelzalts, Walraven, McKenny, Pieters, & de Vrier, 2011). The least likely activities the teachers were to engage with were formal qualifications or conferences.

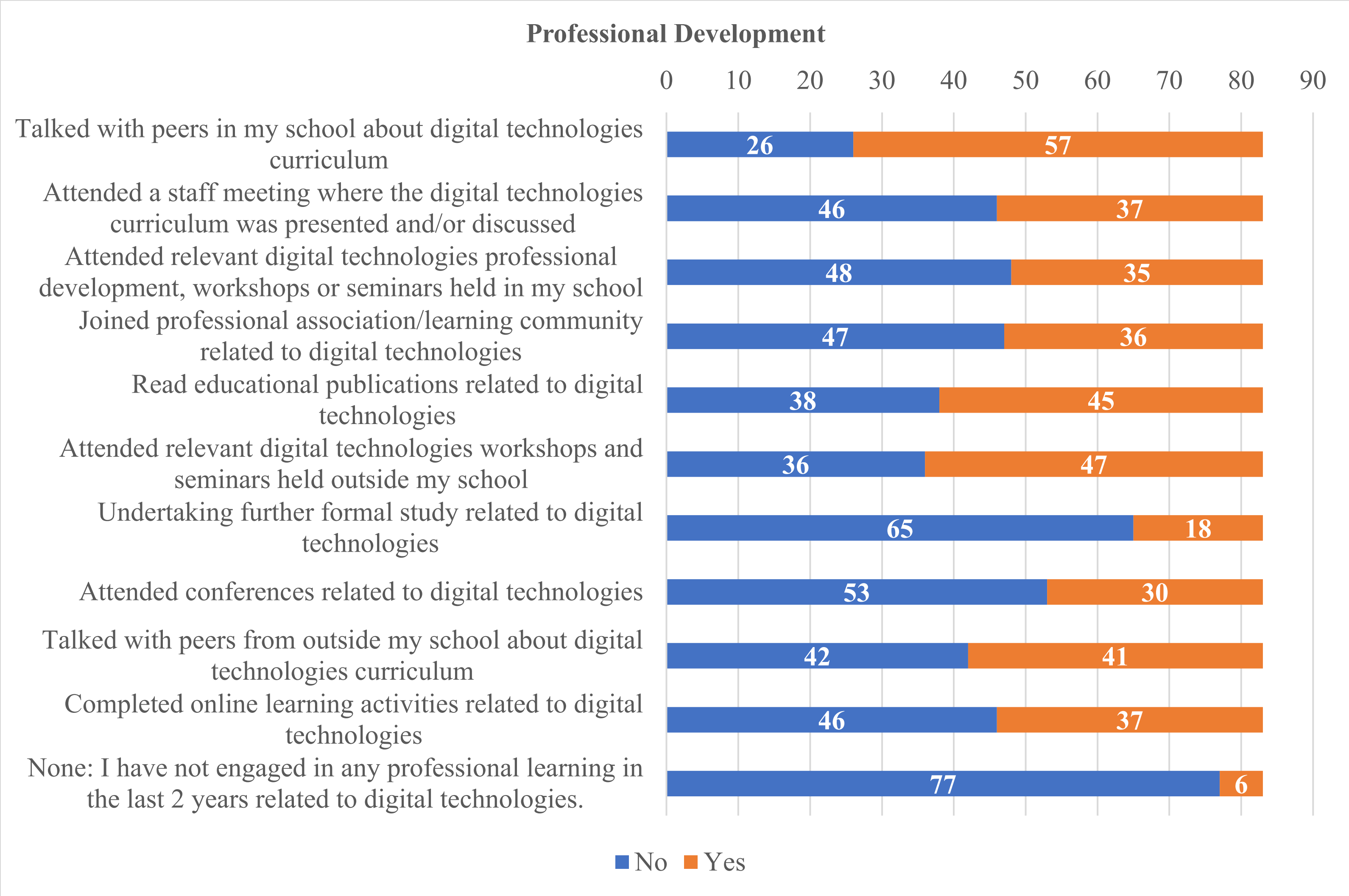


Figure 5. Teachers' digital technologies professional learning

Teachers were also asked how frequently they had accessed professional learning about digital technologies in the last 2 years. These data are presented in Figure 6, highlighting that 10% of the teachers had had no engagement in any professional development related to digital technologies over the past 2 years. Over half the participants engaged in professional learning related to digital technologies between 1 and 5 times over the past two years, whereas 26% of the teachers accessed professional learning more than 10 times.

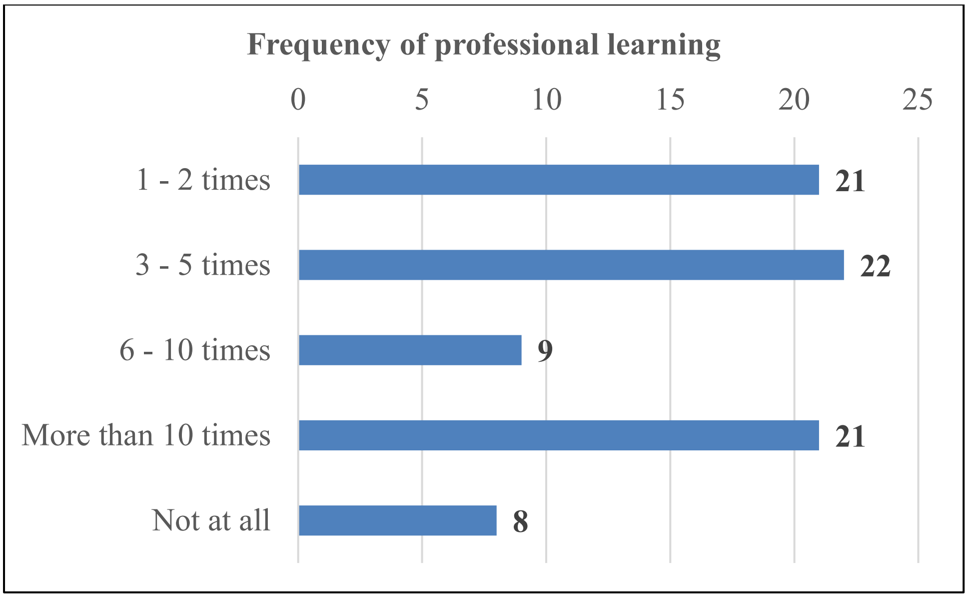
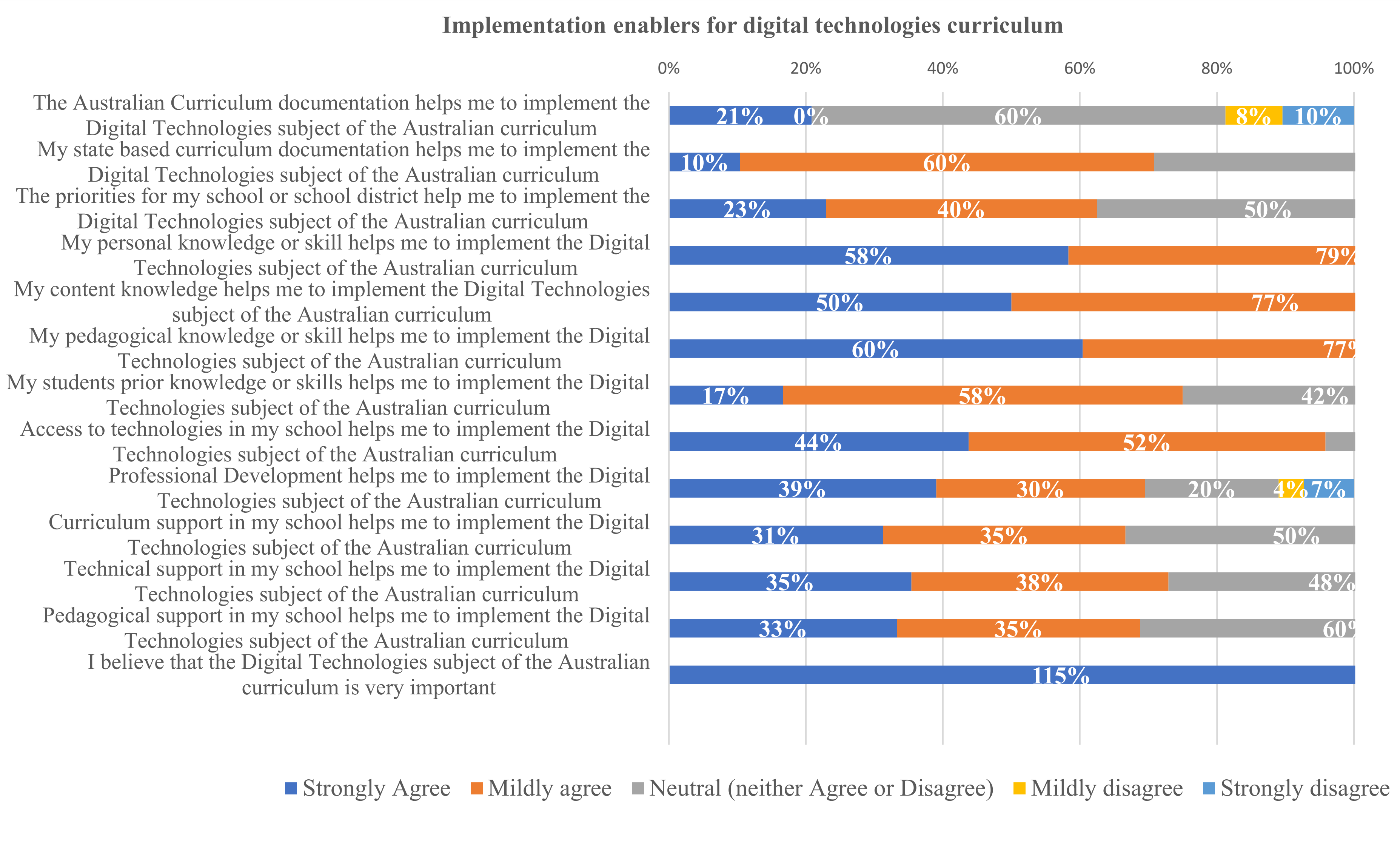


Figure 6. Frequency of teachers' access to professional learning

5. Implementation enablers for the digital technologies curriculum

Teachers were asked to rate items on a 5-point Likert scale (1 strongly disagree to 5 strongly agree) and identify what might be enablers to assist them in implementing the digital technologies curriculum. Figure 7 provides a summary of their responses. Table 3 provides the mean and standard deviation for each of the items. AC refers to the Australian Curriculum, and DT refers to the Digital Technologies subject in the curriculum.



Implementation enablers for digital technologies curriculum
0%
20%
40%
60%
80%
100%
The Australian Curriculum documentation helps me to implement the Digital Technologies subject of the Australian curriculum
21%
0%
60%
8%
10%
My state based curriculum documentation helps me to implement the Digital Technologies subject of the Australian curriculum
10%
60%
The priorities for my school or school district help me to implement the Digital Technologies subject of the Australian curriculum
23%
40%
50%
My personal knowledge or skill helps me to implement the Digital Technologies subject of the Australian curriculum
58%
79%
My content knowledge helps me to implement the Digital Technologies subject of the Australian curriculum
50%
77%
My pedagogical knowledge or skill helps me to implement the Digital Technologies subject of the Australian curriculum
60%
77%
My students prior knowledge or skills helps me to implement the Digital Technologies subject of the Australian curriculum
17%
58%
42%
Access to technologies in my school helps me to implement the Digital Technologies subject of the Australian curriculum
44%
52%
Professional Development helps me to implement the Digital Technologies subject of the Australian curriculum
39%
30%
20%
4%
7%
Curriculum support in my school helps me to implement the Digital Technologies subject of the Australian curriculum
31%
35%
50%
Technical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum
35%
38%
48%
Pedagogical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum
33%
35%
60%
I believe that the Digital Technologies subject of the Australian curriculum is very important
115%
Strongly Agree
Mildly agree
Neutral (neither Agree or Disagree)
Mildly disagree
Strongly disagree

Figure 7. Summary of implementation enablers for the digital technologies curriculum

In summary, teachers see the development of their knowledge and skills as the most likely way to enable effective implementation of the digital technologies curriculum. There were high levels of agreement that personal knowledge or skill; personal pedagogical knowledge; personal content knowledge; and professional development (80%, 80%, 74% and 69%) respectively strongly or mildly agreed made substantial differences in the use of digital technologies in the classroom.

Two interviewees acknowledged that the role of the digital technologies coordinator in the school supported teachers in gaining access to information, skills and ideas about how to teach about and with digital technologies. Another participant in the survey mentioned that the "digital capacities of my peers" was also an enabler. By the same token, in the open-ended section of the survey, many participants mentioned ideas related to learning with and from others, such as "support from our digital technologies coach"; "being connected to others through personal learning networks, i.e., Twitter chats, Facebook, Instagram and blogs"; "discussions with colleagues" and the "sharing of resources with other teachers".

Table 3
Implementation enablers for digital technologies curriculum

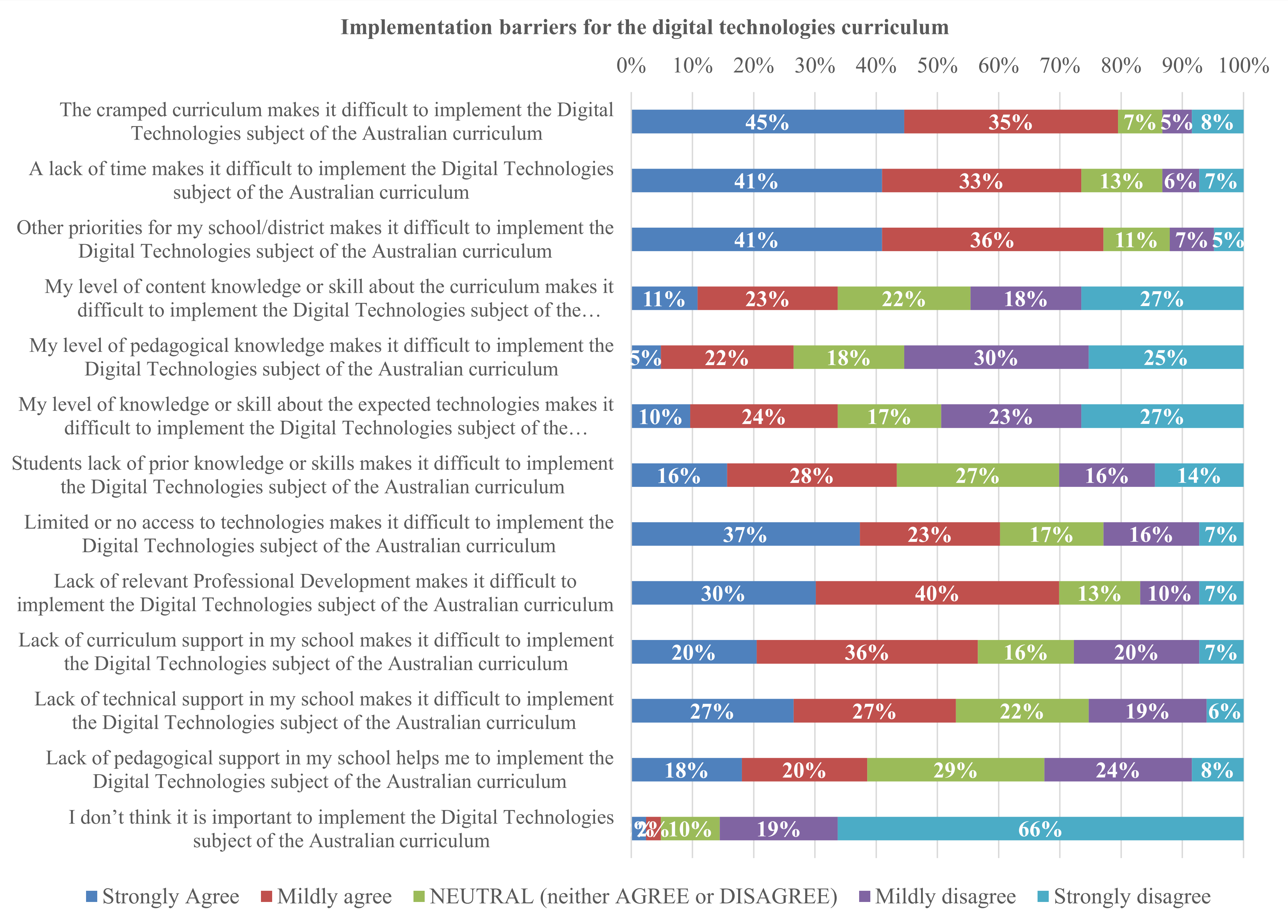
Enablers (n = 83)	**Mean**	**Standard Deviation**
The Australian Curriculum documentation helps me to implement the Digital Technologies subject of the Australian curriculum	3.5	0.98
My state-based curriculum documentation helps me to implement the Digital Technologies subject of the Australian curriculum	3.2	0.97
The priorities for my school or school district help me to implement the Digital Technologies subject of the Australian curriculum	3.0	1.22
My personal knowledge or skill helps me to implement the Digital Technologies subject of the Australian curriculum	4.0	0.96
My content knowledge helps me to implement the Digital Technologies subject of the Australian curriculum	3.9	0.96
My pedagogical knowledge or skill helps me to implement the Digital Technologies subject of the Australian curriculum	4.1	0.73
My students' prior knowledge or skills helps me to implement the Digital Technologies subject of the Australian curriculum	3.1	1.16
Access to technologies in my school helps me to implement the Digital Technologies subject of the Australian curriculum	3.6	1.17
Professional Development helps me to implement the Digital Technologies subject of the Australian curriculum	3.9	1.18
Curriculum support in my school helps me to implement the Digital Technologies subject of the Australian curriculum	3.1	1.27
Technical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum	3.2	1.31

Pedagogical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum	3.3	1.18
I believe that the Digital Technologies subject of the Australian curriculum is very important	4.4	0.97

The results of this study align with earlier research. In a recent synthesis of international studies, Spiteri and Rundgren (2018) also found that for primary teachers, their knowledge and skills, along with their attitudes and school culture, were the key factors affecting the use of digital technologies in classrooms. Correspondingly, Vivian and Falkner (2018) found that, although there is a focus on building teachers' knowledge and skills of content, there is also a need to build their teaching and assessment practices or pedagogical knowledge. They also found that professional learning should include opportunities for collaboration with colleagues.

6. Barriers to teachers' implementation of digital technologies

The barriers to effective and innovative use of technology in the classroom have been acknowledged over decades (Blundell, Lee & Nykvist, 2016; Ertmer, 1999; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; McLean, Dixon, & Verenikina, 2014; Author, 2015). Figure 8 summarises the teachers' perspectives about the barriers to implementing the Digital Technologies subject where they were asked to rate statements from strongly agree to disagree strongly. Table 4 provides the mean and standard deviation for each of the items.



Implementation barriers for the digital technologies curriculum
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
The cramped curriculum makes it difficult to implement the Digital Technologies subject of the Australian curriculum
45% 35% 7% 5% 8%
A lack of time makes it difficult to implement the Digital Technologies subject of the Australian curriculum
41% 33% 13% 6% 7%
Other priorities for my school/district makes it difficult to implement the Digital Technologies subject of the Australian curriculum
41% 36% 11% 7% 5%
My level of content knowledge or skill about the curriculum makes it difficult to implement the Digital Technologies subject of the…
11% 23% 22% 18% 27%
My level of pedagogical knowledge makes it difficult to implement the Digital Technologies subject of the Australian curriculum
5% 22% 18% 30% 25%
My level of knowledge or skill about the expected technologies makes it difficult to implement the Digital Technologies subject of the…
10% 24% 17% 23% 27%
Students lack of prior knowledge or skills makes it difficult to implement the Digital Technologies subject of the Australian curriculum
16% 28% 27% 16% 14%
Limited or no access to technologies makes it difficult to implement the Digital Technologies subject of the Australian curriculum
37% 23% 17% 16% 7%
Lack of relevant Professional Development makes it difficult to implement the Digital Technologies subject of the Australian curriculum
30% 40% 13% 10% 7%
Lack of curriculum support in my school makes it difficult to implement the Digital Technologies subject of the Australian curriculum
20% 36% 16% 20% 7%
Lack of technical support in my school makes it difficult to implement the Digital Technologies subject of the Australian curriculum
27% 27% 22% 19% 6%
Lack of pedagogical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum
18% 20% 29% 24% 8%
I don't think it is important to implement the Digital Technologies subject of the Australian curriculum
10% 19% 66%
Strongly Agree
Mildly agree
NEUTRAL (neither AGREE or DISAGREE)
Mildly disagree
Strongly disagree

Figure 8. Barriers to teachers' implementation of digital technologies

The pivotal work by Ertmer (1999) initially recognised these obstacles as first and second-order barriers. First-order barriers include technology access, along with training and support. Second-order barriers are more difficult to overcome as they are related to teachers' beliefs about and approaches to learning and teaching and their attitudes towards technology in their personal lives and in education. There was a high level of agreement (over 70%) by teachers in identifying the barriers to the effective implementation of digital technologies. The highest level of agreement was that the crowded curriculum (80% strongly or mildly agreed) was a limitation to digital technologies implementation.

In the open-ended comment section, one of the participants noted that the "cramped curriculum and lack of integration of subject areas" made it difficult to implement digital technologies. Other statements made by teachers about the curriculum suggested that the "content is very 'dry'"; "the curriculum does not realistically meet the needs of my students," and because the curriculum "is banded [and] without a strong understanding of the curriculum you don't know what to focus on at each year level". The move away from teaching an integrated curriculum may have exacerbated this issue. Indeed, one teacher commented there is "a strong argument for the development of integrated units". This idea was supported by other comments such as "the cramped curriculum and lack of integration" and a "lack of understanding of how to integrate across the curriculum to support learning in all curriculum areas" are significant barriers for effective implementation. When exploring curriculum integration between digital technologies and other content areas in diverse classrooms, Kohler and Mishra (2009) promote an approach where "integration efforts should be creatively designed or structured for particular subject matter ideas in specific classroom contexts" (p. 62). There is a recognition that primary teachers are concerned about the overcrowded curriculum they teach (Australian Government, Department of Education and Training, 2014) and the Australian government called for a review of the curriculum during 2020 and a decluttering of the curriculum (Karp, 2019).

There was also a high level of agreement among teachers (77%) about competing school or district priorities One teacher stated that "If administration does not prioritise implementation … then it's not going to happen". Another commented that "the leadership team at my school does not prioritise anything but English and Maths". One of the interviewees revealed that "the biggest priority was getting the literacy, number, and learning support to a good place" but digital technology is "[be]coming a priority, because our principal has said, we need to get our kids into the 21st century". The notion of competing demands has not previously been identified in the research as a barrier to digital technologies implementation. Perhaps this concern has been driven by the increased pressure on schools to enhance standardised testing performance at international and national levels. Further investigation of this topic from a national and international level would be useful.

Lack of time was indicated by the participants as another high-level barrier (74%). A teacher revealed that "the pressure of adopting it [digital technologies] too quickly, not giving staff enough time to play before implementing the curriculum and assessment" was a significant barrier. Others shared that "time is a huge barrier"; that "there is "not enough time in a day - there are far more important subjects to deliver", and that there is not enough "time to create meaningful and context-rich lessons". A further impost on time was alleged by one teacher who commented that "students don't have the prior knowledge required to teach the expected level". Similarly, another teacher noted that "the biggest issue is … prior knowledge". Teachers do not have time to teach the foundation knowledge that is missing in addition to the expected curriculum. Time has long been a barrier to digital technologies (Ertmer & Ottenbreit-Leftwich, 2013; Lawrence & Tar, 2018; McLean, Dixon, & Verenikina, 2014). According to Curran (2017):

> Schools need a strategy to give all relevant teachers the time, resources, and support to engage with the new subject in a meaningful way, so they can develop their confidence and skills in the concepts, technology and pedagogy necessary to fully realise the potential of Digital Technologies and ultimately thrive in a world where mobile devices have become ubiquitous.

Lack of relevant professional development was also identified by the participants (70%) as a reason why the digital technologies curriculum is not implemented effectively. In the interview, one participant commented that "teachers take no responsibility for learning or to upskill or take ownership" of their own development. This was supported by another participant who observed that "staff have been really reluctant to learn something new". Another participant attested that "the only PD I have had access to in the past 6 years is that which I have paid for and attended in my own holidays". In contrast, another participant commented that "there is more PD than ever before". One of the interview participants commented that because "teachers are time-poor, they don't really want to learn something brand new if it's not really important". Professional development was identified as a first-order barrier by Ertmer (1999), and other researchers in the intervening years have also determined that it is an ongoing issue (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; McLean, Dixon, & Verenikina, 2014). In agreement, James Curran (2017), who was involved in the writing of the Australian Curriculum: Technologies, stated: "teachers will need substantial support and professional development to teach it confidently and correctly".

Table 4
Summary of responses to Barriers for teachers' implementation of digital technologies

Barriers (N = 83)	**Mean**	**Standard Deviation**
The cramped curriculum makes it difficult to implement the Digital Technologies subject of the Australian curriculum	4.0	1.22
A lack of time makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.9	1.20
Other priorities for my school/district make it difficult to implement the Digital Technologies subject of the Australian curriculum	4.0	1.12
My level of content knowledge or skill about the curriculum makes it difficult to implement the Digital Technologies subject of the Australian curriculum	2.7	1.36
My level of pedagogical knowledge makes it difficult to implement the Digital Technologies subject of the Australian curriculum	2.5	1.22
My level of knowledge or skill about the expected technologies makes it difficult to implement the Digital Technologies subject of the Australian curriculum	2.7	1.35
Students lack of prior knowledge or skills makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.1	1.28
Limited or no access to technologies makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.7	1.32
Lack of relevant Professional Development makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.8	1.20
Lack of curriculum support in my school makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.4	1.23
Lack of technical support in my school makes it difficult to implement the Digital Technologies subject of the Australian curriculum	3.5	1.24
Lack of pedagogical support in my school helps me to implement the Digital Technologies subject of the Australian curriculum	3.2	1.22
I don’t think it is important to implement the Digital Technologies subject of the Australian curriculum	1.6	0.94

Strongly indicated in the interviews and the open-ended questions is that the digital divide has yet to be crossed in both homes and schools. Many teachers commented on the lack of access to working digital tools and limited or slow internet at their school. This is evidenced by comments like “one of my biggest limitations is actually access to technology”; and “I’ve managed to beg, borrow and steal as many digital resources as I can”. Another commented that they had five iPads at the start of the year and that “three of them no longer connect to the network. I have four computers, none of which work". In contrast, Ertmer et al. (2012) attested that access is no longer the barrier it used to be. Perhaps the shift over time is not about the initial purchase of computers and digital tools to provide access, but that insufficient funding is provided to replace and maintain aging or redundant technologies.

Despite curriculum and social expectations and explicit teacher standards related to teaching digital technologies, digital technologies teaching remains a wicked problem that is challenging for teachers to implement effectively (Mishra & Koehler, 2007). When looking at the well-documented barriers identified since Ertmer's (1999) work, there has been very little substantial change in the barriers over time. Both the closed and open-ended questions of this study provided evidence of multiple first and second-order barriers that are still experienced by teachers when trying to effectively implement digital technologies curriculum.

Additionally, some of the teachers' comments demonstrate that Ertmer's (1999) second-order barriers related to the teachers themselves interconnect with first-order barriers, making the barriers even more difficult to resolve. For example, if teachers prioritise one discipline above digital technologies, they will not have the time to teach the digital technologies curriculum effectively.

Implications and Recommendations

An overcrowded curriculum has led to the inconsistent implementation of the digital technologies curriculum. This inconsistency is exacerbated by competing demands, lack of time and limited access to professional learning. These barriers are interconnected. For example, the limited access to professional learning could be due to teachers trying to overcome the cramped curriculum and competing priorities of schools and systems due to standardised testing. Similarly, the barrier of time is related to teachers accessing professional learning, and their ability to teach year level expectations as well as foundation content within a crowded curriculum.

The overcrowded curriculum could be relieved by teaching the digital technologies curriculum, not as a stand-alone subject, but by integrating the digital technologies knowledge with other curriculum areas. This does require teachers to have broad and deep knowledge about their discipline content and how technology influences content development.

The issue is further complicated because it has been assumed that teachers have the content, pedagogical and technological knowledge and skill proficiency to teach the digital technologies content, yet few, if any, teacher education programs, even in the most recent years, could claim to provide a sufficient knowledge base for all Digital Technologies content descriptions from foundation to year 6 even though primary (elementary) school teachers are expected to be able to teach all of these. For experienced teachers, collaborative professional learning experiences should be provided to ensure sufficient confidence and proficiency, but they should be made available in ways that will ensure ongoing and just in time support and development.

Also, there is also an assumption that students have already learnt the relevant the foundation knowledge and skills in previous years so that the teachers are able to teach the expected stage content. As one of the participants claimed, “the Australian curriculum … assumes that kids have already got a pretty solid understanding of … [digital] skills … Unfortunately, this hadn’t been the case … I had to try and build up that prior knowledge as well as teach the … expectations at the year 5 level”. This again relates to time, as a crowded curriculum offers no time to teach digital technologies knowledge and skills for year levels below where the students are enrolled, while also meeting the expectations of the current year level curriculum.

Although the Australian Curriculum provides work samples, a lack of teachers’ knowledge, understanding and skills makes it difficult for them to use the samples in their classrooms effectively. As one teacher said, “the Australian Curriculum is future-proofed … but it’s really vague”. The digital technologies curriculum includes broad concepts rather than specific technologies or applications, allowing for a seamless evolution of the curriculum as digital technologies evolve. However, it requires teachers to have the knowledge necessary to interpret the broad statements and to translate them into specifics for their classes. That would be challenging for ill-prepared teachers. This could also be a problem because of the limited metalanguage some teachers and students have about the digital technologies curriculum. As one interviewee highlighted, it is “having that language … it is really a literacy about the technology”. Many teachers are fearful of terms like algorithms; as one of the interviewees observed, “when I say we're going to teach algorithms … their head explodes because of the new word”. The limited digital technologies content foundation skills of some students means that they cannot effectively complete the work sample activities for their year level.

An implication for those who develop the digital technologies’ curriculum is the necessity to audit the knowledge and proficiency of both students and teachers and to consider a staggered or staged implementation. Teachers need to change their behaviours and move to using technology for more high-level tasks with the levels of proficiency they have in the low-level tasks. To assist with ongoing teacher education, continued efforts are needed to ensure professional learning opportunities related to the digital technologies curriculum are provided just in time rather than just in case. Teachers should be able to access quality learning resources to assist with developing knowledge and skills for themselves and their students.

Limitations and future research

The small sample (N=83) did not permit statistical testing, and it might be helpful to rerun the survey to expand the numbers. The majority of the respondents came from one state in Australia, and the sample does not provide a national representation. Also, there were numerous incomplete surveys. Kaarakainen, Kivinen, and Vainio (2018) commented that most ICT skill assessment is based on self-reports where participants often overrate or underrate their proficiency. This means that the data could be impacted by the participants' self-assessments. However, the significant number of comments for the open-ended questions and the interviews helped to moderate the self-assessment results. In addition, social media was used as a distribution channel for spreading the invitation for the survey, so the participants who completed the online survey are likely to have an affinity with technology and this could bias the results.

Future research could compare novice and experienced teachers' confidence with digital technologies and their use for learning and teaching purposes. Future research should also investigate the impact of competing demands on implementing digital technologies, particularly in primary schools. Although considerable research has investigated the barriers to using and teaching digital technologies, little research has revealed those factors which empower teachers to teach with and about digital technologies. This could be a fruitful area of research for future research.

Conclusion

This study explored teachers' confidence with the digital technologies curriculum in Australia. The participating teachers did not have high levels of technical skills, deep knowledge about some of the key curriculum constructs or strong and transformative digital pedagogical approaches. Their understanding of TPACK remained at a low-level using technology for low-level tasks. It seemed that although teachers were confident with the technologies, they did use, they had low levels of proficiency and/or technology knowledge. The optimism for the benefits of using digital technologies in classrooms has not yet been borne out in practice.

While numerous teaching activities related to digital technologies exist, there are limited publicly available work samples that provide specific links to a country's curriculum. This research is distinctive because it maps teachers' confidence about curriculum expectations and student work samples. In answering the research question "How ready are Australian teachers to teach the digital technologies curriculum?", the findings demonstrate that although there are some levels of confidence for most teachers, they are not at a high level.

Effective teaching about and with digital technologies remains a wicked problem even after four decades when the earliest computers were provided in classrooms. There is no easy or single answer, making it difficult for schools and systems to create sustainable solutions. This is often due to incomplete or contradictory information being provided and the evolving requirements that are often difficult to recognise.

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