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Digital Learning in Schools: Conceptualizing the Challenges and Influences on Teacher Practice

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Abstract

Digital technologies are an important requirement for curriculum expectations, including general ICT capability and STEM education. These technologies are also positioned as mechanisms for educational reform via transformation of teacher practice. It seems, however, that wide-scale transformation of teacher practice and digital learning remain unrealized. This is commonly attributed to a range of challenges associated with extrinsic and intrinsic influences, which while acknowledged, are not well conceptualized. Using evidence from a case study of teachers working to transform their practice with digital technologies, this paper presents a tri-theory framework that was used to conceptualize these challenges. Activity Theory provided a mechanism for teachers to identify extrinsic influences in activity systems then contextualize and reduce the perceived significance of challenging contradictions. System 1 and System 2 Thinking Theory was used by the teachers to explore the role of routine, attitudes, and beliefs in their practice and conceptualize discomfort associated with changes in practice. Transformative Learning Theory is presented as a mechanism to explain the interaction between extrinsic and intrinsic influences during the teachers' collaborative attempts to consciously transform their practice. As a common language for discourse, the tri-theory framework allowed the teachers to collaboratively contextualize challenges of realizing digital learning.

Keywords: digital technologies, digital learning, transformation, pedagogy, influences, barriers, professional learning, teachers

Introduction

Integration of digital technologies in schooling is positioned as a mechanism for educational reform via transformation of teacher practice (Hammond, 2013) and to actualize digital learning. Digital technologies are positioned as Vygotskian mediating tools to facilitate change in schools, improving standards and facilitating personalized learning (Fullan, 2013; Hammond, 2013). They are also necessary to satisfy curriculum expectations and facilitate Science-Technology-Engineering-Mathematics (STEM) education (AiGroup, 2016). Despite considerable funding for the provision of digital technologies for schools in Australia (Australian National Audit Office, 2011) and overseas, the reformative and transformative capacity of digital technologies has not been widely realized (Wastiau et al., 2013). Evidence of effect on stu-

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dent learning is mixed (Zheng, Warschauer, Lin, & Chang, 2016). Digital technologies are more commonly used to enhance existing teacher practice than transform it (Ertmer & Ottenbreit-Leftwich, 2013; Hammond, 2013; Shear, Gallagher, & Patel, 2011; Wastiau et al., 2013). The lack of reformation and transformation is attributed to a range of challenging extrinsic and intrinsic influences on teacher practice that can become barriers. Extrinsic influences occur in the context into which digital technologies are introduced. Intrinsic influences relate to personal challenges faced by the individual teacher (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). The realization of digital learning occurs through the transformation of teacher practice at the confluence of interacting extrinsic and intrinsic influences. Limited evidence for the realization of digital learning strongly suggests the need for a framework for researchers and teachers to conceptualize the apparent complexity of these influences.

This paper offers a tri-theory framework for conceptualizing the context and challenges of transforming teacher practice using digital technologies to actualize digital learning, specifically, contradictions in teachers' activity systems, the disruption of teacher routines, and the influence of attitudes and beliefs. The term 'digital technologies' is used to broadly describe various hardware and software tools, including information communication technologies (ICT), that can be used to collect, store, process, and action data as well as facilitate creative and critical thinking, problem solving, collaboration, and communication. The term digital learning is used to broadly describe a wide range of educational opportunities made possible by digital technologies (Dobrovolny, Edwards, Friend, & Harrington, 2015). Evidence from a case study is used to illustrate how the tri-theory framework conceptualizes the challenges of realizing digital learning for students through changes in teacher practice. The framework is a synthesis of three theoretical lenses. Second and third generation Activity Theory (Engeström, 2009a) is used in the literature (Nielsen, Miller, & Hoban, 2012), and in this paper, as an analytical tool for extrinsic influences on digital technology integration. System 1 and System 2 Thinking Theory (Kahneman, 2011) is positioned as a complementary tool to conceptualize the roles of routines, attitudes, and beliefs as intrinsic influences on teacher practice. Transformative Learning Theory (Mezirow, 2009) is offered to conceptualize the interaction of extrinsic and intrinsic influences when reshaping practice for improved digital learning. The paper concludes that teachers can collaboratively use the tri-theory framework to conceptualize the challenges of transformation of teacher practice to actualize digital learning.

Literature Review

Like film, radio, and television, digital technologies are positioned as important tools for reformation or transformation of schooling (Howard & Mozejko, 2015). Rationales for the integration of digital technologies include improving standards; increasing vocational relevance; contributing to knowledge-based economies; enriching learning experiences; transforming pedagogy to make it more student-centered, constructivist in nature, and with a focus on higher-order learning; and facilitating personalized learning (Fullan, 2013; Hammond, 2013; Somekh, 2007). Digital technologies are also essential to satisfy curriculum requirements, for example the Australian Curriculum's ICT general capability (ACARA, 2014), and to facilitate emerging trends, for example STEM education and workforce preparation (AiGroup, 2016; Baranyai et al., 2016). Despite being the subject of considerable attention and research, the evidence of reformation or transformation of education through the integration of digital technologies is limited and evidence of improved educational outcomes through digital learning is variable (Tamim, Borokhovski, Pickup, Bernard, & Saadi, 2015; Zheng et al., 2016). This literature review explores the contributing factors. It addresses the context of digital technology integration and the challenges associated with extrinsic and intrinsic influences on teacher practice. It will explore the extrinsic influences within teachers' activity systems through the lens of Activity Theory (Engeström, 2009b). The intrin-

sic influences of disruption of routine and teacher attitudes and beliefs are addressed. Complicating factors to the integration of digital technologies in schooling are also identified.

Context and Challenges

Integrating digital technologies in schooling and activating digital learning must occur in and through teacher practice within a specific educational context. The gap between aspirational expectations and realized outcomes is attributed to challenges that result from a range of influences on teachers when seeking to transform their practice. The term influences is used in this paper in place of the more commonly used term, barriers (Ertmer et al., 2012), in acknowledgement that not all influences are barriers, some might be enablers. Figure 1 provides a visual representation of influences on the integration of digital technologies in teacher practice.

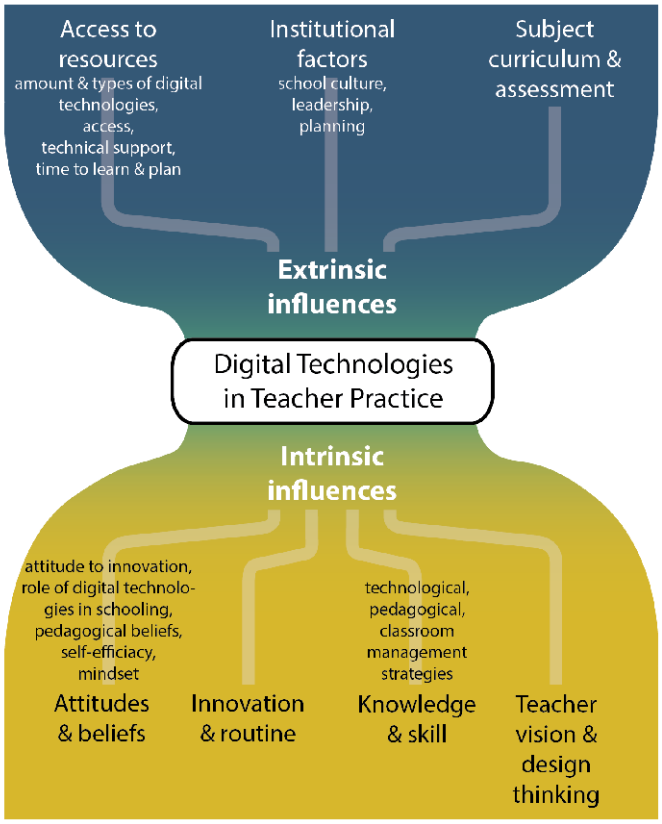

Figure 1. Extrinsic and intrinsic influences on digital technologies in teacher practice
(Blundell, Nykvist, & Lee, 2015, p. 45.)

Extrinsic Influences

Ertmer et al. (2012) identified various extrinsic influences, which they describe as first-order barriers. These extrinsic influences can be categorized into three groups: access to resources, institutional factors, and subject curriculum and assessment (refer to Figure 1). Firstly, students and teachers need access to resources. Use of digital technologies in schooling is dependent on sufficient access to appropriate hardware, software, and infrastructure, including technical support (Fu, 2013). Given the protean nature of digital technologies, teachers also need time to learn and plan (Skues & Cunningham, 2013). Institutional factors such as school culture and leadership play a mediating role (Fu, 2013). The value placed on different kinds of pedagogies by members of the school community, including teachers and school leaders, can positively or negatively im-

pact on how digital technologies are used. Similarly, institutional regard for or resistance to innovation is influential (Ertmer et al., 2012). Subject curriculum and assessment, particularly with high-stakes external assessment, represents a barrier to digital learning (Fu, 2013; Orlando, 2013). While it has been argued that access to resources has been largely addressed in some educational jurisdictions, such as United States of America (Ertmer et al., 2012), the other extrinsic factors remain influential.

The introduction of digital technologies in schooling is often associated with an agenda that overtly or implicitly requires improvement, for example, the Australian Government's Digital Education Revolution (Australian National Audit Office, 2011). As such, digital technologies are Vygotskian mediating tools introduced to activate change within activity systems as described by Activity Theory. 'Subjects' (teachers) use 'tools' (digital technologies) to facilitate an 'object' (pedagogy) towards an 'outcome' (student learning). This is influenced by other elements of the sociocultural context: rules, community, and division of labor (Feldman & Weiss, 2010; Nielsen et al., 2012; Tay, Lim, & Lim, 2013), as represented in Figure 2. Within school communities, multiple parties, all with their own activity systems, are concerned with and have an influence on student learning. Third generation Activity Theory highlights that multiple activity systems can interact to a common outcome (Engeström, 2009b). Refer to Figure 3 for a representation.

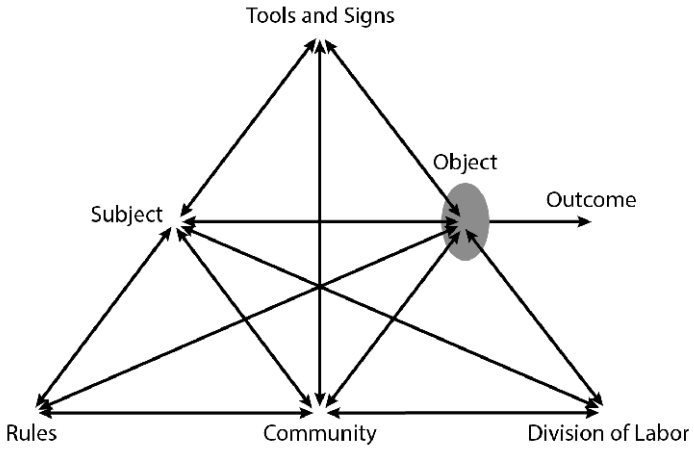

Figure 2. Second generation Activity Theory representation of an activity system
(based on Engeström, 2009a)

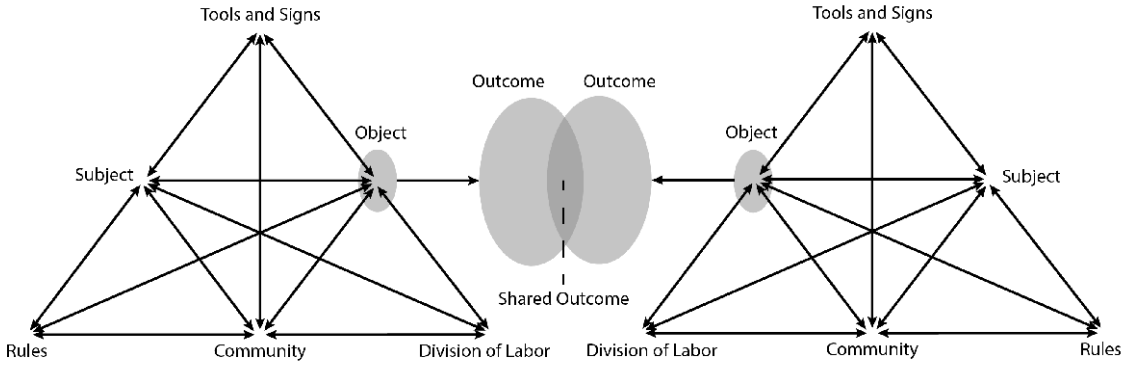

Figure 3. Third generation Activity Theory representation of an activity system
(based on Engeström, 2009a)

Changes to one or more elements in the activity system can create contradictions within the system (Engeström, 2009a). Tay et al. (2013) used Activity Theory to identify contradictions in activity systems surrounding the introduction of digital technologies in primary school classrooms. They note that, if unresolved, contradictions impact on the central activity. While contradictions may be a source of concern, they are also positioned as 'expansive learning' opportunities – opportunities for participants in the system to explore new possibilities within their zone of proximal development (Engeström & Sannino, 2010). The limitation of using Activity Theory is that, while its systems approach is useful for conceptualizing the extrinsic challenges of realizing digital learning, it appears to inadequately elucidate intrinsic factors. Tay et al. (2013) identified contradictions linked to teachers' pedagogical beliefs, but they were unable to conceptualize those beliefs using Activity Theory. This suggests the need for a complementary theoretical lens more suited to conceptualizing intrinsic influences.

Intrinsic Influences

In addition to extrinsic influences, teacher practice is also subject to intrinsic influences, also called second-order barriers (Ertmer, Ottenbreit-Leftwich, & York, 2007). When integrating digital technologies, intrinsic influences on teacher practice are dominant and more challenging (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013; Hsu & Kuan, 2013; Vanderlinde & van Braak, 2010). According to Ertmer et al. (2012, p. 433), intrinsic influences are "the true gatekeepers". Intrinsic influences include factors that occur within the individual teacher and can be categorized into four groups: attitudes and beliefs; innovation and routine; knowledge and skill; and vision and design thinking (Refer to Figure 1).

Teachers' attitudes – like or dislike – towards digital technologies is a strong predictor of their acceptance of and engagement with digital learning; like is associated with acceptance and engagement, dislike is not (Hsu & Kuan, 2013; Pegler, Kollewyn, & Crichton, 2010). Use of technology in schooling is compounded by an individual's attitude to innovation as described by Rogers' (2003) *diffusion of innovations* (Pegler et al., 2010). Personal attitudes and beliefs are strongly linked to professional beliefs and habits of mind, both of which control teacher practice (Cranton & King, 2003; Galvis, 2012). Beliefs about digital technologies in teaching and learning are similarly influential (Hsu & Kuan, 2013; Pegler et al., 2010; Petko, 2012). The transformative representation of digital technologies in teaching and learning, namely, facilitation of student-centered, constructivist pedagogies, can conflict with a teacher's pedagogical beliefs (Ertmer & Ottenbreit-Leftwich, 2010). Teachers who prefer teacher-centric pedagogies find the student-centric rationale for digital learning difficult to accept (Mama & Hennessy, 2013). When attempting to integrate digital technologies in practice, there is a gap between teachers' espoused and enacted beliefs (Prestridge, 2012).

Routines also play an important role in teacher practice; unfortunately, the integration of digital technologies disrupts routines (Somekh, 2007). This factor was originally identified by Ertmer (1999) yet, given its significance to teacher practice and centrality in epistemic identity (Claxton, 2008; Cranton & King, 2003), it has not been explored in the literature to the same extent as other intrinsic influences. This represents a limitation of current research because teachers use routines and associated intuitive practices to quickly read and respond in a wide range of situations. According to Somekh (2007), routines are important for teachers. When introduced in classrooms, digital technologies can disrupt existing routines (Ertmer, 1999) and negatively influence teacher confidence (Prestridge, 2012), reputation, and identity (Claxton, 2008).

There is considerable focus in the literature on the intrinsic influence of teacher knowledge and skill as well as teacher vision and design thinking (Refer to Figure 1). The Technological Pedagogical Content Knowledge (TPACK) framework (Koehler & Mishra, 2009) highlights the importance of developing a teacher's Technology Knowledge, Content Knowledge, and Pedagogy

Knowledge. Professional learning models and associated resources typically focus on developing teacher knowledge and skill (see Angeli & Valanides, 2009; Ertmer & Ottenbreit-Leftwich, 2010; Groth, Spickler, Bergner, & Bardzell, 2009; Harris & Hofer, 2011; Jimoyiannis, 2010) and design thinking – the act of creating new knowledge in response to challenges (see Tsai & Chai, 2012). The remaining influences in Figure 1 – individual teacher attitudes and beliefs about digital technologies in schooling, and the impacts of digital technologies on teacher routine – are considered more influential and harder to address. They are more implicit and harder to access (Prestridge, 2012; Somekh, 2007). Hence, the disruption of routine and teacher attitudes and beliefs are the focus of this paper.

Complicating Factors

The integration of digital technologies in schooling and actualization of digital learning is an ongoing challenge that is complicated by a range of factors. Firstly, there has been an improvement in the access to and adoption of technology, "but not in the timeframe or ways expected by society" (Howard & Mozejko, 2015, p. 166). The expectations of society are compounded by the fact that the process of change is complex and not uniform (Orlando, 2014). As a result, the path to actualizing digital learning is unclear due to variety in expectations and the challenges associated with change. Secondly, the constructivist presupposition for digital learning has been questioned by some researchers (Orlando, 2013). Teachers can employ a range of pedagogies to facilitate learning; not all are constructivist in nature. The constructivist presupposition of digital learning may clash with teachers' understanding of good practice thereby making its application problematic. If non-constructivist uses of digital technologies are gauged through a constructivist lens, the value of teachers' practice and associated student learning may not be evident. Finally, it seems the new pedagogies made possible via the integration of technology, constructivist or otherwise, are not well or widely understood (Fullan, 2013). The integration of digital technologies in schooling and actualization of digital learning is occurring in contested territory and the yardsticks for success are inconsistent.

Unlike the extrinsic influences of digital technologies in teacher practice, a framework does not exist to conceptualize the intrinsic influences. Indeed, the complex interaction between extrinsic and intrinsic influences is not well conceptualized. This paper offers a framework to address this need.

Methodology

Research Design

This research was a case study conducted in an independent college in Queensland, Australia. All teachers and students had ubiquitous access to personal digital technologies (iPads) supported by extensive infrastructure (campus-wide WiFi and high-speed internet access) and cloud-based solutions (Apple's ecosystem and Google Apps). The school's model of technology provision started in 2011 with two year-levels. By 2014, all students and teachers had access to personal technology. There was an institutional expectation that digital technologies were integrated in teaching and learning. Prior to the case study, the school's 'e-learning coach' conducted a school-wide analysis based on teacher self-assessment using Puentedura's (2013) Substitution Augmentation Modification Redefinition (SAMR) model. Based on voluntary responses from sixty teachers (N=60), two-thirds (N=40) indicated that digital technologies were typically used to enhance practice via substitution into or augmentation of established pedagogies. One-third of respondents (N=20) indicated that digital technologies had allowed them to explore transformation their practice, most commonly through modification of existing practice. In a few instances, teachers had redefined their practice to actualize new teaching and learning opportunities. According to the

school's 'e-learning coach', transforming pedagogical practice was, for most staff, challenging due to a range of influences that were difficult for teachers to conceptualize and hence address. This informed the research question: how can theoretical lenses be leveraged to conceptualize the challenges of transforming practice to actualize digital learning?

Six teachers (N=6) volunteered to participate in a project to collaboratively design and implement transformative digital learning experiences. They were supported in this endeavor by the first author and two additional teachers: the school's 'e-learning coach' whose role is to support the actualization of digital learning and another volunteer teacher who previously demonstrated transformation of pedagogy in support of digital learning. Prior to the case study, the teachers were asked to self-assess their use of digital technologies relative to Puentedura's (2013) SAMR model. Four indicated they enhanced their practice by using digital technologies as a substitute for or augmentation of existing pedagogies. Two teachers reported they had actively explored opportunities to transform their pedagogy by using digital technologies to modify or redefine pedagogies.

As part of their project to design, develop and implement a transformative digital learning experience, the teachers were guided to explore the influences on their practice. Prior to developing a new digital learning experience, the teachers were introduced to the concept of extrinsic and intrinsic influences, and the three facets of the tri-theory framework (Activity Theory, System 1 and System 2 Thinking Theory, and Transformative Learning Theory) were explained in detail. During team meetings and semi-structured interviews, the teachers were collectively and individually asked to identify the extrinsic and intrinsic influences on their practice relative to digital learning in a ubiquitous technology environment. The purpose was to identify challenges and leverage these as learning opportunities, as suggested by Engeström's expression of Activity Theory (Engeström, 2009a) and Transformative Learning Theory (Mezirow, 2009).

The case study was explanatory and diachronic in nature (Thomas, 2011), capturing evidence from a collaborative professional learning activity that was eight months in duration. A qualitative approach was selected because of its capacity to generate detailed evidence about, and allow interpretation of, the phenomenon in its natural setting (Creswell, 2013). Given the complex interaction between extrinsic and intrinsic influences on teacher practice (Ertmer et al., 2012; Hew & Brush, 2007) and that new digital technology-enabled pedagogies are not well or widely understood (Fullan, 2013), an explanatory case study methodology allowed for investigation of a contemporary challenge for teachers where "the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p. 18). While the case study is specific to its context, an explanatory case study does allow generalization relative to the theoretical propositions of the study (Yin, 2009). Case studies have been previously used to investigate the integration of digital technologies in schooling (for example Nielsen et al., 2012; Orlando, 2013) providing useful insights, and elucidating influences.

Methods and Data Collection

Data were collected from three sources: two semi-structured interviews with individual teachers, supplemented by researcher's notes from team meetings. The semi-structured interview protocol involved each participant being asked the same five broad questions that were more specific in the second interview. There were three broad foci. Firstly, capture each teacher's description of their use of digital technologies in teaching and learning using Puentedura's (2013) SAMR model. Secondly, explore the extrinsic and intrinsic challenges faced integrating digital technologies in practice. When discussing extrinsic influences, the teachers were able to refer to Activity Theory diagrams like Figures 2 and 3. Thirdly, collect information about perceptions, attitudes, and beliefs about the role and place of digital technologies in schooling. The first interview was generally 30 minutes in duration for most teachers. The second was generally 50 minutes in duration. Participants were invited to speak freely about their experiences and opinions.

The first semi-structured interview was conducted after the teachers had used the theoretical lenses (discussed later in this paper) in a group activity to reflect on their current practice. Between the first and second interview, the teachers engaged in a professional learning activity. They collaboratively designed, trialed, and implemented digital learning pedagogies that involved transformation of their practice. The second semi-structured interview was conducted after the conclusion of the professional learning activity. In this interview, each teacher was also asked to reflect on the new digital learning pedagogies. Each interview was audio recorded then transcribed in preparation for analysis. Using an observation protocol (Creswell, 2013; Thomas, 2011), the researcher wrote descriptive notes during team meetings and reflective notes after. This mode of data collection allowed the researcher to develop diachronic data (Thomas, 2011) about the case study, facilitating time-series data analysis (Yin, 2009).

Analysis and Findings

During team meetings and semi-structured interviews, the teachers were asked to identify the extrinsic and intrinsic influences on their practice relative to digital learning in a ubiquitous technology environment. To facilitate engagement with extrinsic influences, the teachers were introduced to Activity Theory using activity systems diagrams (as per Figures 2 and 3). Analysis of the teachers' individual and collective descriptions of extrinsic influence was achieved using bottom-up coding to identify frequency patterns in responses. A top-down analysis was then conducted using Activity Theory as the theoretical presupposition (Simons, 2009) to identify and map contradictions on activity systems diagrams. Collated findings were shared with the team prior to developing the new digital learning pedagogies (refer to Table 1). Identification of intrinsic influences was similarly explored, however, the teachers responded to generalized requests to share personal concerns and sources of discomfort. Analysis was achieved using bottom-up coding to identify frequency patterns in responses, which were then considered relative to the categories of intrinsic influences identified in Figure 1 as the theoretical presupposition. Collated findings were shared with the teachers for their reflection and consideration (refer to Table 2). In the second semi-structured interview, each teacher was asked to reflect on the extrinsic and intrinsic influences they identified in the first interview.

These findings explore influences on teacher practice from two interacting perspectives: firstly, the extrinsic influences that led to contradictions in the teachers' activity systems; secondly, the intrinsic influence of routines, attitudes, and beliefs on the teachers' use of digital technologies. An overview of transformation of the teachers' practice is also provided.

Extrinsic Influences

When asked, the teachers collectively described a total of forty-three (43) extrinsic influences on their practice when integrating digital technologies. Bottom-up coding identified common patterns in the teachers' responses. Table 1 identifies these patterns as categories, organized by frequency.

Table 1. Extrinsic Influences Identified by Teachers During First Semi-Structured Interviews and Team Meetings

Category of Extrinsic Influence (frequency in brackets)	Specific Extrinsic Influences (frequency in brackets when described by more than one teacher)
Time for teacher engagement (12)	Learn (3) and relearn technology (2) Plan, develop ideas and resources (2) Finding the right tool / app To be creative / focus Update resources when technology changes Work / life balance
Working with colleagues (10)	'Traditional' ideas and preparedness to change (3) Expectations (2) Attitudes Impact of inconsistency in content and pedagogical knowledge Limited experience of innovation by colleagues means feedback and support is unavailable Perception that teachers in a common subject need to teach the same way Willingness to collaborate
Curriculum and assessment, including time in class to cover material (7)	Less flexibility in higher year levels (2)
Expectations / perceptions / attitudes of students and/or parents (4)	Negative student attitudes about iPads Poor response to student-centric pedagogies Parent perceptions
Organisational (4)	Culture drives expectations to improve resources General expectations / climate Teacher allocated to different subjects in subsequent years, unable to leverage previous effort nor improve on prior work Money for different set-ups to make practice more efficient
Technology (2)	iPads Limitations of Learning Management System compared to other tools
Other (4)	Assessment modes prevent digital technologies integration Keeping up with students' changing uses of digital technologies Demands of other roles / work Professional development in use of specific tools

When the data in Table 1 was considered relative to Activity Theory as a theoretical presupposition, a number of contradictions within the teachers' activity systems were identified. Strongest contradictions identified by the teachers are presented in Figures 4a to 4e. These are represented as zig-zag lines on activity system diagrams.

New digital technologies were determined to impact on teacher time: time to learn new technology and time to create new pedagogies (Figure 4a).

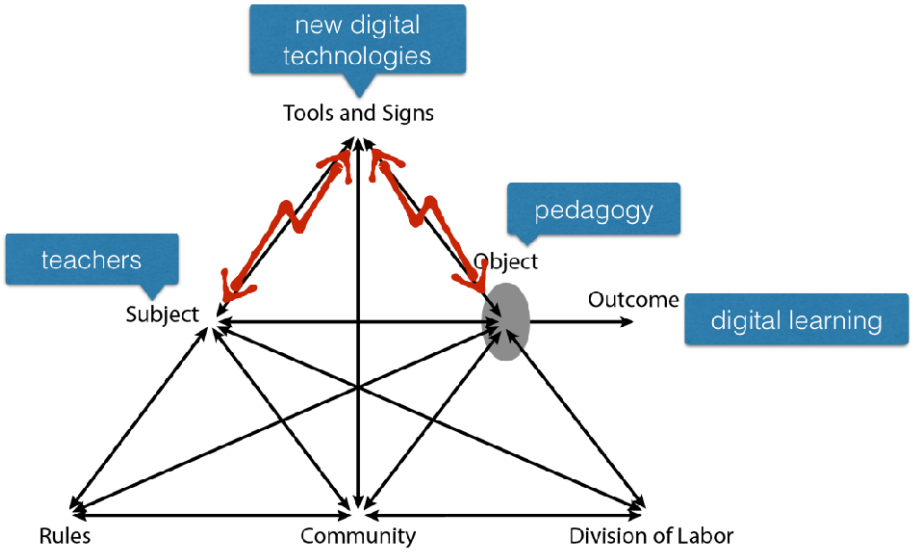

Figure 4a. Teacher-identified contradictions relating to time

Contradictions between digital technologies, pedagogies and the rules associated with curriculum and assessment were evident, including: the time needed to cover curriculum; reduced flexibility in subjects with high definition curriculum; and modes of assessment that prevented integration of digital technologies (Figure 4b).

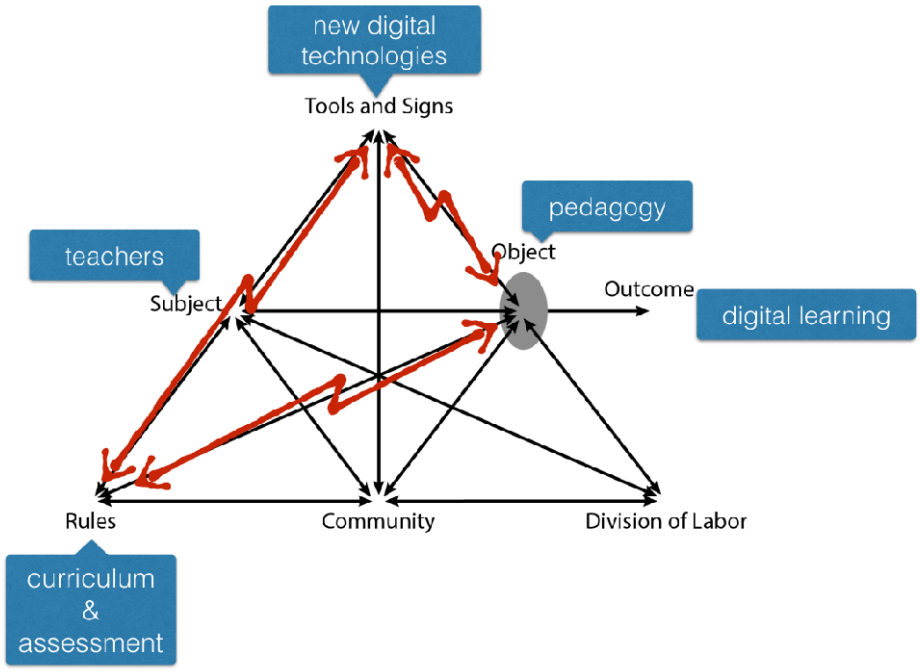

Figure 4b. Teacher-identified contradictions relating to existing paradigms

The results also revealed contradictions that related to perceptions and expectations in the school community, including working with colleagues with different attitudes, beliefs' and expectations, school culture, and keeping up with students' use of digital technologies (Figure 4c).

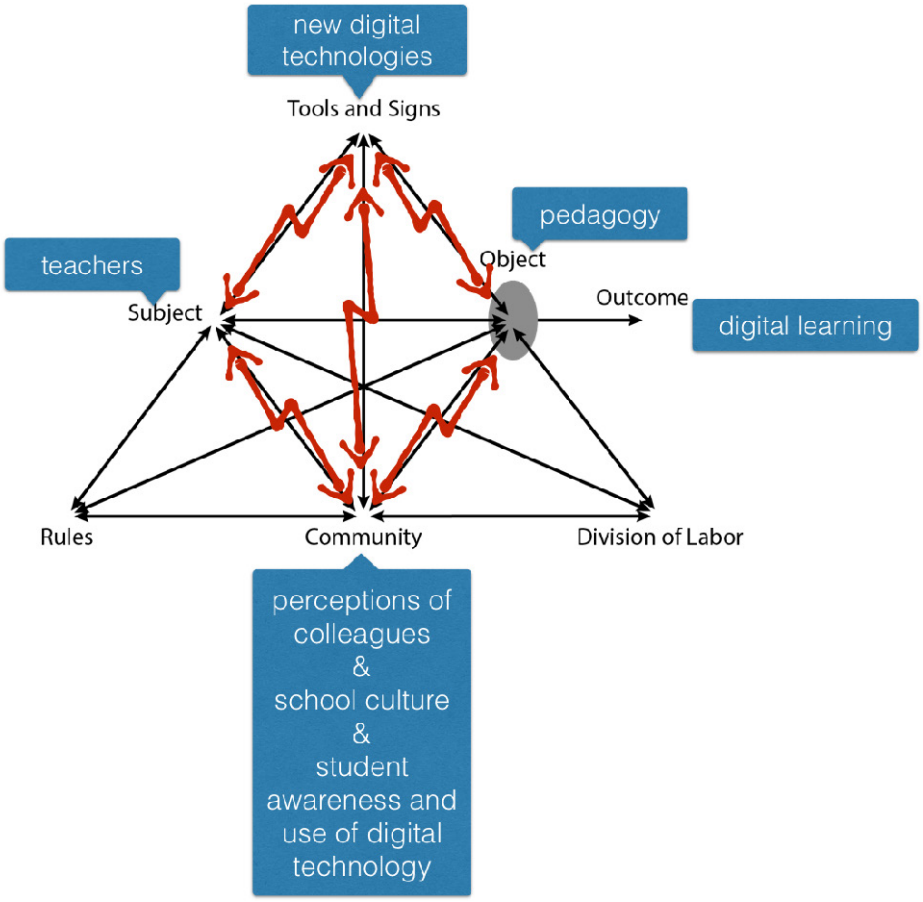

Figure 4c. Teacher-identified contradictions relating to perceptions and expectations

Further, collaboration with colleagues created contradictions such as challenges associated with inconsistencies in pedagogical practice for students in cohorts with more than one teacher, limited feedback from colleagues due to relative inexperience with digital technologies, and demands of other roles in the school that limited opportunities to explore digital technologies in pedagogy (Figure 4d).

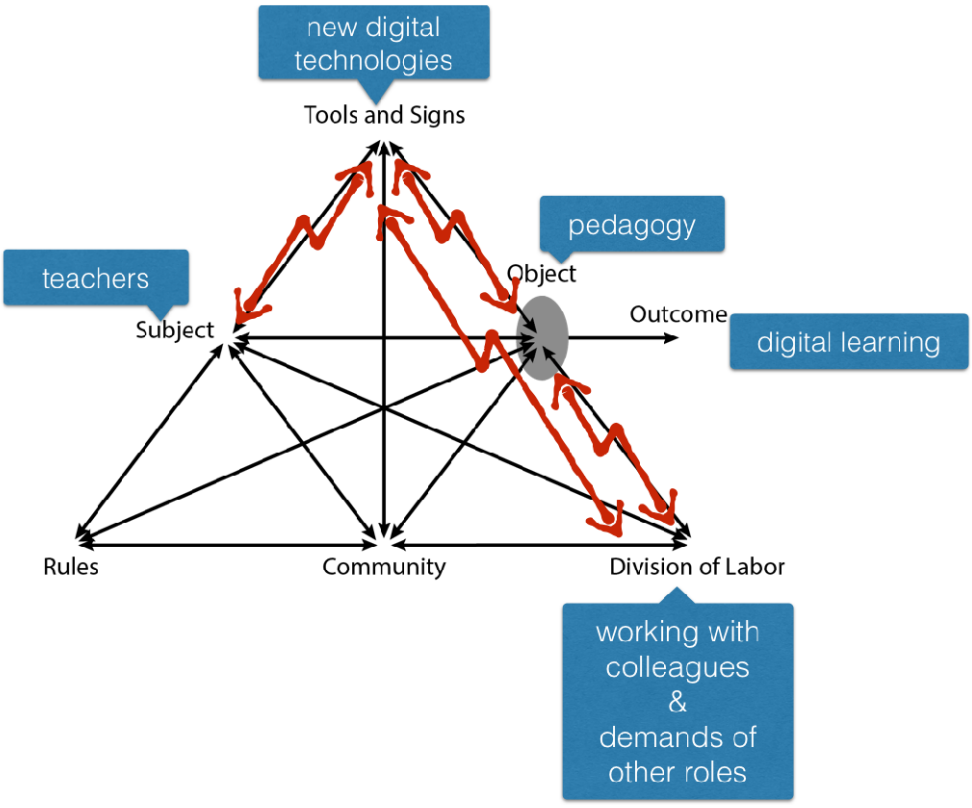

Figure 4d. Teacher-identified contradictions relating to collaboration

Finally, one teacher who had previously used transformed digital learning in their class, identified contradictions that emerged between two interacting activity systems (Figure 4e). The expectations and perceptions of students and their parents created contradictions in the teacher's activity system. These contradictions included negative attitudes towards digital technologies, poor responses to student-centric pedagogies, and perceptions of the nature and purpose of schooling. Most of the other teachers participating in the case study acknowledged the existence of these contradictions during team meetings.

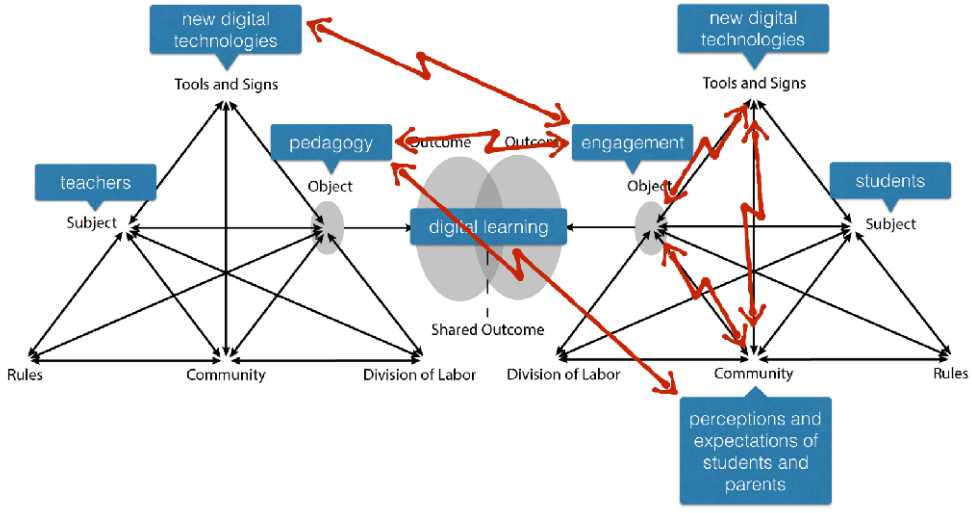

Figure 4e. Teacher-identified contradictions relating to students and parents

In recognition of the diachronic nature of this case, each teacher was asked to reflect on the influences and contradictions they personally identified in the first interview. It was observed that almost all teachers' revised their assessment of the significance of extrinsic influences. Of the six teachers, five reduced their assessment of the challenges associated with most of the influences that they previously identified. One teacher commented:

> *"…some of them (identified influences) seem irrelevant now. Like doing the work (creating new pedagogies) but not teaching the subject in the following year, I mean that's irrelevant as long as it had its purpose and it's been successful. I think the reason that I made that is linked to time. I honestly thought it would be a much, much longer time-consuming exercise."*

One teacher (pseudonym: Taylor) did not reduce her/his assessment of the contradictions initially identified: time to plan, develop ideas, and resources; time to update resources when technology changes; and less flexibility in time to cover curriculum in higher years. Unlike the other teachers, Taylor had very strong opinions about the contradictions presented by digital technologies in school and life. Despite proclaiming a strong personal interest in technology, Taylor also strongly stated concerns about the place of digital technology in learning (see intrinsic influences section). During the implementation of the new digital learning pedagogy developed by the team, Taylor recounted that, due to uncertainty and discomfort, it was difficult to enact the intended roles of the teacher. As a result, Taylor disengaged while the students worked.

During a team-based reflection on the use of Activity Theory, the teachers recognized the value of this lens and its use as an analysis tool. Using Activity Theory facilitated open engagement in conversation about challenges associated with extrinsic influences. By conceptualizing those challenges as contradictions in an activity system, the teachers noted that using Activity Theory prevented the process of identifying extrinsic influences from being viewed as personal criticisms. Rather these contradictions were positioned as elements of a shared context.

Intrinsic Influences

In addition to identifying extrinsic influences on their practice, the teachers were also asked to describe intrinsic influences when utilizing digital technologies (refer to Table 2). The two most common categories of intrinsic influences were the implications for professional routines, and personal attitudes and beliefs about the place and role of digital technologies in teaching and learning. Factors like improving teacher knowledge and skills were also identified. As knowledge and skills are commonly targeted in professional learning (Ertmer & Ottenbreit-Leftwich, 2010), these factors are not addressed in this paper.

Table 2. Intrinsic Influences Identified by Teachers During First Semi-structured Interviews and Team Meetings

Category of Intrinsic Influence (frequency in brackets)	Specific Intrinsic Influences (frequency in brackets when described by more than one teacher)
Implications professional routine, including time (6)	Amount of personal time used for work; uncertainty about time it takes to teach / learning content with digital technologies integration (2) Time taken to make changes, develop new routines (2) Personal energy to engage in change Too many options can be distracting
Personal attitudes and beliefs (5)	Personal attitude – positive (2) Preconceptions of nature of a typical lesson Responses to personal experiences with digital technologies transferred to perceived issues for student Sense of 'teacher inactivity' when not using didactic strategies, leading to discomfort
Knowledge and skills (3)	Knowledge of options available to students Learning curve Level of experience as a teacher

Disruption of professional routine

In team meetings and the first interviews, teachers identified current implications of teaching in a ubiquitous technology environment for their professional routines. Many of these implications were expressed as personal frustrations with change, including the need to consistently question and review current routines in professional practice. It was emphasized there was a change in student behavior in a ubiquitous technology environment that the teachers unconsciously associated with 'off task' behavior. One teacher noted:

> *"…it causes you to have to always re-think what does 'on task' look like, what does 'on task' sound like because, generally, if a student was at their book and writing madly in it, they were doing work. Whereas now they could be staring at that iPad and typing but we don't know what they are typing. They sound different; they work differently with technology. … they tend to work quieter and individually when there is a book than when there is technology. That's not a good or bad thing, it's just different."*

The cues and associated routines no longer functioned reliably, leading to a sense of discomfort.

The changed roles for teachers and students in the digital learning experience also led to discomfort related to disruption of existing routines for monitoring student progress. Some teachers expressed concerns in statements like: *"When I am teaching (didactically) I am aware they are with me. This process was different. I was nervous … are they learning?"* Or questions like, *"Are they doing what they have to do?"* Another teacher noted they were concerned that *"The quiet kids might slip under the radar."* Teacher predictions of how the students would engage and use their time also led to discomfort, for example: *"(I) worried that they weren't going to do it or how they used the time is going to look very differently to how I would ideally like for them to use the time."* It would appear that, in addition to disruption of routines associated with the teachers' roles, existing routines to gauge student engagement were also disrupted leading to discomfort. It is worth noting that during the second semi-structure interview, all teachers reported being pleasantly surprised that their students had engaged very well with all activities in the digital learning experience.

During the second semi-structured interview, each teacher was asked to reflect on the implications of the digital learning experience on their routines as a teacher. Of the six teachers, five noted that changes were required, specifically in relation to their role in the classroom. All of the teachers described their previous pedagogical practice as commonly teacher-centric; afterwards, all noted their role changed to be student-centric. The teachers remained authors of their students' learning through planning the digital learning experience, but during lessons their roles shifted to be facilitators and co-learners. This created discomfort expressed in statements such as: *"I was not relied on that much, and that felt kind of weird … It almost felt like why am I here? … (at first) I felt like I wasn't teaching."* Another teacher noted: *"I was scared to do it. I had to change who I was as a teacher rather than an instructor, more to a developer … it's made me think outside the box."* One teacher described struggling to work outside existing routines: *"It was very hard for me to step back and let them do their work."* Taylor, whose assessment of extrinsic influences did not change, noted:

> *"Normally I'm an in-your-face sort of person. I'm there, I'm leading at the front. (During the digital learning experience) I actively pulled back. I wasn't sure what position to take. (I was) feeling a little insecure as I had left it up to them."*

During the digital learning activity, Taylor moved to the center of the room, advising students to ask if they needed help. Taylor did not use facilitation and coaching strategies employed by the other teachers. It seems that, despite collaboratively authoring the digital learning experience, the change in roles led to discomfort for all teachers. For Taylor, discomfort with the changed role resulted in disengagement, and Taylor left students to work entirely independently.

Attitudes and beliefs

In their initial interviews, all teachers made statements indicating they personally liked digital technology. Two teachers positioned digital technologies as tools that enabled their personal abilities and practice. However, one teacher's positive attitude about technology was tempered by a lack of personal confidence that led them to *"shying away"* from using it. Taylor noted a concern about being overrun by technology in personal life and extended this to a concern for the students. Most teachers also demonstrated positive attitudes towards digital technologies in schooling with statements like, *"ICT is not an option, it's essential"* and *"digital technologies are an important tool in education".* Some teachers positioned digital technologies for specific purposes such as *"ease of access to information"*, *"new opportunities for kids who struggle with literacy"*, *"preparing students for tertiary study and careers."* One teacher noted that digital technologies, like other factors in classrooms, can be a source of distraction for students. Each teacher's attitudes about digital technologies were explored in their second interview and it was noted that their attitudes remained constant.

When explored in the first interview, the teachers' beliefs about the role of digital technologies in pedagogy were more varied, while still generally positive. Their beliefs found expression in generalized statements about pedagogy, such as *"power to positively impact teaching and learning"*, *"better engagement"*, *"digital technologies should be integrated seamlessly"*, *"teacher does not need to be the sole source of all information"* and *"makes teacher practices easier".* Some statements were more specific, such as *"new ways for students to engage, and support learners who previously struggled"* and *"allows for more creativity in showing evidence of learning"*. Two of the teachers tempered their beliefs about pedagogical benefits of digital technologies, saying *"technology alone does not impact pedagogy"* and *"digital technologies are not the best tool for all things."* Both statements were made after positive generalizations, suggesting these teachers' pedagogical beliefs were more nuanced. During the second interview, each teacher was able to more specifically describe their beliefs about digital learning pedagogies. One teacher stated, *"I need to look at them (students) as co-authors of their learning, rather than me directing them on*

a particular path." Another offered the following rather profound statement: *"It's shown me you've got to be open to the idea that you might not be catering for everyone in the room. Don't presume that you are. This will give them a chance to learn on their own because maybe that will reach them in a way that you may not be able to."* It seems that over the duration of the case study, the teachers' pedagogical beliefs became more detailed.

As previously noted, Taylor described concern of digital technologies overrunning personal life. This personal experience was extended to concern for the students: *"If I'm wasting so much time on this (technology), you're (students) spending more time on this, how do you, as children, balance your homework and play life amongst that?"* Taylor expressed strong beliefs about the manner in which students and teachers use digital technologies in classrooms. This included advocating for specific strategies such as limiting student use of digital technologies in strongly teacher-directed ways. When colleagues in the case study suggested a digital learning experience that involved students working collaboratively and self-paced with technologies, this teacher experienced a strong sense of discomfort that was initially expressed as bold statements of pedagogical beliefs.

Of the intrinsic influences considered in this paper, it seems that while the teachers declared generally positive attitudes and pedagogical beliefs about digital learning, the disruption of routine represented a source of discomfort. For some teachers, the source of their discomfort was an extension of personal concerns. For others, their perceptions of the degree of the challenge and time required to actualize digital learning found expression as reservations. Articulating these, however, was quite challenging for most of the teachers, leading to broad statements and generalizations. The concepts from System 1 and System 2 Thinking Theory, as outlined in the discussion, helped teachers to comprehend the nature of routine in teacher practice. These concepts created a common language during teamwork and interviews.

Realizing Digital Learning

The outcomes of the professional learning project provided insight into influences on teachers seeking to transform their practice using digital technologies. As a team, the teachers identified the essential characteristics of digital learning as student-centric, collaborative learning experiences focused on key outcomes that could be approached in any order and for which students had a choice of how to capture evidence of their learning. All facets of the learning – accessing resources and engaging in activities, collaboration, and capturing evidence of learning – were achieved using digital technologies. All teachers reported they were able to implement the digital learning activity and all, bar Taylor, described it as a positive to very positive experience. All teachers noted that the learning outcomes were successful, as measured by the assessment tasks for the term. Most teachers reported their students engaged in the learning experience. Taylor noted students were initially reluctant and some were negative but they enjoyed the variety of the activity. Benefits of the digital learning experience, as described by the teachers, included having a greater sense of how the students worked and learned; strong student engagement and openness to provide feedback to their teacher; better quality of work; more creativity; and improved pace of learning. Taylor noted student performance on post-activity assessment was good, but did not feel it was successful due to discomfort with changes in teacher role.

In terms of changed roles and relationships in the digital learning activity, all teachers, bar Taylor, were able to enact their new roles. A number of benefits were identified. One teacher noted: *"I'd never before this sat down and spoken to the kids about some of the things I asked them. It was extremely valuable to me."* This same teacher observed: *"It made me realize the kids … have the capacity to have a say in their own learning, and I don't ask them enough. I don't consult with them enough."* Increased student independence in learning was commonly cited, so too increased opportunities for the teachers to work with individuals or small groups. All teachers experienced

some form of concern in relation to changes in role. Most reported their response to this change improved over the duration of the activity; the benefits became clearer. One noted, *"I'd be more comfortable if this (mode of learning) was enriching learning, not the sole way"*, which suggests some of this teacher's concerns remained. Taylor's concerns remained unresolved, noting *"(I was) feeling a little insecure as I had left it up to them (students)."*

When asked about the changes to the roles and relationships of students, most of the teachers noted a range of reactions from students. One teacher noted *"Most of them (students) raved about it."* Another said that the students liked that they could talk about the work and help each other; they liked that they could organize their learning and that it was self-paced. While the teachers indicated that most students did not express concerns, some were noted. Some students were initially concerned about the student-centric, non-linear nature of the learning because they did not understand the process, requiring support from their teacher. One student reportedly said, *"What if I can't learn this way?"* The teachers recounted that these concerns diminished over the duration of the case study. One teacher noted, *"One student hated it, but loved it at the end."* Taylor reported that the students were quite negative and preferred direct teaching. Another noted that, while the students enjoyed the learning experience, some indicated they would rather be taught the content directly; some saw it as extra work. The comments suggest that, like the teachers, changes in the students' roles and relationships created a range of responses informed by routine and prior experience.

Discussion

The findings provide evidence of the extrinsic and intrinsic influences on teacher collaboratively working to enact digital learning for their students. The teachers explored these influences, and in the process of doing so, it seemed most changed their perceptions to some degree, and all were able to design and implement a digital learning experience. A tri-theory framework, composed of Activity Theory, System 1 and System 2 Thinking Theory, and Transformative Learning Theory, is presented to conceptualize the findings.

Conceptualizing Extrinsic Influences

The findings from the case study suggest that Activity Theory allows for the exploration and conceptualization of extrinsic factors and the identification of sources of contradiction. Activity Theory is used by researchers to conceptualize and analyze the systems into which digital technologies are integrated, helping to elucidate the challenges (for example Feldman & Weiss, 2010; Nielsen et al., 2012; Tay et al., 2013). Employing Activity Theory to analyze the case helped to elucidate extrinsic factors surrounding the teachers' direct activity system. Contradictions in activity systems are presented as the driving force for so-called expansive learning opportunities (Engeström, 2009a). The experience of teachers in this case appears to confirm Engeström's assertion that Activity Theory can be used by members of an activity system to understand the influences and contradictions. Indeed, it helped to stop individuals viewing contradictions within the activity system as personal criticisms, thereby promoting teacher engagement in conversation about those challenges.

This case study's evidence suggests that identifying contradictions had an unexpected effect. Engeström and Sandino (2010) argue that, within the context of intense change towards an unknown 'outcome', consideration and resolution of contradictions in a social setting allows for the actualization of a new 'object'. In this case study, the unknown 'outcome' was digital learning achieved through a new 'object' – pedagogies facilitated through a change in teachers' and students' roles, and the integration of digital technologies. Rather than being a driving force for change, identification and discussion of contradictions in the activity system seemed to give these

influences context and reduced their perceived effect over the duration of the case study. One teacher noted:

> *"…it (Activity Theory) helped to visualize my potential reservations, fears and concerns about implementing the technology … It helped me to visualize some of the expanded opportunities for learning that perhaps I hadn't seen in the past. And the types of disconnects and obstacles that would need to be overcome to achieve this, or how to circumnavigate some of those obstacles because they are not always able to be removed … It has also helped me to understand the interaction between people and tools or artifacts, I suppose. I felt like I have gained a better understanding or sense of that: how we interact with them (people and tools)."*

While the contradictions identified by the teachers were raised by the researcher during team meetings, the teachers did not overtly strive to resolve these contradictions as suggested by expansive learning (Engeström, 2009a). It seems that using Activity Theory allowed the teachers to better understand the contradictions and, in the process of doing so, there was a reduction in the perceived significance of those contradictions for all teachers except Taylor. The contradictions identified by Taylor – time complications and curriculum challenges – seemed linked with deeper intrinsic concerns and dilemma associated with changes in roles.

Responses from the case study highlight the limitations of solely relying on Activity Theory to investigate the complexity of digital learning in schools. As illustrated in Figures 4c and 4e, participants in the case study identified the perceptions of colleagues, students, and parents towards the role of digital technologies in schooling as important influences in their practice. By its nature, Activity Theory focuses on systems. While it acknowledges that these systems are the product of human activity, Activity Theory inadequately elucidates intrinsic factors. Routines, attitudes, and beliefs, which are particularly influential on the integration of digital technologies in teacher practice (Prestridge, 2012), are not sufficiently elucidated. This appears to be reinforced by Taylor's unchanged assessment of extrinsic influences. This teacher's strong, intrinsically held attitudes and beliefs seemed to influence her/his assessment of the influences in her/his activity system. For these reasons, relying solely on Activity Theory to conceptualize the challenges of digital learning is limiting because intrinsic influences are not adequately addressed. A second lens was needed to conceptualize these challenges relating to the intrinsic influence of individual teachers.

Conceptualizing Intrinsic Influences

System 1 and System 2 Thinking Theory (Kahneman, 2011) is a useful theoretical lens to conceptualize professional learning relative to intrinsic influences. System 1 and System 2 Thinking Theory describes thinking as two metaphorical agents: one form is unconscious automated thinking (System 1), the other is conscious thinking (System 2) (Kahneman, 2011). System 1 represents all apparently fast, unconscious or automated thought including impressions, feelings, intuition, and creativity. It also includes cognitive-kinesthetic processes like tracking and catching a ball. System 1 processes can be developed through classical and operant conditioning. System 2 represents analytical and self-aware thought associated with the conscious act of thinking. These processes are apparently slower, more deliberate modes of thinking. System 1 is always actively monitoring and filtering stimuli, executing routines as needed. It can process complex information in novel ways, hence its role in intuition and creativity. System 1 does not tire easily. When certain patterns are recognized or when stimuli cannot be adequately processed, System 1 calls System 2 into action. System 2 has capacity for analytical and complex computation leading to considered decision-making; it also has capacity to plan ahead. System 2 processes consume large amounts of energy, and when strongly activated, System 2 tires easily. For this reason, System 2 prioritizes activities, and when at capacity, other information and alerts from System 1 are

not processed. In essence, automated processes in System 1 preserve the limited resources of System 2 for specific functions, when needed (Hattie & Yates, 2014; Kahneman, 2011).

For teachers, System 1 and System 2 thinking processes play important, complementary roles. Teaching requires long hours of practice in dynamic social situations. System 1 allows teachers to skillfully perform over extended periods by quickly reading and responding to stimuli (Hattie & Yates, 2014), using routines and intuitions (Kahneman, 2011). This capacity to unconsciously read a situation is called a blink response (Hattie & Yates, 2014), and the associated rapid response is described as an expert intuition (Duggan, 2007). Insights, intuitions, feelings, and implicit attitudes form in System 1, and if considered by System 2, can become explicit attitudes and thoughts. Hence System 1 and System 2 Thinking Theory is useful for conceptualizing the role of routine, attitudes, and beliefs in teacher practice and their influence on digital technologies in teaching and learning.

Disruption of routine

Through experience and expertise, teachers develop capacity to quickly read and respond to a range of situations (Berliner, 2004; Somekh, 2007). Classroom and school practice results in the development of pattern recognition and associated behaviors that are triggered, often unconsciously, by stimuli (Hattie & Yates, 2014). The integration of digital technologies in classroom learning is acknowledged to disrupt established routines, leading to teachers feeling discomfort, drained, and tired (Somekh, 2007). The finding that teachers needed to relearn what 'on task' behaviour looked and sounded like is a strong case in point. The classroom cues generated by students using technology led to automated System-1-based responses that, on conscious inspection by the teachers, were wrong: the students were engaged, but this looked and sounded different to what was unconsciously expected. Similarly, the disruption of teachers' routines for monitoring student engagement and progress also led to discomfort and uncertainty. Responding to these changes required teachers to consciously engage System 2 thinking to develop strategies to respond appropriately in the new classroom dynamic. In time and with practice, these new strategies may have become more automated by involving System 1 thinking. In the absence of automated strategies, however, a sense of discomfort was experienced by all teachers.

The digital learning experience collaboratively developed by the teachers required a change in their roles in the classroom. Questions like *"why am I here?"* and emotional responses, such as *"I was scared"* and *"feeling a little insecure"*, highlight teacher dependence on routine. Despite being authors of this change, the associated discomfort and uncertainty was clearly evident, highlighting the contribution of System 1 routines to teacher practice. Once developed and consistently reliable, classroom routines build teacher confidence (Somekh, 2007), ultimately leading to routines and habits of mind that inform a teacher's epistemic identity (Claxton, 2008; Cranton & King, 2003). This serves to conceptualize the significant discomfort associated with any change in teacher role.

Attitudes and beliefs

When digital technologies are introduced into schools, teachers evaluate the perceived value of the technologies relative to their personal attitudes and beliefs about the nature of good teaching (Mama & Hennessy, 2013; Pegler et al., 2010). System 1 and System 2 Thinking Theory provides insight. System 1 processes cannot be articulated directly and must be communicated via System 2. Implicit attitudes form in System 1, but must be transformed into explicit attitudes in System 2 in order to be expressed (Kahneman, 2011). Similarly, System 1 can develop impressions and intuitions, but these must be expressed as beliefs by System 2 (Hattie & Yates, 2014). This offers useful conceptualization: implicit attitudes, impressions, and intuitions form in System 1 in response to the complex stimuli it receives and filters. However, the communication of explicit atti-

tudes and beliefs via System 2 suggests potential reformation and loss of complexity. Similarly, new ideas received via System 2 are compared to existing frames of reference – implicit attitudes and beliefs – in System 1. Inconsistent ideas may be discarded, though the reasons may be unclear and hard for the individual to re-examine (Hattie & Yates, 2014; Kahneman, 2011). In essence, an individual may experience discomfort triggered by System 1, but may find difficulty articulating, in detail, the exact cause.

The teachers in the case study all expressed positive attitudes to digital technologies in schooling and pedagogy. Their articulations of pedagogical beliefs in the first interview were quite general though typically positive, suggesting the teachers' implicit attitudes and beliefs in System 1 were largely consistent with conscious engagement with the topic of digital technologies in schooling using System 2. As noted in the findings, following the implementation of the digital learning experience, the teachers were more specific in their description of newly formed pedagogical beliefs, suggesting a more conscious elaboration of those beliefs. Some conflict between implicit attitudes and beliefs in System 1 and reforming explicit attitudes and beliefs in System 2 was evident in the discomfort associated with changed teacher and student roles. The failure of existing routines for determining 'on task' behaviour and management of student progress might have been compounded by implicit attitudes and beliefs in System 1 about the nature of student engagement in learning. Conflict between System 1 and System 2 was most evident in Taylor's case. While articulating positive attitudes and beliefs about the role of digital technology in schooling, this teacher struggled to resolve her/his changed role during the student-centric digital learning activity. The System 1 and System 2 conceptualization suggests profound conflict as evidenced by this teacher's withdrawal from these changes in role.

Conceptualizing the Link between Extrinsic and Intrinsic Influences

To this juncture, Activity Theory is presented as a tool to conceptualize the extrinsic influences on teacher practice when integrating digital technologies and digital learning pedagogies. System 1 and System 2 Thinking Theory allows for consideration of the intrinsic influences of routine, attitudes, and beliefs as the function of dual systems of unconscious and conscious thinking. Transformative Learning Theory (Mezirow, 2009) is offered as a tool to conceptualize the dynamics surrounding changes in teacher practice in the milieu of interacting extrinsic and intrinsic influences.

The reformation or transformation of teacher practice via the integration of digital technologies and actualization of digital learning pedagogies involves change and, hence, is associated with learning and meaning making for teachers. Mezirow's (2009) Transformative Learning Theory posits that adult learning is distinct from childhood learning because the development of meaning is influenced by prior experience and learning, perceptions, assumptions, and expectations. Responses to new ideas are influenced by frames of reference, habits of mind, and points of view. Frames of references are deeply intrinsic structures used to understand the world that are based on experiences, associations, concepts, values, feelings, and conditioned responses (Mezirow, 1996). Frames of reference are consistent with System 1 thinking processes as they comprise predispositions and difficult-to-articulate attitudes, beliefs, and mindsets (Cranton & King, 2003). They also incorporate constructs that are "inferred from repetitive affective experience outside of awareness" (Mezirow, 2012, p. 82). Frames of reference become the basis for habits of mind, which are broad ways of thinking, feeling, and acting that orient behaviors (Mezirow, 1997). Habits of mind are based on experience and are considered to inform teacher practice and identity. While they are difficult to articulate, habits of mind are influenced by a teacher's extrinsic institutional culture and intrinsic practices (Cranton & King, 2003). Habits of mind are expressed as points of view, which are readily articulable interpretations of attitudes, beliefs, values, and mindsets. Points of

view are open to feedback, and it is possible to "try on" someone else's point of view (Mezirow, 2012). Points of view seem consistent with System 2 thinking in that they can be shaped or challenged by extrinsic influences. Transformative Learning Theory argues that an individual may experience a disorienting dilemma when faced with new ideas that conflict with deeply held perspectives and meaning schemes (Mezirow, 2009). This is the intrinsic equivalent to the extrinsic contradictions that occur in activity systems as the result of change (Engeström, 2009a).

When engaged in collaborative professional learning about digital technologies in practice, teachers are able to "try on" other points of view (beliefs) and process these with System 2 thinking. For some teachers in the case study, the new points of view were sufficiently consistent with existing frames of reference and habits of mind. Others felt some disorientation but collaboration seemed to allow engagement with and consideration of underlying elements leading to some form of resolution. This seems to supports Kahneman's (2011) proposition that points of view change when the perceived risk of an activity is reduced. However, in Taylor's case the new points of view were inconsistent with underlying frames of reference and habits of mind, so there was a strong tendency to reject them. This is particularly evident in the apparent conflict between Taylor's positive statements about technology in schooling and the resistance demonstrated to the change in role during the digital learning experience.

Transformative Learning Theory has the capacity to describe the interacting influences of extrinsic and intrinsic factors evident in teacher responses to changes associated with the actualization of digital learning pedagogies. It conceptualizes the basis for perceptions of adults using technology as part of their education (Wang & Cranton, 2013). Transformative Learning Theory also highlights that professional learning towards the integration of digital technologies in practice needs to allow for the transformation of an individual's frames of reference and habits of mind via collaboration and discourse-based critical reflection (Cranton, 2011).

Conclusion

Globally, the integration of digital technologies in teaching and learning is positioned to transform schooling, yet this has not been widely realized (Wastiau et al., 2013) and evidence of effect is mixed (Tamim et al., 2015). This is attributed to a range of interacting extrinsic and intrinsic influences (Ertmer et al., 2012). Activity Theory has been previously used in the literature to conceptualize extrinsic influences (Feldman & Weiss, 2010; Nielsen et al., 2012; Tay et al., 2013). The tri-theory framework described in this paper uses Activity Theory to conceptualize extrinsic influences and complements it with System 1 and System 2 Thinking Theory to conceptualize the influence of teachers' professional routines, attitudes, and beliefs. At the point of confluence between extrinsic and intrinsic influences on teacher practice, Transformative Learning Theory is offered to guide collaborative professional learning focused on transformation of practice.

The findings of this case study demonstrate how the tri-theory framework was used by teachers to conceptualize and reduce the perceived significance of extrinsic influences in their activity system. Similarly, the framework provided teachers with a common language that allowed them to collaboratively consider and develop an appreciation of their attitudes and beliefs as well as concerns about changes in their routines. In the process of acknowledging and conceptualizing challenges, most of the teachers' levels of concern reduced, which allowed them to transform their roles to facilitate digital learning. This appears to confirm Kahneman's (2011, p. 103) claim: "Your beliefs, and even your emotional attitude, may change (at least a little) when you learn that the risk of an activity you disliked is smaller than you thought." The tri-theory framework also conceptualized how changes in a teacher's role were prohibited by disorienting dilemma associated with deeply held frames of reference, as Taylor's case highlights.

This case study provides insight to a team of six volunteer teachers seeking to transform their practice to realize digital learning through collaborative professional learning in a school with a mature ubiquitous technology environment. Although this case is specific to its context, this study's generalizations are applicable to the emphasis that Activity Theory and Transformative Learning Theory place on using discourse about extrinsic and intrinsic challenges as the basis for professional learning. Change, however, is dependent on teachers transforming their frames of reference (attitudes and beliefs) as well as teachers reducing their assessment of risks associated with those transformations. There are at least two avenues for further research: firstly, the applicability of this study's collaborative professional learning activity and its tri-theory framework in other contexts where teachers seek to realize digital learning, for example, its applicability in schools at early stages of a ubiquitous technology deployment, or in situations when the use of digital technologies is mandated by curriculum documents; secondly, whether the tri-theory framework can be utilized in other situations not related to digital technologies in which teachers need to transform their practice.

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Shaun Nykvist (Doctor) is a Senior Lecturer in the Faculty of Education, Queensland University of Technology, Australia. His research expertise is in the areas of pedagogy associated with higher education teaching and learning, and the use of digital media tools and emerging technologies in blended learning environments. Shaun provides strategic leadership around key learning and teaching initiatives at QUT whilst developing strong national and international partnerships in education that provide a global perspective.