Pedagogical Practice for 21st Century Education

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Debates about research into effective pedagogy have highlighted a potential crisis in Australian teacher education, that has wider implications for the teaching profession. These pedagogical debates identify misinterpretations about teachers and teaching over several decades, namely: teachers know how to teach effectively; that on graduation, new teachers can teach effectively enough to be employed; and that teaching is primarily concerned with 'learners' and their needs and interests rather than with 'knowledge'. The pedagogy debates indicate that effective teaching is strategically important to the learning process if student achievement outcomes are valued. Instructional theory and design that lead to explicit pedagogical strategies are revealed as core knowledge for effective teaching. Hence, explicit instructional strategies challenge the hegemonic status of constructivist learning theories from early childhood to higher education levels. To illustrate these points, we cite evidenced-based research in which skilled e-Learning Managers, working in Blended Learning environments that used explicit instruction, proved effective in increasing the achievement levels of their students. The article proposes that teacher education programs ought to focus more strongly on how to teach effectively and its justification in the interests of students and their communities in a global digital environment.

Introduction

Teachers are confused about pedagogy. They are told that what they do is both art and science, and that they need to combine these to develop a repertoire of practices rather than a single pedagogical approach. They graduate from pre-service teacher education having studied the conceptual frameworks that describe how information is absorbed, processed and retained by students. In addition, and simultaneously, the graduate teacher must also respond to cognitive, emotional and environmental influences. Then the challenge for the graduate teacher is to translate such theory into their pedagogical approach Pedagogical practice, however, is rather less developed and systematic than learning theory in pre-service preparation (Smith & Lynch, 2005).

The present school environment presents dilemmas for teachers and curriculum writers. First, the avalanche of information and other data available on the Internet challenges the narrowness of school curricula. The clients of schools can too easily dismiss school knowledge as archaic and irrelevant when the smorgasbord of interesting material is readily accessible 24/7 on smartphones, tablets and computers. Second, teachers, no matter what their age, now realise that the use of devices is all pervasive with the young. On all sides, teachers are encouraged to 'use' these platforms to better engage students and to make teaching more efficient. Recent discussion around the management of 'cognitive load' for digital learners emphasises the growing complexity of 21st Century pedagogical practice (Hastie, Chen & Smith, 2012). Without systematic 'teaching' frameworks, such advice can lead to cursory content and unsystematic use of the available IT potential. Third, despite the pervasiveness of the Internet and its associated services, there remains the need for young children to gain some mastery with language, mathematics, science, languages, music and the arts and so on. Stitching the so-called 'traditional' curriculum into an online program is not simply a matter of absorbing the former into the latter. It is apparent that teaching and learning online using digital resources requires highly developed teaching and knowledge processing expertise.

With these issues in mind, we define 'pedagogy' as the practice of teaching that is framed and informed by a shared, structured body of knowledge which teachers deploy to assist students in achieving curriculum expectations. Pedagogy is what teachers do and is the fundamental 'how' of the work of schools while the 'what' is the intended curriculum (Education Queensland, 2013).

Blended Learning is defined as the use of a combination of different instructional methods, different modalities and delivery media, for online and face-to-face instruction where students and teachers may be physically present and/or 'cyber' (Hastie, Chen & Smith, 2008, 2011). The development of effective pedagogy is now discussed in terms of learning theory and how this has been misinterpreted in the teacher education.

In the discussion that follows we describe explicit Blended Learning instructional methodologies for digitised teaching that teachers, irrespective of their level of experience, can apply to 21st Century educational environments.

Learning Theory and Teacher Culture

Traditionally, learning 'theory' is used to guide teaching practice. In universities and training institutions charged with teacher education, the study of educational theory and theorists is standard fare, the presumption being that teachers who know the 'why' and 'what' of teaching, will know 'how' to teach. This is the fallacy that teachers, by definition, know how to teach. It is closely linked to a second fallacy, that teacher education programs graduate people who can teach effectively, and a third that teaching is primarily concerned with 'learners' and their needs and interests rather than with 'knowledge'. Our view is that learning theory has the status of received truth in Western teacher education but its influence has blocked the development of pedagogical theory and practice. (see for example, Simon, Bain and Luriya 2009; Lundgren, 2016; Alexander, 2004).

In Australia, alarm bells have sounded for some time about falling educational 'standards' (Thomson, Cresswell & De Bortoli, 2004). Falling student achievement when comparisons are drawn between Australia and other nations in world rankings (Thomson & De Bortoli, 2008) are attributed to a preoccupation with 'learners' and their characteristics rather than the acquisition of incremental knowledge. While education is acknowledged as playing a critical role in shaping the lives of the nation's future citizens, a lack of certainty around the 'how' of teaching appears to have affected educational decision-making at every level in Australia.

In recent times, the predominant learning theory in Western education has been 'Constructivism'. The constructivist philosophy has attempted to explain how humans construct knowledge when 'new' information meets existing experientially learned knowledge. With its roots in early nineteenth century Piagetian cognitive psychology and biology and with parallel social theory, the constructivist approach emphasised learning through 'discovery', hands-on, experiential, collaborative, project-based, and task-based activity. This 'developmental' approach was also evident in the child-rearing advice of the 1960s with proponents like Dr Spock advising parents to simply trust themselves, saying that they cannot go wrong if they listen to advice that makes sense to them (Spock, 2012).

Von Glasersfeld (1984) took this further to develop an approach termed 'Radical Constructivism' where learning was defined exclusively in terms of an ordering and organization of a world constituted by the learner's experience. Rather than creating a picture or description of any absolute reality, Radical Constructivism was proposed as a 'possible' model of knowing and knowledge acquisition. Humans were referred to as 'cognitive organisms', and seen as being capable of constructing for themselves a more-or-less reliable world, based on their own experience. The premise was that behaviourally active learners will 'learn'. Mayer (2004), however, disputed this calling it is the 'constructivist teaching fallacy' because it equated active learning with active teaching focused on 'activities'. He proposed instead a 'guided practice' approach by teachers in learning situations where the learner was 'cognitively active' (Mayer, 2004, p. 15).

The confusion around learning theory, identified by Mayer and others, has arisen because the emphasis, since the early nineteenth century, has been placed on the learner 'constructing' knowledge, rather than the ways in which skilful teachers 'teach' it. At the same time in Europe, Lundgren and associates were investigating teaching as a science, a contrasting direction.

In the late 1960s there was a rather intensive discussion concerning education/pedagogy as a science. The discussion in the US was focused on the relation between theory and practice, while the one taking place in Sweden was more concerned with the independence of education as a science. The first chair in education (Pedagogy) was established at Uppsala in 1910. The first chair in psychology came 40 years later.

This divergence resulted in a major power shift, a change in the dynamic between teacher and student, and indeed between parents and their children as a pedagogical emphasis was silenced in the USA (for example, see http://www.zigsite.com/PDFs/chapter5-6intro.pdf). Teachers in countries dominated by constructivist ideas rather than those of pedagogical science no longer saw their primary role as the transmission of the concepts, premises and understandings – formal knowledge - that had traditionally been debated and agreed upon within discourse communities outside the classroom, recorded in textbooks and used as the basis to set international standards. Rather, teachers saw themselves as 'facilitators' of learning environments in which learners could teach themselves, reflected also in 'laissez-faire' attitudes to child-rearing.

A focus on 'knowledge' has the effect of drawing attention to the way humans learn (Hastie, Chen & Smith, 2012). Kirschner et al (2006) argue persuasively that unless long-term memory is engaged in teaching situations, learning is not likely to occur. If this is indeed the case, it follows that in formal educational settings, teachers have a key role to play in designing and implementing programs that assist students to exercise long term memory, whether it is at the conceptual or process and skill level. Given this premise, it is incumbent on teachers to make use of those pedagogical strategies that have a solid theoretical and empirical basis for producing such an outcome. In addition, the learner's cognitive capacity is enhanced by learning environments in which the teacher manages extraneous cognitive load.

Learning Theory and Blended Learning

The same confusion and ambiguity around learning theory that exists in traditional face-to-face settings is also evident in digital environments. In our experience, teachers are expected to develop their own pedagogical approach, choosing from a selection of pedagogical strategies. Some approaches may claim to be both a learning framework and a lesson design. Teacher dialogue is encouraged, but without additional input about digital tools and to e-learning processes, there is the risk that professional 'conversations' reinforce existing teaching behaviours. Some IT advocates do little more than reinforce the pedagogical approaches in what exists already. Consequently, teaching practice is likely to remain unchanged and commonly used strategies are applied in the mistaken belief that the technology *itself* provides a 'new' pedagogy.

The digital age, then, presents both challenges and opportunities for teachers and students. We define 'e-learning' as learning that can be attributed to experiences and interactions in an Internet environment. These digitised teaching and learning technologies have placed new focus on learning 'content' and its place in the 'teaching' and 'education' cultures.

In a study of technology enhanced teaching and learning solutions (Hastie and Chen, 2010), the development of educationally, culturally and socially relevant digitised learning content found that digital tools can be successfully used to enable digital learners to create ways of thinking and learning which challenge the very notions of teaching and content.

Traditional teaching focus	**e-Learning teaching focus**
Based on knowledge 'traditions'	Introduces enormous range of content
Institution centric	Situation and learner specific
Focus is on mastery of content	Focus is on mastery of established and emergent content with technology-assisted learning tools
Learning is formal	Learning is both formal and informal
Setting is usually Physical Face-to-Face (PF2F)	Setting can be Physical Face-to-Face (PF2F) or Blended Cyber (BC) or Cyber Face-to-Face (CF2F)
Single teacher/Instructor provides content	Teams learning managers and subject matter experts create content
Instructor imparts 'knowledge' in print and/or via PF2F lecture (message delivery)	Learning managers facilitate learner participation in e-learning content development (conversation) in BC or CF2F environments
Emphasis is on passive decoding	Emphasis is on interactivity and encoding
Learners exit knowing 'what'	Learners exit knowing 'what', 'how' and 'where'

Table 1: Traditional Content vs. Negotiated Content (Hastie, M., & Smith, R., 2010)

Before proceeding, we point out that 'blended' in this context is not a new idea. There are many echoes with the classical 'one teacher school' in which a single teacher was responsible for several age cohorts. In dealing with the complexities produced by these settings, teachers became skilful in designing and managing multiple programs. For example, one group of students might undertake exercises produced by the teacher on boards or cards the day before, while teaching one third of the class grammar or reading, while some students read to each other on the veranda. see http://education.qld.gov.au/library/edhistory/topics/oneteacher/strategies.html).

In the digital age, teachers and their increasingly tech-savvy students have unprecedented access to information. For many teachers, the up-skilling required to master Information Communication Technologies (ICT) can prove daunting. Some teachers have made the transition more easily than others to digital teaching. Some school systems have been supportive (Laurillard, 2013), in offering professional development programs to teachers so that they can master the use of computers, interactive whiteboards and digitised resources. Nevertheless, simply knowing how to use the new digital tools does not equate to knowing *how* to teach in digital teaching contexts. The Blended Learning approach, in which the left and right columns of Table 1 are combined, is a promising approach for developing improved pedagogy and better student outcomes. Blended learning can be summarised as shown in Table 2.

Mode	Formula	The Participant Experience
1	PA (Physical Asynchronous) PS (Physical Synchronous)	Access print and/or multi-media resources Attend a physical lecture or discussion
2	PA (Physical Asynchronous) + CA	Access print/multi-media resources and Use discussion forum or social media
3	PA (Physical Asynchronous) + CS (Cyber Synchronous)	Access print and/or multi-media resources Participate in a cyber synchronous session
4	PS (Physical Synchronous) + CA (Cyber Asynchronous)	Attend a physical lecture/discussion Access web-based digital resources
5	PS (Physical Synchronous) + CS (Cyber Synchronous)	Attend a physical lecture or discussion Participate in a cyber synchronous session
6	CA (Cyber Asynchronous) + CS (Cyber Synchronous)	Access web-hosted digital resources Participate in a cyber synchronous session
7	PA (Physical Asynchronous) + PS (Physical Synchronous) + CA (Cyber Asynchronous)	Access print and/or multi-media resources Attend a physical lecture or discussion Access web-based digital resources
8	PA (Physical Asynchronous) + CA (Cyber Asynchronous) + CS (Cyber Synchronous)	Access print and/or multi-media resources Use discussion forum or social media Participate in a cyber synchronous session
9	PS (Physical Synchronous) + CA (Cyber Asynchronous) + CS (Cyber Synchronous)	Attend a physical lecture Access web-based digital resources Participate in a cyber synchronous session
10	PA (Physical Asynchronous) + PS (Physical Synchronous) + CA (Cyber Asynchronous) + CS (Cyber Synchronous)	Access print and/or multi-media resources Attend a physical lecture or discussion Access web-based digital resources and participate in a cyber synchronous session

Table 2: The Holistic Blended Cyber Model (Hastie, Hung, Chen, & Kinshuk, 2010) - Applied to Instruction

Each Mode 1-10 (or combinations of Modes) can be used in a wide range of situations (Hastie, Chen & Leeming, 2010). This depiction shows how the combination of different teacher-student relationships and the framing of teaching together offer a vast variety of teaching approaches. Despite this optimistic and quite revolutionary prospect, the success of Blended Learning can be predicted if - and only if - the 'teacher' is able to maximise those pedagogical strategies embedded in terms such as 'participate', 'access', 'attend', that optimise student learning. However, not all interpretations of these terms have the potential to optimise student learning.

The challenge then is to ensure that teachers understand and use 'optimal' pedagogical practices when working in a blended learning environment. That process requires changes in pre-service teacher preparation and upskilling of practising teachers. The next section of the article contains an indicative discussion.

Instructional Methodologies

First, we note some relevant background. Hattie's seminal work (2003) identified the teacher as the greatest source of variance in student learning, and concluded that 'excellence in teaching is the single most powerful influence on achievement. Hattie explains that the evidence he unearthed shows expert teachers who exhibit explicit teaching strategies have a significant impact on student academic performance. That impact can be measured in higher-levels of student understanding of the concepts targeted in instruction. These findings support other studies that identify the role of the teacher as central to the learning process and learning specific outcomes through explicit pedagogical strategies, instructional design and instructional theory (Scheerens, 2013; Marzano & Pickering, 1997).

Marzano's Direct Instruction methodology for example includes nine strategies that are most likely to improve student achievement across all content areas and across all grade levels when used by teachers. These are:

1. Identifying similarities and differences
2. Summarizing and note taking
3. Reinforcing effort and providing recognition
4. Homework and practice
5. Non-linguistic representations
6. Cooperative learning
7. Setting objectives and providing feedback
8. Generating and testing hypotheses
9. Cues, questions, and advance organizer

Marzano (1997) provides a list of questions that teachers can use to design an explicit teaching practice. We have adapted these to a Blended Learning approach in what follows.

1. What will I do to establish and communicate learning goals, track student progress, and celebrate success in a Blended Learning environment, that is, via Cyber Asynchronous (CA), Cyber Synchronous (CS), Physical Asynchronous (PA) and Physical Synchronous (PS) learning?
2. What will I do to help students effectively interact with new knowledge when they access their learning in a Blended Learning setting using digital tools?
3. What will I do to help students practice and deepen their understanding of new knowledge when they use digital tools to access their learning in a Blended Learning setting?

4. What will I do to help students use digital tools to generate and test hypotheses about new knowledge when they access that knowledge in a Blended Learning setting?
5. What will I do to engage students during lessons that use digital tools in a Blended Learning setting?
6. What will I do to establish or maintain classroom rules and procedures during lessons that use digital tools in a Blended Learning setting?
7. What will I do to recognize and acknowledge adherence and lack of adherence to classroom rules and procedures during lessons that use digital tools in a Blended Learning setting?
8. What will I do to establish and maintain effective relationships with students during lessons that use digital tools in a Blended Learning setting?
9. What will I do communicate high expectations for all students when they access their learning in a Blended Learning setting using digital tools??
10. What will I do to develop effective lessons organized in to a cohesive unit in a Blended Learning environment?

Each of these marked up questions challenges a teacher to think in explicit detail, about what the student is being asked to do given a conceptual or skill outcome that the teaching event is intended to achieve. In the early years of schooling such intensity of purpose is to the great advantage of those students who traditionally fail at school but it also advantages the others as well. Moreover, in some instances teachers may also invite students to explore, investigate, discover and so on their own, but we insist that such decisions ought to have a definite learning outcome that the teacher has considered in advance.

To reiterate, while the work of Marzano, Hattie and others placed renewed emphasis on the central role of the teacher, it also highlighted the need for teachers to apply evidence-based teaching strategies to their pedagogical practice as we have described. Their work is strategically critical for the teaching profession, representing as it does a repertoire of technical language and theory that parallels that of medical practitioners, airline pilots, and other professions. Nevertheless, this work challenges many educators, educational researchers, instructional designers, learning materials developers and education policy experts who appear to believe that constructivist minimally guided instruction is *the* 'new' and are keen to implement it.

They seem unaware or cannot accept Hattie's position that these approaches are almost *directly opposite* to what the research indicates is most effective if the goal is better student learning outcomes. As Hattie notes, learning is not always pleasurable and easy and if the early years of development fail to provide the necessary skill-base in language, mathematics, music, social concepts etc, then students are put at risk. Moreover, the students who traditionally fall into the lower achievement levels are the most discriminated against by pedagogy that is unsuccessful. Selecting pedagogical approaches then involves recognition of the potential effect on students they may have thus reinforcing the political nature of education. That is, not only is unguided instruction normally less effective, it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge (Kirschner et al, 2006).

The research on effective instruction vis a vis the endless education debate about 'inequality', 'fairness' and 'social justice' in education led Smith (2000) to develop the concept of a 'learning manager', a professional able to design, implement, and evaluate improved student academic performance, that is a consequence of their professional practice (Smith and Lynch, 2005). In later research, Hastie, Chen & Smith (2011) have shown that the role of the *e-learning manager* is pivotal in ensuring pedagogy translates to effective practice.

To illustrate how the concepts and principles discussed so far can be implemented, we briefly sketch the details of one of the author's (Hattie) pedagogical practice focussed on educational robots and STEM learning.

Educational Robots and STEM Learning

The author conducted a study based on her regular teaching in a Queensland Australia school. It involved an approach to STEM teaching using a Long-Distance Control Robot (LDCR) system, in conjunction with educational robots (Hastie et al., 2010; Minamide, Takemata, Naoe, Yamada, & Hoon, 2008; Minamide, Takemata, & Hoon, 2009). The aim of the study was to determine the learning impact of a Long-Distance Control Robot (LDCR) system when used by Australian students who could not access or had limited access to a physical robot.

Students (N=32) in the study lived in a range of rural and remote and metropolitan settings throughout Queensland (Minamide, Takemata, Yamada & Hastie, 2012). The Holistic Blended Learning Model (Hastie, Hung, Chen, & Kinshuk, 2010) was applied to this study to meet the situation-specific requirements of the diverse cohort of students in the study. The instructional design model implemented by the e-learning manager in the trial of the LDCR system was based on Gagné's nine instructional events and developed for a Holistic Blended Learning mode of delivery as shown in Table 3:

Gagné's Instructional Events	Applied to Robots Project Cyber Synchronous sessions	Examples
Gain attention	Welcome students to the Robots Project session.	Start recording of session Welcome to our Robots Project online session (state date).
Inform learners of objectives	Show the session agenda on the Cyber Synchronous classroom whiteboard and determine the order of students for remote operation of the robot.	In this Robots Project session, we will take turns using the LDCR system to operate the robot remotely around the robot field. While one team member operates the robot, we'll share research and ideas on robotics on the Synchronous Cyber classroom whiteboard
Stimulate recall of prior learning	Ask students to reflect on their prior knowledge and understandings of remote operation of the robot using the LDCR system.	Do you have the URL for the server for the LDCR system? Do you remember how to log-on to the server to operate the robot remotely? How is your bandwidth and connectivity today?
Present the content	Sequence lesson content using: verbal representations (VoIP) visual representations (whiteboard) webcams on robot and robot field	Name of student) please start operating the robot remotely. We'll conduct time trials and record the time it takes you to complete a full circuit of the robot field as you remotely operate the robot.

Provide 'learning guidance'	Build connections between visual and verbal representations using webcams on robot and robot field to guide remote operation of the robot	On the webcams, we can see (name of student) driving the robot straight up the robot field and now turning the robot to the right to go around the corner … (Name of student) is driving fast and skilfully around the robot field today! See how s/he had to back-up (reverse) to reposition the robot? Name of student), our mechatronics engineer is saying to fix your coding error you need to try this to move the robot X centimetres up the robot field before turning it.
Elicit performance (practice)	Provide activities for students to practice skills and demonstrate understandings of remote operation of the robot: Individual and group discussion Verbal responses and discussion Written responses on whiteboard/in chat-room	Name) please describe what you can see from the front webcam on the robot. (Student name), you need to go faster towards the finish line on the robot field to beat your own personal best time trial last week.
Provide feedback	Provide verbal and written feedback via VoIP, on whiteboard/in chat-room to: Individual students Whole Group Teacher colleagues Parents/Home Tutors	Congratulations Robots Project team, your remote operation of the robot was highly skilful today. This was reflected in faster time trial results. Well done! (Student name), your time trial result today was a personal best, great work! Student name), you may need to check your bandwidth as your connection was not stable today. Better luck next time!
Assess performance	Provide opportunities for student/s to demonstrate mastery of remote robot operation skill/s and concept development via VoIP, webcams, shared/individual whiteboard screens/chat-room Observe and record student/s skill and concept development through: Before and After survey data Recordings and transcripts of remote operation of the robots Review of session recordings Whiteboard screen-captures taken during sessions Analysis of Blog contributions from students	Explain how you accessed the LDCR system and the steps in operating the robot remotely. Call-in via VoIP to give us feedback on your experience of operating the robot remotely. Do you now feel confident/more skilful when operating the robot remotely compared to your first attempt? Record your perceptions about remote robot operation in the chat-room or in our blog.
1. Enhance retention	Link the lesson content to situations relevant to the students, specifically robotics and STEM learning, and their digital futures. Link to learning outcomes and assessment for STEM. Provide a Summary of the session content, and what students achieved in the session.	• Today we worked on achieving personal best time trials in our remote operation of the robot around the robot field. • Learning to operate a robot remotely via the Internet is like the remote operation of robots that surgeons are using to perform remote surgery, like the use of a robotic arm by NASA Scientists to add components to the International Space Station, and is how mining companies are driving trucks remotely on mine sites. • Please note our guest speaker event on (date): we'll link up online with a guest speaker who is a robotics expert. • The next task for you to master is to learn to code the robot to control its movement around the robot field. • In the next session, we will continue to operate the robot remotely adding a theme to the robot field that we'll be able to see on the webcams.

Table 3: Instructional Design for the Synchronous Cyber Classroom (Adopted from Hastie, Chen, Smith et al, 2012) and applied to the trial of the LDCR system

An instructional design methodology was applied by the e-Learning Manager to Cyber Synchronous (CS) sessions that were used to facilitate the trial of the LDCR system. These sessions provided students with multiple opportunities to learn and practise the remote operation of the robot.

First, students would log-on to the synchronous cyber classroom where the e-learning manager directed their remote operation of the robot via the LDCR system. Then, based on their prior learning about the LDCR system, gained through explicit instruction from the e-Learning Manager, students took turns at operating the robot remotely, in collaboration with the mechatronics engineer. As students gained mastery of the basic controls for the LDCR system, time trials were conducted using a robot field. Students received feedback via the webcams and VoIP that enabled them to adjust the direction of the robot as they operated it around the robot field. Multiple attempts at remote operation of the robot enabled students to practise and retain their skills. Video recordings were made of the remote operation of the robot by students and students shared their perceptions and ideas of their learning in an online blog that was available 24/7 on the school learning management system.

Outcomes

There were three broad outcomes from the study of educational robots and STEM that was undertaken during 2014, and facilitated by an experienced e-Learning Manager.

First, when students learned to operate a robot remotely using a Long-Distance Control Robots (LDCR) system, the data collected from surveys indicated that students had higher motivation and enhanced self-efficacy and these were directly attributed to participation in online and blended learning sessions about robots. In addition, the data indicated that students developed STEM specific skills such as quantification, critical thinking, and creativity, in parallel with STEM disciplinary knowledge. The study showed that following their operation of a robot, the students developed greater proficiency in their use of metacognitive strategies, particularly in their use of strategic knowledge, knowledge about cognitive tasks, and self-knowledge in relation to robots.

Second, an analysis of blog postings by students throughout the study, indicated they developed social and cognitive presence (Jimoyiannis & Angelaina, 2012). They also increased their ability to engage in reflective reasoning about robots, as evidence of STEM learning (Australian Government, 2014c), in which science, technology, engineering and mathematics were integrated (Kaufman et al., 2003). The data showed the majority of students who responded through the blog had used STEM concepts to understand and solve complex problems about robots (Balka, 2011), engaged in STEM learning that included creativity, problem solving, critical thinking and communication skills, and their engagement matched the criterion for STEM learning that has been articulated by the Australian Government (2014c).

Third, students developed mastery of the procedural knowledge and technical skills required for remote operation of robots when using a LDCR system. Video recording transcripts (Abasi

& Taylor, 2007), captured student behaviour. The in-depth analysis (Knoblauch & Schnettler, 2012) showed that students developed the technical skills needed to physically operate the robot remotely using the LDCR system, and they developed metacognition through computer programming, coding, and suggesting modifications that also involved coding.

Conclusions

In our view, several implications for teaching and school leadership policy flow from this discussion. First, for teachers to become expert in the use of Blended Learning techniques, it is imperative that they have expert knowledge and practice in the selection, structuring, presenting, assessing and reporting knowledge drawn from a spectrum of sources. It follows that teacher education and professional development programs require a conceptual and applied revision of principles and practice to provide such 'know-how' that complements learning about the complexity of the Internet of Things (IoT) and the ways in which devices interact with it. Without such background knowledge and capability, the potential for neutralising the promise of online teaching and learning is ever present.

Second, there is an enormous task to prepare and upskill teachers and their managers to understand and use the pedagogical strategies that the IT age requires. In short, a claim to have pedagogical skill implies that the claimant can dissect a knowledge and skill base that pre-figures conceptual and behavioural outcomes so that there is a coherent sequence built into the IT capacity of devices and which is underpinned by credible research about effective pedagogies. In the early years the technologies demand specific, decisive expertise compared with the open-endedness of constructivist approaches if the union of knowledge content and device potential is to be achieved. Again, the need for an overhaul of what passes presently as professional development is significant.

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