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Lessons in persistence: Investigating the challenges faced by preservice teachers in teaching coding and computational thinking in an unfamiliar context

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Lessons In Persistence: Investigating The Challenges Faced By Preservice Teachers In Teaching Coding And Computational Thinking In An Unfamiliar Context

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Abstract: An ongoing problem for teacher education institutions is bridging the gap between theory and practice and offering authentic experiences to challenge preservice teachers' pedagogical decision-making. Preservice practicums simulate teaching and can, at best, offer controlled experiences in familiar settings. This restricts the opportunities for preservice teachers to develop confidence in their own pedagogical decision-making and to adapt curriculum to meet unknown or unforeseen conditions. This paper describes, through a small-scale qualitative case study, a teaching experience in an unfamiliar setting, the persistent actions taken to respond to a specific context and the impact this had on preservice teacher knowledge and self-efficacy. The study found that preservice teacher self-efficacy can be scaffolded in real-world contexts provided sufficient planning, peer support and mentoring is available.

Introduction

The current regulatory climate in Australia makes it mandatory for teacher education institutions to ensure that preservice teachers are "classroom ready" and confident in integrating technologies in their classrooms and in teaching coding and computational skills (see ACARA, n.d.-a, n.d.-b, n.d.-c; AITSL, 2014, 2018; Australian Government, 2015). This imposes the need to provide "specialised instruction on how to teach core content with technology while simultaneously guiding students in learning about new forms of technology" (Mouza, Karchmer-Klein, Nandakumar, & Ozden, 2014, p. 206). We were keen, as teacher educators, to investigate whether and if/how the preservice teachers in our care could develop the requisite competence and confidence.

This paper describes the experiences of a group of Australian preservice teachers participating in an outreach project funded by the Australian Government's New Colombo Plan (Australian Government, 2017). It will discuss the pedagogical strategies they collaboratively adopted and iteratively adapted to respond to the challenge of teaching in an unfamiliar setting, namely, teaching coding and computational thinking in a rural primary school in Malaysia and how this impacted on their self-efficacy as teachers. It will attempt to add a contemporary set of factors, relating to technology use, to the challenges faced by beginning teachers which stand to impact on their self-efficacy as teachers.

In this paper, coding is understood to be a "cognitive activity that involves problem solving and mastering [computer] programming concepts and skills" (Bers, 2018, p. 3). Computational thinking has been defined as "solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer

science" (Wing, 2006, p. 33). With the release of the Australian Curriculum: Digital Technologies subject in 2016 (ACARA, n.d.-a), coding and computational thinking have to be explicitly taught in Australian schools from Foundation (Kindergarten) to Year 8 (see Lloyd & Chandra, 2020).

The preservice teachers in this study had completed a course entitled *Teaching Technologies* to prepare them to teach Digital Technologies. The co-ordinator of the course, the lead author of this paper, offered to supervise and mentor a small group in teaching the units they had developed for assessment in the course in an overseas school. The rationale for this caveat was connected to his ongoing work through the SEE Project in developing countries which supports education in rural and remote communities (see Chandra, 2019). His motivation for involving preservice teachers was to encourage a shift from vicarious to lived experience by enacting and adapting planned learning activities in unfamiliar settings. In so doing, the preservice teachers would hopefully come to new understandings of their own self-efficacy as teachers and gain confidence in their technological pedagogical content knowledge. This experience also provided an opportunity to reflect on how the course played out in the real world and enabled an informal review of its content and structure.

Literature Review

The study described in this paper was informed by multiple aspects of research: self-efficacy theory particularly relating to teachers; TPACK (technological, pedagogical and content knowledge); and, curriculum interpretation.

Teacher Self-Efficacy

Bandura (1994) explained that self-efficacy, synonymous with confidence and resilience, is a person's belief in their capability to "exercise influence over events that affect their lives" (p. 71). Self-efficacy determines individual and collective behaviours through cognitive, motivational, affective and selection processes. Sciuchetti and Yssel (2019), in a study of preservice teachers' self-efficacy in regard to behaviour management, added that it also affects "choice of activities, degree of effort expended, and duration of sustained effort when presented with stressful situations" (p. 20).

Teacher self-efficacy has been traditionally interpreted against specific problems, with a problem being "a difficulty … encounter[ed] in the performance of … [a teacher's] task, so that intended goals may be hindered" (Veenman, 1984, p. 143). Teachers question their self-efficacy in matters such as: classroom discipline, motivating students, dealing with individual differences, assessment, relationships with parents, organisation of class work, insufficient and/or inadequate teaching materials, and dealing with problems of individual students (Veenman, 1984). It has been shown that "higher self-efficacy beliefs … function as a positive support for action, whereas lower self-efficacy beliefs can have hindering effects on the decision to proceed with a particular course of action" (Abbitt, 2011, p. 136).

Self-efficacy is not an innate characteristic but is rather "a dynamic acquired system of beliefs possessed by the individual, that stems from experimentation in a unique and specific context" (Wagner & Imanuel-Noy, 2014, p. 35). It is "most malleable" during initial teacher education and experiences the "most dramatic changes" during practicums when "theoretical coursework [is integrated] into 'real' teaching" (Ma & Cavanagh, 2018, p. 134). Increasing self-efficacy is determined by "the quality of teaching practice rather than simply the existence of teaching practice" and enhanced by opportunities to "participate in the design

of professional experience activities, receiving constructive feedback, and modelling the instructors' teaching" (p. 137).

TPACK

The Technological Pedagogical and Content Knowledge (TPACK) Framework (Mishra & Koehler, 2006) is used for research and to inform practice (Harris, Phillips, Koehler & Rosenberg, 2017) (see Figure 1). TPACK was also a framework that the preservice teachers explored to design activities. Its use in preservice education is widely acknowledged with Abbitt (2011) concluding that it "provides a valuable structure for teacher preparation and the ways that technology creates new dynamics in the teaching and learning process" (p. 141).
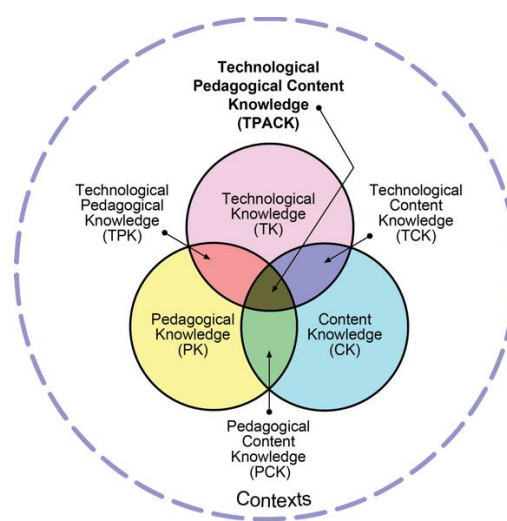
Figure 1: Technological, pedagogical and content knowledge (TPACK). Reproduced by permission of the publisher, © 2012 by tpack.org (Source: http://tpack.org)

TPACK builds on Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) which is the overlap between pedagogical knowledge (PK) and content knowledge (CK) and understood to be what teachers need to deliver meaningful classroom activities (Koehler & Mishra, 2009). Narayan, Birdsall and Lee (2019) offered a new research-informed model of PCK based in kitchen-garden programmes in New Zealand schools. It defined PCK as embodying how teachers "understand, interpret and make sense of their subject to facilitate learning; it provides insight into the contextually specific knowledge that is part of teaching/learning, along with the understandings and considerations that influence their teaching and planning" (p. 3).

Technological knowledge (TK) is knowing about technologies and their purposes (Koehler & Mishra, 2009). Technological Content Knowledge (TCK) is an overlap between TK and CK. To demonstrate TCK, Koehler and Mishra (2009) proposed that "teachers need to master more than the subject matter they teach; they must also have a deep understanding of the manner in which the subject matter … can be changed by the application of particular technologies" (p. 16). According to Koehler and Mishra (2009), Technological Pedagogical Knowledge (TPK) is an overlap between TK and PK, which teachers need to understand how "teaching and learning can change when particular technologies are used in particular ways" (p. 16). Abbitt (2011), inadvertently describing TPACK, explained that:

> *Teacher preparation efforts that focus solely on developing knowledge, however, also face the challenge of addressing the complete picture of how preservice teachers become practising teachers who use technology in creative and effective practice. (pp. 134-135)*

Porras-Hernández and Salinas-Amescua (2013) broadened the TPACK framework to include a consideration of the context in which learning occurs. They argued that context (learning environment) should be considered across two dimensions: scope and actor. Scope has three levels: (a) the macro-level which entails social, political, technological, and economic conditions; (b) the meso-level which is influenced by school leadership and community, and (c) the micro-level which involves the day to day variables such as resources, norms, and practices. Porras-Hernández and Salinas-Amescua (2013) believed that teachers, as actors, bring "unique characteristics that influence the interactions and the learning process" (p. 231).

TPACK and Self-Efficacy

Abbitt (2011) conducted an exploratory study into the relationship between self-efficacy beliefs and TPACK among US preservice teachers. He noted that positive experiences, termed as "enactive mastery experiences," led to increased self-efficacy "provided that … [they] are in an authentic environment and the task requires overcoming obstacles through perseverant effort" (p. 136). He noted differences in the relationship between self-efficacy and separate TPACK domains. There was no significant relationship between self-efficacy and CK in Mathematics, Science, Social Studies and Literacy and only a weak relationship with PK and PCK. Stronger relationships were noted with the TPACK domains relating to technology, namely, TPK and TCK. With regard to the context of this study, Leonard et al. (2018), in a study of preparation for teaching computer science in a rural US school, argued that "simply acquiring knowledge, skills, and competence in subject matter does not ensure the implementation of equitable and best practices, particularly in STEM education" (p. 387). It could be contended that TPACK is enacted through the parallel development of self-efficacy.

Curriculum Interpretation

"Curriculum interpretation" is an umbrella term for how intended curriculum is enacted and is a critical understanding in how preservice teachers take their learnt knowledge into their classrooms. Ben-Peretz (1990) suggested that there were two levels of curriculum interpretation. The first is how a curriculum developer translates the subject matter of a learning area into an intended or written curriculum. Remillard and Heck (2014), in a study which investigated the factors that influenced curriculum policy, design, and classroom enactment, referred to this level of interpretation as the "official curriculum."

The second level defined by Ben-Peretz (1990) is where a teacher operationalises the intended curriculum. Remillard and Heck (2014) described this level as a "teacher-intended" interpretation of the official curriculum. They suggested that there was an additional enacted level which encompasses the planned and unplanned activities that happen during curriculum enactment.

In a recent doctoral study, Ross (2017) investigated teachers' experience of the Australian Curriculum: Mathematics learning area from "intended to planned" and from the

"planned to enacted" curriculum. Similar to Remillard and Heck (2014), she identified three levels of curriculum interpretation which, using the metaphor of travel, may be defined as:

- *Intended Curriculum (The map)*
  Curriculum policy documents set the direction for a defined population of schools in a particular learning area, discipline or subject. Constructed by curriculum authorities.
- *Planned Curriculum (The charted course)*
  An interpretation of the intended curriculum presented in the form of documents to organise a prepared way through the curriculum policy document. Constructed by teachers and/or Head of Department/Curriculum in accordance with schooling sector/ employer policy as well as other purposefully designed resources and/or professional development.
- *Enacted Curriculum (The journey)*
  The total classroom experience, comprising all planned and unplanned activities and interactions that take place as part of learning. Constructed by teachers and students as together they bring the curriculum "to life."

Figure 2 shows the journey Ross (2017) identified in her thesis and used as the basis for individual mappings for each of the participating teachers. This progression informs the analysis of data in this study (see also Figures 6 and 8). Her research showed that the enactment of the curriclum was influenced by a number of factors that included the process of curriculum interpretation, content/pitch of the curriculum, textbooks or other resources, and digital technology. Teachers embedded some common and some unique approaches to deal with the factors (Ross, 2017).

Intended Curriculum (The map)	Planned Curriculum (The charted course)	Enacted Curriculum (The journey)
Curriculum policy documents which set the direction for a defined population of schools in a particular learning area, discipline or subject.	An interpretation of the intended curriculum presented in the form of documents to organize a prepared way through the curriculum policy document.	The total classroom experience, comprising all the planned and unplanned activities and interactions that take place as part of learning.
Constructed by curriculum authorities.	Constructed by teachers and/or head of department/ curriculum in accordance with schooling sector/ employer policy as well as other purposefully designed resources and/or professional development.	Constructed by teachers and students as together they bring the curriculum "to life".

Figure 2: A model of curriculum interpretation: the intended (the map), planned (the charted course) and enacted (the journey) curriculum. (Adapted from Ross, 2017, p. 87)

With the advent of the Australian Curriculum (as an "official" or "intended" curriculum) and, in some instances, additional state and territory variations, Australian teachers are currently facing what has been called "highly detailed and more prescriptive" curriculum documents and a "narrowing" of curriculum delivery options because of "high-stakes testing and teacher accountability" (Moss, Godinho & Chao, 2019, p. 25). This increases the complexity for preservice and practising teachers to interpret curriculum to match the needs of their students.

While there are some studies on pre-service teachers teaching in unfamiliar settings in developing countries (e.g., Chandra, 2019; Chandra & Tangen, 2018), our brief review has shown that there is no research that specifically focusses on similar cohorts' enactment of curriculum relating to coding and computational thinking. The strategies applied to enact the curriculum are also subject dependent. This led us to propose the first and second research questions. Our study, informed by the literature presented in this section, was guided by three research questions:

- What factors influenced the enactment of the planned curriculum? [RQ1]
- What strategies were applied to deal with the influencing factors? {RQ2}
- How did the experience impact on the participants' teacher self-efficacy? {RQ3}

Research Design

The qualitative case study described in this paper may be said to be an intrinsic case study where small groups of subjects are studied to examine a certain pattern of behaviour (Mills, Durepos, & Wiebe, 2010). The data for this study was derived primarily from the participants' frames of reference rather than that of the researcher as an "objective observer of the action" (Ponelis, 2015, p. 538). The research is influenced by an interpretive paradigm because its foundations are anchored in real-world ontology with the preservice teachers developing the researcher's knowledge of reality. While this approach served to provide us with a more thorough understanding of the challenges faced by our preservice teachers in an unfamiliar setting, it also limited the generalisability of our findings. This section details the research setting, the participants and the collection and analysis of data.

Research Setting

The school in Malaysia was in a rural area and all children at the school were of Orang Asli origin. An academic from a collaborating Malaysian university selected the school and liaised with the principal, teachers, and school community who agreed with the objectives of the project and the intended content. There were sufficient parallels between the Malaysian and Australian Curriculums to assure the appropriateness of teaching coding and computational thinking to students in a Malaysian school (Chin, 2019). In addition to coding and computational thinking, the preservice teachers were asked to include strategies to enhance students' English language skills. Given the small size of the school, it was agreed that activities would be delivered in three composite groups as follows: Years K–2, Years 3–4, and Years 5–6 (see Table 1).

A further component of the research setting are the technologies selected for use in the school. Those chosen fitted well with the recommendation to use unplugged activities and codable robots with younger children and block-based coding activities for older primary and junior secondary students (Hunsaker, 2018). These were:

- *Bee-Bots*® were selected for use with the K-2 group (see Figure 3). A Bee-Bot is a programmable floor robot designed for use by younger children. It is particularly useful for developing algorithms, a series of simple logical steps, to direct the robot's movements (see ESA, n.d.-a). Sullivan, Kazakoff and Bers (2013) explained that:
  Children who work with robotics are not sitting in front of a computer but are engaged in developing fine motor skills while manipulating the robotic objects. They can move around the room, work on the floor or table, and act out, with their own bodies, the programming sequences the robots will follow. (p. 205)


Figure 3: Bee-Bot

- ***Edison*®** robots were selected for use with the Year 3-4 group (see Figure 4). It is, similarly, a programmable floor robot but one which uses more formal programming commands than the Bee-Bot.

Figure 4: Edison robot

Bulgarelli, Bianquin, Besio and Molina (2018) explained that the:
Edison looks like a small orange parallelepiped with two wheels. Its sensors make it possible for it to react to sounds, light, proximity, and to follow lines. This toy also has several actuators (lights, speaker, and motors) and is programmable either via a programming language, or by reacting to a bar code that activates one out of the six pre-loaded different games. (p. 4)

- ***Scratch*®**, a free open-source visual or block-based programming language developed at MIT, was selected for use with the Year 5-6 group (see Figure 5). Sáez-López, Román-González, and Vázquez-Cano (2016) explained that Scratch:
… allows students to create and develop programs related to animations, games, interfaces, and presentations that can expand understanding of computational concepts and computational practices. … [It] enables an intuitive drag and drop method of programming which allows users to explore and create in educational settings at several levels in primary school. (p. 130)
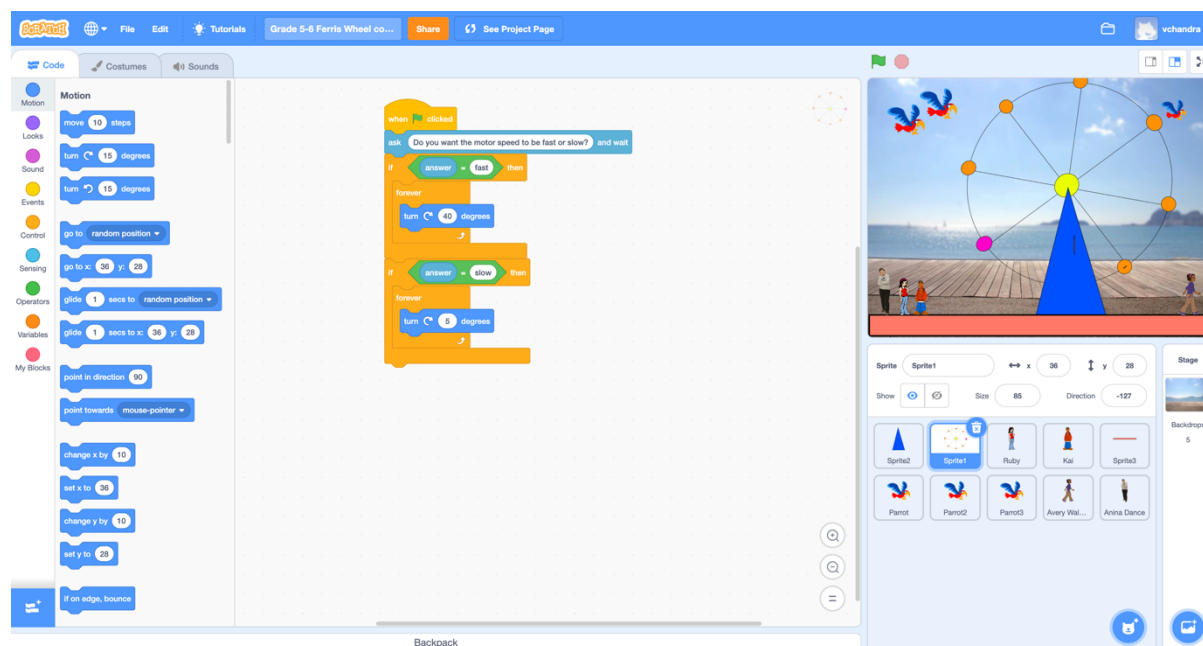
Figure 5: Scratch program (screen shot)

At its simplest, a Scratch program is made up of "scripts" and "sprites." The script is the code made up of blocks with pre-loaded colour-coded commands. The sprites are images which can be used within programs, particularly animations. The commands enable the sprites to move, change size and shape, make sounds or be controlled by a game player.

Participants

The participants were six Australian university students. Five were preservice teachers enrolled in an undergraduate initial teaching degree: one male (David), four females (Kim, Beth, Grace, and Cathy). The sixth was a final year student (Ned) from a Science Faculty (majoring in software systems) who filled in for a preservice teacher unable to accompany the group. Ned was known to the researcher as he had participated in a previous project in Malaysia and had experience with teaching coding in different settings. All names are pseudonyms.

Table 1 summarises the working pairs formed by the participants and the details (age group, selected technology) of the Digital Technologies unit they developed.

Target classes	Participant Pairs (pseudonym)	Technology
Years K-2	Kim and Beth	Bee-Bots
Years 3-4	Grace and Cathy	Edison Robots
Years 5-6	David and Ned	Scratch

Table 1: Participant and activity details (by year level)

The lead author of this paper was a part of the participants' "lived experiences" as they engaged with the course content on campus and was responsible for coordinating the teaching activities at the Malaysian school. His role also included the selection of Australian preservice teachers. At the start of the academic year, all preservice teachers in the cohort were invited to submit an Expression of Interest (EOI) to participate in the project over ten

days during the mid-semester break. Six responses were received, all of whom were accepted.

In Malaysia, the participants were matched with local university students, all of whom were from faculties other than Education, making operational teams which were not only international but also transdisciplinary. The Australian participants led the delivery of their unit plans and gave instructions to the local team members who acted as teacher aides and translators. The Malaysian team members also provided their Australian counterparts with commentaries of the local culture and traditions. They also assisted in a showcase event (on the last day of school) for the local member of parliament, the parents/community, and teachers from other schools in the district. The involvement of the Malaysian team members created an additional leadership responsibility for the participants.

Data Collection and Analysis

Upon their return to Australia, the preservice teachers had to engage immediately in mandatory practicum. Hence, semi-structured interviews could not be conducted until five weeks after their return. The participants were encouraged to draw upon their classroom notes from Malaysia during the interview to facilitate recall. These interviews, along with the researcher's field notes and participants' unit plans, comprised the data set for the study. Textual data were read a number of times and coded.

The overarching aim of the study was to investigate how units designed by the preservice teachers were implemented in practice. Figure 6 shows the curriculum interpretation model for this study (see Figure 9 for the negotiated model).
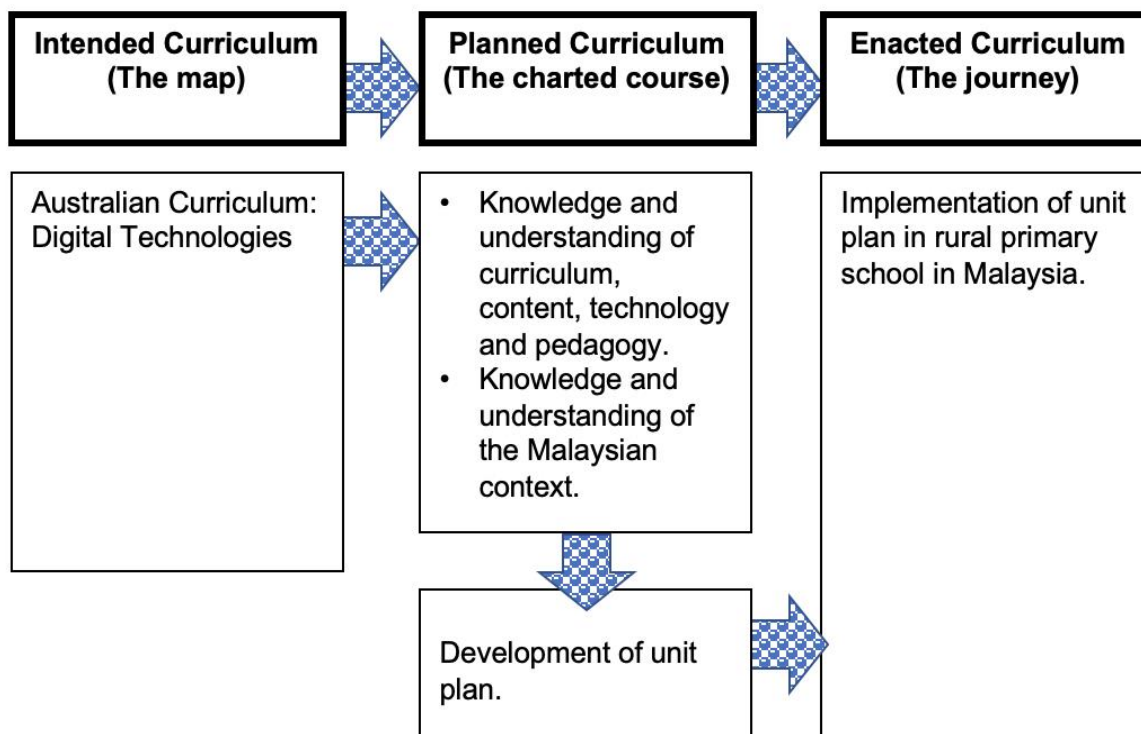
Figure 6: Proposed curriculum interpretation in this study. Adapted from Ross (2017).

The study identified the factors that impacted on the preservice teachers in the process of curriculum interpretation from "intended to planned" and from "planned to enacted"

curriculum (Research Questions 1 and 2). The findings relating to Research Question 1, namely, the factors influencing the enactment of the planned curriculum, were drawn from a deductive thematic analysis of interview data. The themes were predetermined dimensions relating to TPACK, namely, scope and actor (Porras-Hernández & Salinas-Amescua, 2013). The findings relating to Research Question 2, that is, the strategies applied to deal with the influencing factors, drew on summative content analysis of the interview data (Hsieh & Shannon, 2015). The strategies were interpreted in terms of a five-step pedagogical model (see Figure 6).

The corollary aim, namely, to note the impact of the context on preservice teachers' self-efficacy was addressed through Research Question 3. The themes relating to the cognitive, motivational, affective and selection processes associated with self-efficacy were illustrated by using both the semantic (surface) and latent (underlying ideas, assumptions and conceptualisations) levels described by Braun and Clarke (2006).

Figure 7 presents a visual summary of the qualitative analyses undertaken in regard to each research question. Each component is presented in greater detail in the following section.
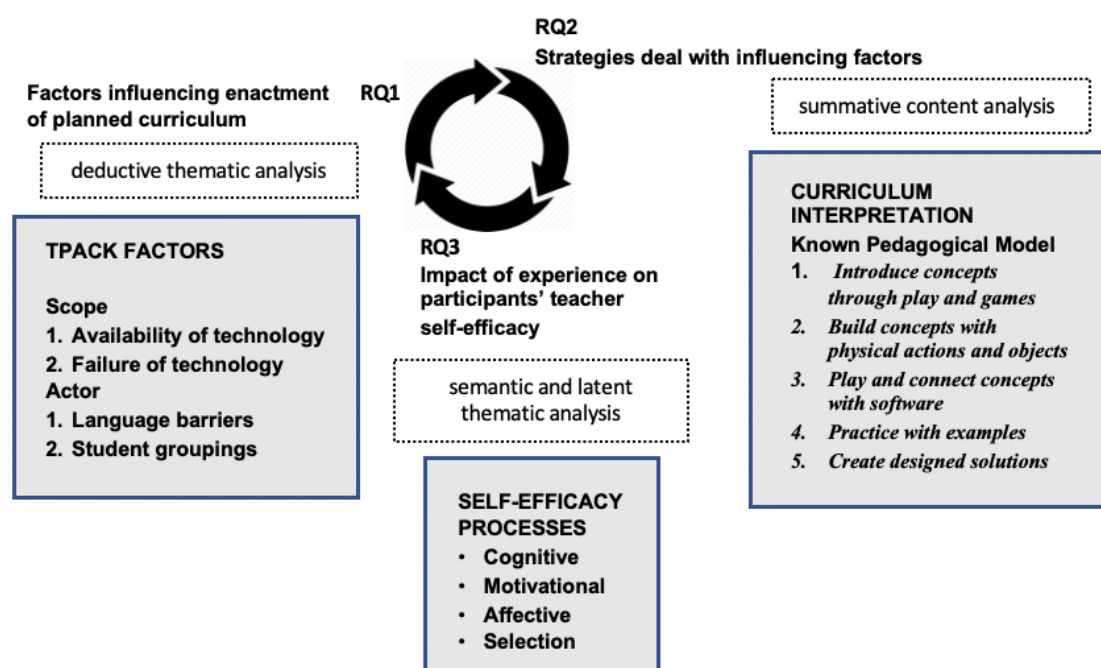

Figure 7: Research questions and guide to analysis frameworks.

Results
Research Question 1: What Factors Influenced the Enactment of the Planned Curriculum?

Despite variations between the planned and the enacted curriculum, all teams taught aspects of the intended content (i.e., language concepts and coding through the application of computational thinking skills). Some activities had to be either trimmed or modified because of contextual factors beyond the teams' control. David summarised the modification process as follows:

Initially we thought we would go through all these concepts within five lessons —
bang, bang, bang, bang, bang — yet the reality was that it took at least two

> *sessions to cover one concept…. The way we structured our plan made it difficult to skip any step because the steps relied on the students having some understanding of the concepts presented earlier… we were only really able to cover the first two concepts well.*

According to Kincheloe (2008), "each teaching and learning context has its unique dimensions that must be dealt with individually. … educational purpose is … shaped by the complexity of these contextual appreciations" (p. 32). As previously noted, the context within the TPACK framework can be considered across two dimensions: scope and actor (Porras-Hernández & Salinas-Amescua, 2013). In this study, the availability and failure of technology were factors within the scope dimension while the factors within the actor dimension were language barriers and student groupings. These dimensions were adopted as predetermined themes in our deductive thematic analysis of interview data.

Scope Factor (1): Availability of Technology

The school had a relatively modern air-conditioned computer lab with more than 30 desktop computers and the planning of the units was contingent on the availability of this resource. However, upon arrival, the team learned that the computers were not working because the central server to which they were connected had been out of action for a few months. Despite the school making requests to the company that installed the technology, the issue was not rectified. Internet connectivity was also an issue. The lack of access had a significant impact on how the activities for Years 3-4 and 5-6 could be implemented. Fortunately, ten second-hand laptops were brought to the school to be donated, that is, to remain behind to encourage ongoing engagement with the demonstrated activities.

According to David, the planned curriculum entailed use of the online version of Scratch affected by a poor Internet connection. They had also planned to adopt a paired programming approach with a minimum of one computer for two students, an approach found to be effective in teaching programming (see Werner, Denner, & Campe, 2014). The availability issue, however, left them with only five of the available laptops and this was "just not feasible" (David) for delivering the curriculum as planned. The creation of games using Scratch requires students to have greater access to computers because of the need to iteratively execute and debug their codes. As an alternative, the Year 5-6 students were taught to use Scratch to create "animations for entertainment purposes" and "interactive slideshows of the school," which demonstrated their coding and computational thinking skills at a lower degree of complexity.

Scope Factor (2): Failure of Technology

The six Edison robots, taken to Malaysia for use with the Year 3-4 students, failed to read the pre-programmed bar codes so that all planned activities could not be completed. For Grace, repeated troubleshooting "became a lesson in persistence … because all technologies can present failure and challenges from time to time" and "we do not just give up." However, given time constraints, Grace and Cathy decided to change their activity to a PowerPoint presentation as the means for teaching sequence. Cathy explained that "they [the students] had a bunch of photos they could choose from" and "they used them to ... say what they had done during the week." Given that there were only five laptops for use with the Year 3-4 students, there were between 6 to 7 students per group rotating between planning and building activities.

Actor Factor (1): Language Barriers

The participants knew that the Malaysian students would not be confident with communicating in English but that their counterparts from the Malaysian university would act as translators. While appreciative of this assistance, David acknowledged the continuing complexity of communicating and coordinating with the Malaysian team members. He offered that "they were amazing, but we still needed to instruct them on the plan, then teach the students and run around checking everything."

Grace's strategy was different. Rather than "instructing," she aimed to involve the Malaysian team members from the beginning. She spent the first day getting to know them and convincing them that they were "a part of it." To overcome the language barrier, she used play as a way of interacting with her Year 3-4 students. According to Grace, this initiative developed a "nice little bond after that first day," and engendered mutual trust between all parties in her classroom. Kim explained that, because of the simplicity of the planned activity for Years K-2, she found "other ways of communicating other than language" using visual and kinaesthetic strategies, including a "human Bee-Bot activity" where students' movements were programmed through simple commands.

Actor Factor (2): Student Groupings

As noted, the students were placed in composite groups (Table 1) which caused unintended problems. For example, David noted that there were age gaps of up to "two years" in his Year 5-6 group. While he "found it personally interesting" to see how age affected how students were able to "pick up and run with the concepts," he would have liked to have more information about the students, particularly their prior learning. This was exacerbated by language difficulties (Actor factor 1) which limited his facilitating differentiated learning. Kim also noted that the age range of students in her K-2 group was an issue. She explained that, while some of the "Year 2s got to the coding bit," the younger children in the group still felt challenged.

**Research Question 2: What Strategies Were Applied to Deal with the Influencing Factors?**

All participants were challenged in/by the unfamiliar classroom environment and the scope/actor factors described in response to Research Question 1. The scope factors tested the participants' technological knowledge. The plans for both the Year 3-4 and 5-6 groups had to be altered. The actor factors tested their pedagogical knowledge. To investigate this further, we conducted a summative content analysis of the interview data.

The participants' frames of reference were only what they had seen and experienced in Australian primary schools. According to David, despite the context, "the content remained the same." He explained that the challenges meant they had to find pedagogies that enabled the building of "a shared experience" not dependent on "our cultural backpack for communicating." The intercultural aspects of this experience were beyond the scope of this study, but David's explicit reference to a "cultural backpack" is of interest as is Kim's realisation that "when I came back in to the Australian context, I [was aware that I] was in a very white middle class school." The outreach project had given new awareness to each of these preservice teachers.

The teams got together at the end of each day which David said allowed them "to think about how we are going to make it more interesting." He added, with an implicit reference to TPACK, that "we were always thinking … what's the best pedagogical way to

explain this concept and how does our technology fit in with that. How do we best teach the technology and … teach with the technology with the students?"

The interview data and field notes suggested that the preservice teachers followed a series of steps to develop students' conceptual understanding of coding and computational thinking in this context (Figure 8). These steps had been progressively revealed during the Teaching Technologies course and there was evidence that the teams followed the steps during their placement in the Malaysian school.
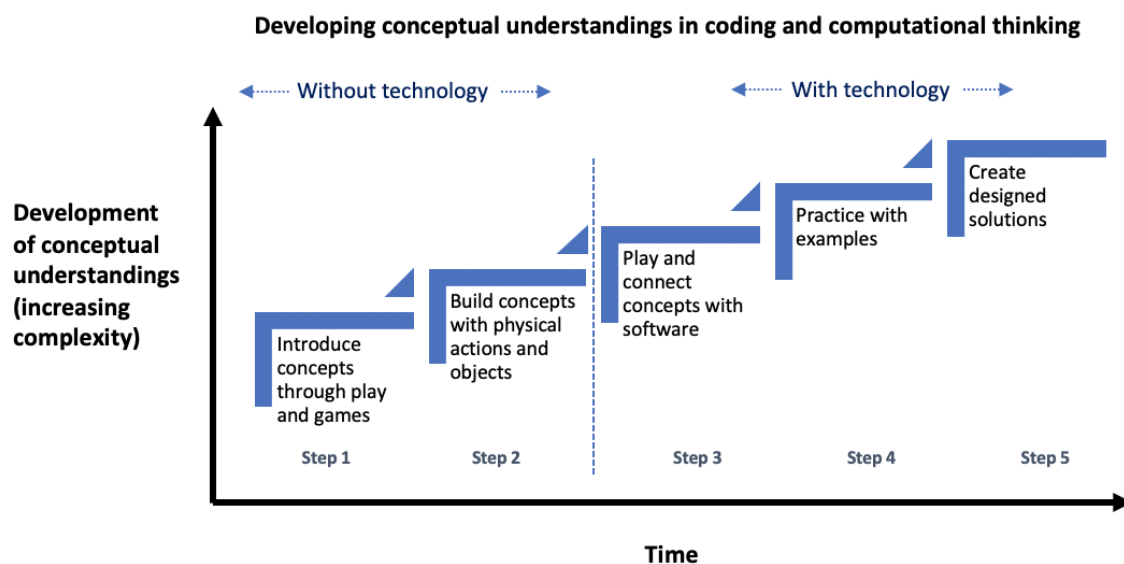
Figure 8: Five-Step Process for Developing Conceptual Understandings.

The first two steps are "unplugged," that is, they make no use of technology. The Digital Technologies Hub explains these steps as "guided play, including hands-on, kinaesthetic and interactive learning experiences" useful in developing an understanding of sequence and procedure (ESA, n-d.b, para. 1). The final three steps consolidate the development of conceptual understandings through engagement with software and hardware to create digital solutions. The following describes selected enacted strategies in terms of these steps.

Step 1: Introduce Concepts Through Play and Games

This step did not use technology and focussed on games and play. For Kim, who was studying to become an early childhood teacher, this fitted well with her belief in play pedagogy and in allowing K-2 students to explore "on their own" and develop knowledge with minimal restrictions. Grace and Cathy found that the game "Simon Says" was very effective in not only overcoming cultural and communication barriers but also in introducing the concept of sequencing which is critical in coding and computational thinking. The Year 3-4 children they were teaching were introduced to simple directional commands such as forwards and backwards. Importantly, no command was to be executed unless the phrase "Simon says" was heard thus mimicking how computers only execute the precise instructions they are given.

Step 2: Build Concepts with Physical Actions and Objects

David and Ned gave their Year 5-6 students command cards with simple instructions in both Malay and English, e.g., move forward one step – turn left – jump. David believed that this worked well because the cards were "physical" and gave students an opportunity to practise coding skills "before they got on the computer." The students "programmed" their teacher and peers to perform actions, similar to how sprites (images) are programmed in Scratch, except, in this instance, an actor is engaged in real action. In an activity called "Program your Teacher," the students used the commands on the cards to create a sequence to allow their teachers navigate an obstacle course. The students found this challenging as they were not used to giving commands to their teachers. The next activity was "Program your Friend." Ned explained that, at first, the students made "really simple errors like instead of walking three steps forward and turning right to navigate around a table," they would "walk ten steps and then turn right and finish off at a different point than anticipated."

Thus, students were learning to program in Scratch and the underlying structure of basic codes (sequencing, repetition, if/then statements, debugging) without relying on computers, that is, through an unplugged activity. According to Ned, this approach encouraged the students to think and act like sprites. Consequently, they "move[d] around … [with] a better idea of what was happening, … [making] it more real for them."

Step 3: Play and Connect Concepts with Software

In the third step, Kim and Beth asked their Year K-2 students to "essentially do what they had been doing in [the Step 1 and 2] games" but with the Bee-Bots. Thus, if in the game, the command was "Simon says move two steps and stop" then the programming command would be "move the Bee Bots two steps and stop."

Adopting a didactic approach, David and Ned guided the Year 5-6 students step-by-step. Students were shown how to identify relevant coding blocks, how to drag the blocks to the scripts area and click on them to see how it impacted on the sprite. They picked simple coding examples that involved "navigating sprites around obstacles" and in the process, drew meaningful "connections with the games they played earlier" [in Steps 1 and 2]. The students could see that the Scratch cards they had used to program the teachers or peers were now being used as programming blocks to program the sprites. Once this was grasped, David said that the students were shown "other more powerful things you could do in the game, like bouncing off walls, moving a sprite based on arrow keys, changing colours of the sprite." Ned noted that by setting tasks for the Year 5-6 students that were contextually appropriate, "children can learn challenging concepts without realising it."

Step 4: Practice with Examples

Ned expressed his belief that, to build students' knowledge, "you have to get them comfortable building a few little projects, giving them some time to modify each project at the end, as opposed to just quickly moving onto the next thing." Tweaking a sample program gives students a chance to develop new knowledge. For example, changing a command from "Turn [clockwise] 15 degrees" to "Turn [clockwise] 30 degrees" or "Turn [clockwise] -15 degrees" creates a new understanding of how the coding blocks and the sprites worked together.

Step 5: Create Designed Solutions

Kim and Beth had taken a map of Australia to challenge their K-2 students to program the Bee-Bots to travel between landmarks. However, they soon realized that while this map was useful for demonstrations, engaging more than 30 students with one map was problematic. Realising this, they transformed the classroom floor and asked students to focus on the Malaysian context developing their own maps using four or five different locations known to them. Their aim was to get the Bee-Bot from one familiar location to another. Kim explained, that while she and Beth scaffolded the activity, they did not "give too much direction. We let them do what they wanted. … we were proud of their maps in the end." The landmarks the students chose ranged from homes in the vicinity to the Petronas Towers in Kuala Lumpur. By this step, the K-2 students had become relatively independent and, as a consequence, the level of scaffolding diminished.

Research Question 3: How did the Experience Impact on the Participants' Teacher Self-Efficacy?

The participants were asked directly, in interview, how the experience had impacted on them and their perception of their capacity to teach coding and computational thinking. The responses align with the Wagner and Imanuel-Noy's (2014) definition of self-efficacy as a "dynamic acquired system of beliefs" which is shaped by "experimentation in a unique and specific context" (p. 35) For example, Kim emphatically stated that:

To believe in myself. I think, that I can be a teacher. I used to say … that I was pretending to be a teacher when I went on prac, … this was the first time that I was like okay, I can do this, I'm a teacher. Really to believe in myself, and … that I can control the classroom. I can teach them something. That was real. … I've never felt so confident as a teacher.

Grace similarly spoke of the individual confidence she developed, adding that "what I want to do is I want to teach remote and I want to teach in Asia and do a bit of travelling … [it] gave me a lot of confidence to be able to teach at a school that's got a different language." She explained that the unfamiliarity of the context had them "flying by the seat of our pants" on the first day, but that they adjusted to the constraining factors (addressed in response to Research Question 1) and worked to build a bond of trust with the students and school community. Grace also implied the development of collective efficacy by saying that "everyone felt like they could really make a difference. … everyone felt a part of the team."

It was previously noted that self-efficacy determines an individual's behaviour through cognitive, motivational, affective and selection processes. The self-efficacy of the preservice teachers in this study, that is, belief and confidence in their capacity to teach coding and computational thinking in an unfamiliar setting, was evident through the following complex processes and demonstration of increasing levels of TPACK. We used the previously introduced processes of self-efficacy described by Bandura (1994) as our framework for analysis, namely, cognitive, motivational, affective and selection.

Cognitive Processes

The participants in this study showed confidence in their cognitive processes through their deliberate redesign of classroom activities and adaptation of their unit plans. This typically drew on their TPK and PCK. This was demonstrated through David's observation that "we were able to teach the content … had to change a bit just to suit the context." It was particularly evident in how Grace and Cathy responded pro-actively to the failure of the Edison robots. The conscious and deliberate cognition required by this experience was implicit in Kim's observation that "because the context was so different, it … changed the whole thing, your pedagogies."

Motivational Processes

Motivation was evident through the persistence shown by preservice teachers in the study to deliver their planned curriculum despite significant problems, namely, failure of technology and language barriers. As noted, Cathy (Years 3-4), demonstrated her resolve by offering that "because all technologies can present failure and challenges from time to time" and "we do not just give up." Kim similarly explained that "every night we had to think about how we were going to make it [the unit plan] more interesting." The noted "degree of effort expended … and duration of sustained effort" (Sciuchetti & Yssel, 2019, p. 20) are in themselves indicative of burgeoning self-efficacy.

Affective Processes

An affective dimension of self-efficacy was evident in how the preservice teachers interacted and collaborated with their Malaysian counterparts. They respected the role they played as translators and as liaison with the local community. They treated them with respect and involved them in professional and personally affirming ways. Kim explained that "we made sure we asked the … [Malaysian preservice teachers], and they gave us some good ideas, which we applied, which was great." Similarly, Grace recalled that she "felt very responsible for making sure that they … knew what we were doing, and they felt like a part of it all."

Selection Processes

The preservice teachers showed self-efficacy in terms of selection processes in how they differentiated learning for the students in their groups as noted in their addressing age differences in the multi-age groups they were teaching. Further, the selection dimension was evident in how they responded to and worked to overcome language barriers. Grace and Kim (Years 1-3) used play and gesture as a strategy to communicate with their young students. Most critically, selection was key in deciding to change their planned curriculum and to negotiate a new direction while maintaining fidelity with the intended curriculum. Grace reflected that "it became a lesson in persistence … but … to do that lesson in persistence one more day just wasn't going to work." These selection processes, corroborated by the first author's field notes, drew on all aspects of TPACK as both technological, pedagogical and content factors needed to be addressed.

Discussion

The findings from Ross's (2017) study revealed a complexity in curriculum interpretation with no two of her participants having the same "journey" despite beginning with the same "plan" or official curriculum. The simple progression from intended to enacted curriculum offered as Figure 6 was progressively and continuously altered as the study continued. Figure 9 presents a graphic representation of the curriculum interpretation model of the outreach teaching experience.
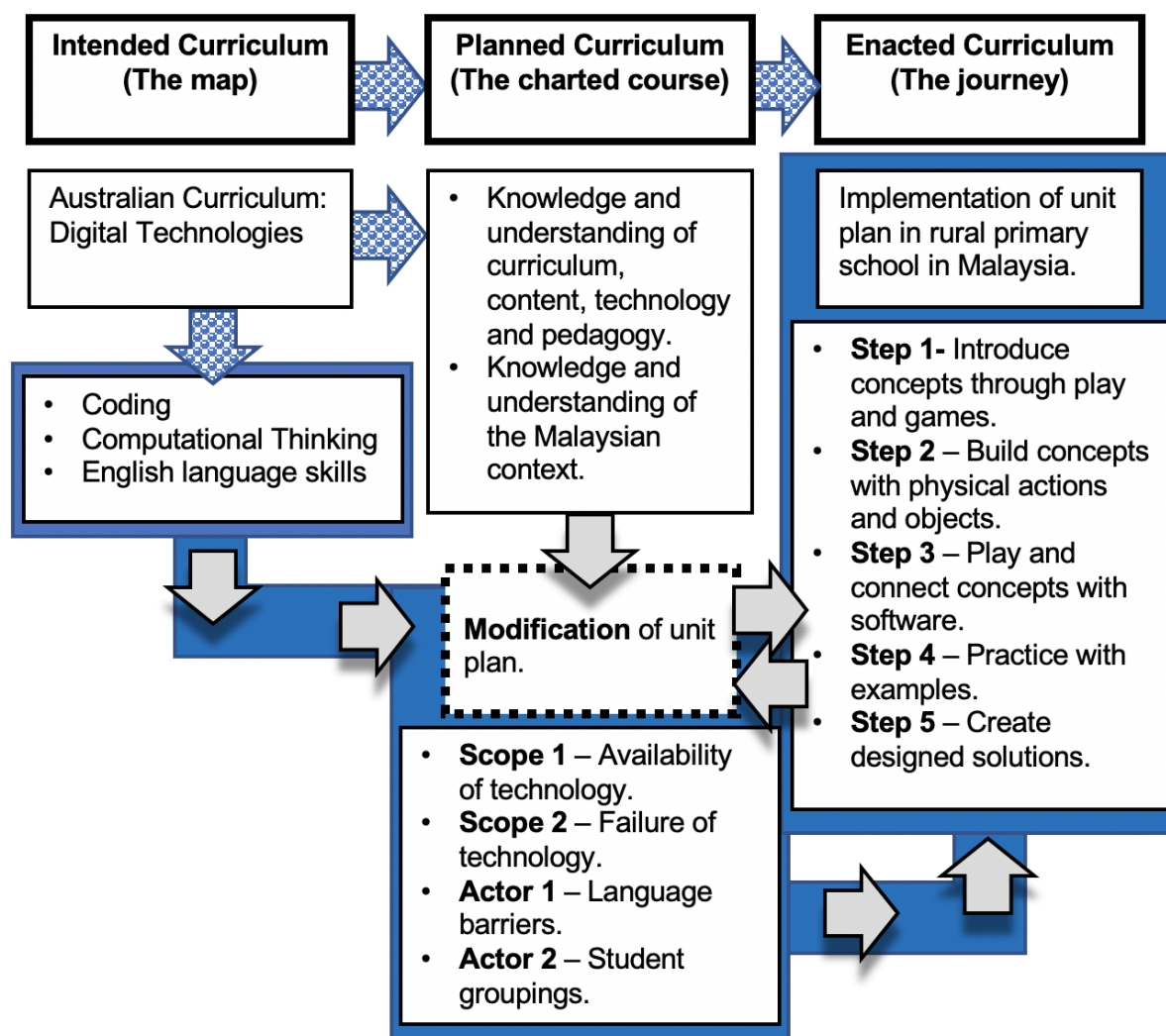

Figure 9: Negotiated Curriculum Interpretation in this Study.

The "development of unit plan" step is closed in Figure 6 but is opened in Figure 9 and consequently relabelled from development to "modification". The intended curriculum was first altered by the host school in Malaysia through the addition of English language skills. This, as noted, created the need to trim or modify the unit plan. The iterative adaptations between the planned and enacted curriculum were forced by the "scope" and "actor" factors. The eventual negotiated curriculum interpretation can be described in terms of a five-step pedagogical model (see Figure 8). The participants engaged in "enactive mastery experiences" which led to increased self-efficacy. This corroborates Abbitt's (2011) conclusion that experience enhances self-efficacy "provided that these experiences are in an

authentic environment and the task requires overcoming obstacles through perseverant effort" (p. 136).

Implications for Practice

This study has shown the role that context can play in terms of how the planned curriculum plays out in the real world. Preservice teachers need to know that they have to be flexible and realistic. A lack [or failure] of technological resources often prevents many preservice teachers from applying their knowledge and training in classrooms. In this project, the preservice teachers knew the content. More importantly they also understood that coding and computational thinking was not all about the "hard computer stuff" (Cathy). The design and the implementation of their units demonstrated teaching some of the coding concepts can be fun. The TPACK Framework served as a useful tool for the preservice teachers to think about what they wanted to do and also reflect on what they were doing eventually in the classrooms. Even though computers were not used in some parts of the activities, David summed up his approach aptly: "the content did not change and…I still think we were still hitting some of that sweet spot in the middle" without the "actual computer itself." Coding and computational is a new area in primary schools. Understandably, further research in different contexts is needed as this will enhance our understanding of how preservice teachers are applying their university- learnt knowledge in the real world. The findings of such investigations can enable academics to sharpen their strategies on how they train preservice teachers to teach coding and computational thinking.

Conclusion

When preservice teachers graduate and gain employment, they are likely to confront influencing and disruptive factors within their school contexts. For example, while access to technologies in some classrooms may not be an issue, this is not the norm across the world. Even in countries like Australia, access to technologies and technical staff able to troubleshoot technology problems onsite may be an issue. Teachers may also encounter language barriers with their students, especially if they are from a migrant background. In schools where there are composite classes, teachers need to adapt their approaches to the needs of children with varying cognitive capabilities.

Despite challenges in the Malaysian context, the preservice teachers in this study were able to negotiate an enacted curriculum to deliver a number of the planned intended outcomes. Understanding how they dealt with these issues is critical. The task of teacher education is to give future teachers the tools and confidence to deal with the unexpected and to promote their classroom readiness and self-efficacy as teachers. Rather than undermining self-efficacy, this study has shown that preservice teachers can develop self-efficacy when challenged, provided that sufficient planning, peer support and mentoring is available.

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