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ABSTRACT

This research examines how the pedagogical orientations of teachers affect technology adoption in the classroom. At the same time, we account for the stage of concern (Hall, Wallace, & Dossett, 1973) that teachers are experiencing regarding the use of the technology, their access to the technology, and the level of schooling at which they teach. Our investigation of these factors occurs in the context of a contemporary technology, the interactive whiteboard (IWB), in Australian schools. A structural equation model (SEM) was estimated using a reflective measure of technology usage with antecedents in the form of pedagogical-oriented beliefs and best-worst scaling derived scores for a teacher's SoC regarding IWBs. Teachers with constructivist-oriented pedagogical beliefs were significantly more likely to use IWBs than transmission-oriented teachers. However, the strongest determinant of usage was whether the technology is immediately accessible or not.

Keywords: pedagogical issues; teaching/learning strategies; computer-mediated communication; elementary and secondary education; interactive whiteboards.

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Exploring teacher pedagogy, stages of concern and accessibility as determinants of technology adoption

1. Introduction

Ensuring effective technology use for learning is a perennial problem for education, exacerbated by rapid technological development. Technology adoption and technology use by teachers are moderated by a variety of factors, comprising external (first order) factors such as access, school support, provision of professional development, and internal (second order) factors, such as teachers' attitudes, concerns, technological competence and beliefs (Ertmer, 2005; Miller & Glover, 2010; Teo, 2014). The aim of the present research is to investigate the relationship between teacher characteristics and their use of an educational technology. The characteristics studied were teachers' pedagogical beliefs, their concerns with technology, and their access to the technology. The work is significant because it is the first to integrate SoC, pedagogical orientations and access to technologies using a Structured Equation Model. At the same time, it validates a new reflective scale of technology use. In addition, best-worst scaling (BWS) methodology (Finn & Louviere, 1992; Marley & Louviere, 2005) is used to more readily discriminate teachers in relation to the SoC measure, thus improving the ability to detect related outcomes in technology use. Furthermore, the study is the first to test the properties of Ravitz, Becker, and Wong's (2000) scale of pedagogical orientation.

The study examines teachers' use of interactive whiteboards (IWBs) in Australian primary and secondary schools. IWB usage among teachers is interesting to study because, despite its unprecedented uptake in various educational settings and schools, usage varies considerably (Beauchamp, 2004; Lee, 2010; Miller & Glover, 2010). While our methodology and findings are particularly valuable for educational systems in which IWBs are heavily used, it has potential for investigating our understanding of other educational technologies.

2. Literature review

Factors influencing teachers' adoption and use of technologies in their classrooms have been extensively researched, including in the context of IWBs (e.g., Dunn & Rakes, 2010; Ertmer, 2005; Higgins, Beauchamp, & Miller, 2007). This paper focuses on the influence of second-order factors in the form of teachers' pedagogical orientations and concerns about the technology, while accounting for first-order factors of access and level of schooling. As such, we focus our review on related critical factors validated in previous literature: the Stages of Concern (SoC) experienced in use of educational technologies (Hall, Chamblee, & Slough, 2013) and pedagogical approaches (Dunn & Rakes, 2010; Ravitz et al., 2000).

2.1 Stages of Concern and learning technologies

A key element influencing technology adoption relates to concerns teachers have. A model categorizing teachers' reservations about educational innovations is the Concerns Based Adoption Model (CBAM) (Hall, 1974; Hall, Wallace, & Dossett, 1973). CBAM provides three diagnostic dimensions measuring concerns about and use of an innovation: Innovation Configuration, Stages of Concern (SoC) and Levels of Use (Hord et al., 2006). The SoC component of the model builds upon Fuller's (1969) conceptualization used to describe teachers' concerns in curriculum implementation. Fuller proposed that teachers have concerns about themselves in the early stages of curriculum implementation, followed by concerns about the task of teaching; concerns about the impact on students come in the later stages of implementation.

SoC has been extensively used to investigate technology adoption (e.g., Chen & Jang, 2014; Hall et al., 2013). It describes seven levels of sequential responses to an innovation. In the context of teaching, Hall et al. (2013) described these seven stages as follows:

- *Awareness:* A teacher has little concern and involvement with the innovation;

- *Informational:* A teacher has a general awareness of the innovation and interest in learning more about the innovation;
- *Personal:* A teacher is uncertain about the demands of the innovation;
- *Management:* A teacher is concerned about the processes, resourcing and tasks of using the innovation;
- *Consequence:* A teacher focuses on how the innovation will impact students;
- *Collaboration:* A teacher focuses on coordination with others regarding use of the innovation; and,
- *Refocusing:* A teacher focuses on the exploration of more universal benefits from the innovation.

Recently, Chen and Jang (2014) concluded that teachers move through different SoCs "as they better their computer literacy, enrich their pedagogical knowledge and skills, and strengthen their self-efficacy, belief and motivation of technological implementation" (p.80). In studying the adoption of IWBs by teachers over a three year period, Hall et al. (2011) found that teachers' changing concerns about the technology were consistent with the SoC model.

2.2 Pedagogical beliefs and technology use

Teacher beliefs and attitudes towards technology have been posited as affecting teachers' use of technology (Daly, Pachler, & Pelletier, 2009; Ertmer, 2005; Ertmer et al. 2012). Vincent (2007) suggests that when teaching styles match a technology's affordances, that technology is more likely to be positively received and used.

For example, Ravitz et al. (2000) found that constructivist-oriented teachers were more likely to use educational technologies in their classrooms, and to use them in more varied and more powerful ways than transmission-oriented teachers. The constructivist view of learning suggests that learners interpret and modify their own worldviews, strongly influenced by their own experiences and knowledge base (Jonassen, 1994; Tobin & Tippins, 1993). Constructivist teachers typically recognize the views of learners (Duit & Confrey, 1996) and provide technology-mediated experiences that help learners make sense of the world and interpret new information in light of what they already know. From a social constructivist perspective, learning experiences are facilitated by social interactions involving learners constructing consensual meaning through discussions and negotiations with peers and teachers (Prawat, 1993). In contrast, a transmissive view of instruction considers information to be stored in the technology and to be received by students through didactic instructional methods, such as drill and practice tasks for rote learning, recall and reinforcement of concepts (Jonassen et al., 1999). In this way, students learn from rather than with technology (Jonassen & Reeves, 1996).

Several qualitative studies, however, reveal that practices with digital technologies are not always consistent with teachers' espoused pedagogical beliefs, including those aligned with contemporary student-centered theories of learning often evident in beginning teachers (Bate, 2010). Phillips (2010) found that inconsistencies between practice and beliefs about digital technologies were significantly affected by: teacher self-efficacy, skill, knowledge and professional development opportunities; perceived student skill level and knowledge; perceived influence of the school administration; and, the extent to which a teacher believes technology can enhance pedagogical practice and student learning. With respect to IWBs, Schuck and Kearney (2007, 2008) investigated their use in Australian classrooms with students aged 6-17 years old. While they found over 40 different uses of IWBs in the classroom, few teachers understood or fully exploited the technological capacity of IWBs, tending to use transmissive approaches when using them. Instead of using the IWB as a portal to other technologies and to leverage more interactive pedagogies, teachers tended to use them mainly for presentational purposes. While capitalizing on the colors and fonts offered to enhance presentation, teachers did not tend to employ the links to other sites for student investigation, nor did they use the capacity to electronically poll students to understand their beliefs or use the IWB to encourage collaborative use of facilities such as Google Earth or maps in project development. Other Australian research undertaken by Lee (2010) found that teachers initially maintained their existing pedagogical styles with the technology, ranging from strongly teacher-centric to strongly student-centric. After taking about a year to become comfortable with the technology, teachers began to explore new ways of using IWBs, most notably as digital hubs (Lee, 2010, p. 138).

When teachers use IWBs, research has identified that planning and preparation, selection of classroom resources and abilities to teach for interactive learning are among the pedagogical practices that are modified, but changes to pedagogical practice are influenced by various "background" factors, such as teacher beliefs, experiences and educational context (e.g., Cogill, 2010). Following his study of IWB use, Beauchamp (2004) developed a generic progressive framework and developmental model guiding teacher progress in IWB use, emphasizing that varied needs require addressing if technologies are to be used effectively. He noted that technical competence and pedagogical skills were critical, but also that a supportive transition was vital and required synergy between teachers and the technology. Similarly, this study proposes that a framework of synergy between teacher pedagogy and comfort with the technology in question, as well as opportunities to realize such opportunities through adequate accessibility, enables teachers to realize a more comprehensive usage of a given technology.

3. Research design

3.1 Conceptual framework

Teachers' use of information and communication technologies (ICT) cannot be explained in terms of isolated factors. Rather, such use is influenced by a range of interacting factors including teachers' technological knowledge and attitudes to technologies (Perrotta, 2013; Voogt &Knezek, 2008), along with teachers' preferences with respect to approaches to instruction (Ravitz et al., 2000). Ertmer et al. (2012) distinguished between first and second order barriers. First order barriers comprise external factors such as resources and support while second order barriers are teacher-related, such as confidence and beliefs about the worth and efficacy of a technology. Both sets of barriers are considered in this study, including: pedagogy; teachers' concerns regarding the technology; accessibility to the technology; and, level of schooling taught (see Figure 1). We now explore these particular components and hypothesized effects.

< Insert Figure 1 (conceptual model) about here>

First, consistent with Ravitz et al. (2000), we hypothesize that where teachers' pedagogical beliefs are more aligned with constructivist than transmissive orientations, they will be more likely to use the IWB technology more. We suggest that teachers who mainly exhibit a constructivist-oriented approach may be more open to finding tools and activities that can relate ideas in ways that adapt to learners' beliefs. In contrast, teachers preferring transmissive instruction are identified as providing their own explanations, prescribing reading materials, and emphasizing procedural repetitive practice. As such, an expansive adoption of a technology such that all capabilities and functionality are explored is arguably better suited to constructivist teaching, where the how and when of learning is less defined. We expect that full exploration of IWBs appears to be better suited to learning environments that are less prescriptive in teaching practice, where more fluidity, randomness and openness to engagement with methods, contexts and student beliefs is apparent.

At the same time, however, engagement with and extensive adoption of technologies requires recognition of the competency and concerns of users themselves (Hall et al., 2013). That is, while we hypothesize that those with more constructivist pedagogies may be more embracing of technologies that allow flexible forms of engagement, a teacher without knowledge or confidence in such technologies may be hesitant to utilize these, consistent with the SoC model.

In a study about adoption and use of technology, it is important to consider barriers relating to accessibility. Specifically, whilst many teachers may be more open to the idea of extensively using a technology due to their pedagogical alignment and prowess in using technology, issues of limited resources preventing immediate availability of a given technology may not allow them to readily and easily do so. From a psychological perspective, we also predict that the physical proximity of having a technology in the classroom alters the psychological distance associated with inferences about its preparation for use or incorporation in teaching activities (Trope & Liberman, 2010). It is predicted that those without ready access to a given educational technology will be more concerned about the ease with which the technology can be utilized, leading to lower levels of adoption (Aubusson et al., 2014; Burke, 2013).

In the next section, we describe how we operationalized the measures and tested the hypothesized effects relating to this first order factor and the aforementioned second order factors (pedagogical orientation; SoC).

3.2. Methods

The research comprised two phases. First, focus groups were conducted to inform the development of the survey instrument targeting technology choices, in the context of Australian teachers' use of IWBs. Five focus groups comprising a total of 35 teacher participants, teaching students from K-12 (4-18 year olds) in government and non-government schools in NSW, Australia, were conducted. These revealed various ways that teachers were using IWBs, an important input into the proposed scale of usage. The discussions also confirmed the journey that teachers embark on in using technology, consistent with the SoC model. Second, a quantitative survey instrument was developed to collect a range of information to estimate a structural equation model (SEM) to investigate the relationship between IWB levels of usage and several factors including teachers' pedagogical beliefs, SoC, and their access to the technology.

3.2.1 Participants

We surveyed 200 Australian teachers, equally split amongst those working in primary school settings (teaching students aged 4 to 12) and secondary school settings (teaching students aged 12 to 18). A total of 44 respondents were excluded because they either had no access to, or had never seen, the

IWB technology. Among the remaining 156 teachers, some had immediate access to an IWB in their classroom (55%), others could access an IWB by having it brought into the classroom they used (8%) or by booking a classroom in which the IWB was installed (37%). Respondents came from all Australian states and territories, including government (67%) and non-government (33%) schools, as well as remote (6%), rural (27%) and metropolitan (68%) schools. The majority of teachers were female (76%) and working full-time (59%). A range of teaching experience was evident with 32% having five or less years of experience, whilst 28% had more than 20 years of experience. The average age of respondents was 43 years.

3.2.2 Survey Development

The survey instrument included several types of measures. First, we developed a reflective measure of technology use. Second, based on Ravitz, et al. (2000), we modified an instrument to measure pedagogical orientation, which was subsequently reduced and validated. Third, we utilized the SoC framework of Hall et al. (1977). We now provide more detail about these measures.

Measure of extensive technology use

We formulated a reflective measure of a teacher's technology use. The scale consisted of an ordinal indicator of whether teachers use the technology (IWB) as part of their lessons (never; rarely; primarily as a starter activity; throughout the whole lesson) and whether it is a regular feature in their classrooms. In addition, a series of binary indicators indicating frequent use of various applications on the IWB were included. These indicators were based on exemplary practices noted by the focus groups. The complete list of indicators and distribution of responses to these items are presented in Table 1.

<Insert Table 1 about here >

Measuring pedagogical orientation

A reflective measurement approach was used to characterize teachers in terms of whether they were constructivist-oriented or transmission-oriented, using items provided in Ravitz et al. (2000). Four measures asked teachers to indicate which perspective they agreed with most in relation to two contrasting statements about pedagogy (transmission or constructivist oriented). Seven measures asked teachers whether they agreed with various aspects of the transmission versus constructivist pedagogy. The summary of the 11 items is presented in Appendix 1.

A binary ‘agree’ or ‘disagree’ response scale was used. This choice of scale was motivated by our ambition to make the task easier for respondents to complete, to reduce overall response times, to force discrimination of teachers across the items, and supported by growing evidence that the use of such indicators does not compromise measurement reliability (e.g., Dolnicar, Grün, & Leisch, 2011; Romaniuk, 2008). It also avoids various forms of response style bias, which arises when different people use various parts of the scale to indicate the same underlying response or avoid certain elements of the numerical scale, such as its end-points (Baumgartner & Steenkamp, 2001).

Measuring Stages of Concern

To classify teachers with respect to their SoC, we used the original instrument from Hall et al. (1977), replacing the word “innovation” with “interactive whiteboards” or “IWBs.” This instrument has been extensively used (e.g. Christensen, 2002; Dunn & Rakes, 2010). The original instrument contains five items representing each of the seven SoC for a total of 35 items. To avoid idiosyncratic rating scale responses and to encourage greater discrimination among the teachers in relation to the SoC stages, we used a best-worst scaling (BWS) approach (Finn & Louviere, 1992; Marley & Louviere, 2005). A BWS task involves listing a set of items and asking respondents to select two items, one that most and one that least satisfies the question criterion, rather than rating each item independently. A more detailed description of BWS and its use in education is in Burke et al. (2013).

Each teacher answered seven BWS questions, with each BWS question containing four of the 35 original items. The four items corresponded to a different SoC and each teacher was asked to indicate which one of these was the most concerning about the IWB and another of these as the least concerning about the IWB. Each of the seven stages of concern were given an equal opportunity to be nominated as most or least concerning by teachers. To do so in a way that also minimized the number of BWS questions a teacher undertook, a Balanced Incomplete Block Design (BIBD) was used. Subsequently, across the seven BWS questions undertaken, a teacher saw each of the seven SoC an equal number of times (four times in total) and evaluated each stage with every other stage an equal number of times (two times in total). One drawback of this approach is that each teacher saw 28 out of the 35 original items only and items within each SoC did not appear together in the same question. As such, in using this approach, we must assume that each item is a reflective measure of its corresponding SoC construct and that the reliability of the instrument in this regard cannot be formally assessed.

Individual BWS scores for each teacher for each stage were calculated using the difference between the frequencies with which stages were selected as an area of most concern and of least concern (Marley & Louviere, 2005). As a result of the BIBD design, the BWS scores for each SoC are linearly dependent, so that the BWS score of any one SoC can be calculated from the negative sum of the six other BWS scores. In turn, only six parameters are free to be estimated in the model. The estimate of the reference SoC is parameter estimate is recovered by calculating the negative sum of the six other coefficients.

4. Analysis and results

4.1 Quality of the underlying constructs

The psychometric properties of the technology (IWB) usage scale were assessed using exploratory (EFA) and confirmatory factor analysis (CFA) using the Mplus package version 7.2 (L.K. Muthén & Muthén, 2012). This software is well suited to estimating structural models involving categorical measures, using a threshold structure that projects the probability of a given categorical response onto a continuous distribution. In relation to IWB usage, an EFA and CFA indicated that all items loaded onto a single factor, with the exception of items relating to use of the IWB with Microsoft

PowerPoint (u7) or for video playback (u8). Issues with model convergence were encountered as very few respondents used the IWB for video conferencing (u9); this item was removed from the analysis. The CFA measures of fit for the final single factor model involving seven items indicated an appropriate model with the probability of the root mean square error of approximation (RMSEA) being less than .05 ($p=.133$) and a high comparative fit index (CFI) of .992, where fit values above .9 are acceptable (Bagozzi &Yi, 1988). The Composite Reliability (CR) of the resulting scale was 0.911 with the construct validity measured by Average Variance Extracted (AVE) as 0.618, which are both above the ideals of 0.7 and 0.5 for CR and AVE, respectively (Malhotra, 2010). The weighted root mean square residual (WRMR) for the CFA was 0.678, indicating good fit as it is less than 1.0 (Yu, 2002). The χ^2 test of model fit was 20.69 with 14 degrees of freedom, resulting in a normalized chi-square (χ^2/df) of 1.48, well below the benchmark of 2 (Bagozzi & Yi, 1988). In short, the reflective model capturing levels of usage of the IWB technology by a teacher has excellent measurement properties.

The measurement properties of the reflective scale describing constructivist-transmissive pedagogy were not originally assessed by Ravitz et al. (2000), so we subsequently did so using EFA and CFA. Item c4 was excluded from analysis since very few teachers agreed with the statement suggesting that, given their superior knowledge, they should explain answers directly to students. Also, an EFA revealed some suggestion that the 11 items may be represented by two rather than one underlying latent construct, but a CFA found this second factor was explained by one item (c9) with significant cross-loading onto the first factor, with other items (c3, c5) non-significant. After further removing items based on low factor loadings ($\lambda<0.4$), the final measurement model had a single factor measured by four items. The CR of the resulting scale was 0.782. The removal of c8 also saw the AVE increase to above 0.5, but without significant change to the model. Consequently, it was retained in the final model presented. As such, the resulting AVE for the final latent construct was slightly under the frequently cited cut-off value of 0.5; however, we retained the four-item measure on the basis of the acceptable model fit for the individual construct, face validity, and the more conservative nature of the AVE measure (Malhotra, 2010). Overall, the CFA measures of fit indicated an appropriate measurement model of constructivist pedagogy indicated by RMSEA less than .05 (p=.167), CFI=.969, WRMR of .62 and normalized χ^2 value of 1.80, again all in line with suggested benchmarks (Bagozzi & Yi, 1988). Hence, the reflective model capturing whether a teacher is constructivist or transmissive in their pedagogical approach has excellent measurement properties.

<Insert Table 2: Reflective Measures here>

The measures of a teacher's SoC relating to the technology utilized the same 35-item questionnaire devised by Hall et al. (1977), but used a BWS approach to maximizing differences in SoC to better classify teachers. The results demonstrate that, on average, teachers in the sample mostly identified themselves with either collaborative or refocusing stages, and least identified themselves with concerns relating to awareness, personal or management issues pertaining to IWBs. Negative correlations between constructs indicated that, as theorized by Hall et al. (1977), teachers identifying with earlier SoC beyond awareness (e.g., informational) are less likely to identify themselves with concerns exemplified in latter stages of the model (e.g., consequence).

4.2 Structural model of IWB technology usage

The overall structural relationship involving IWB usage and its various antecedents was estimated using a multiple indicators multiple causes (MIMIC) model (Diamantopoulos et al., 2008; Jöreskog & Goldberger, 1975). That is, the model of IWB usage was measured using a set of reflective measures of IWB usage and simultaneously predicted by the aforementioned exogenous constructs (see Figure 2). These antecedents included a reflective measure of constructivist-compatible beliefs, single-item BWS derived terms measuring SoC regarding the IWB technology, and an exogenous variable accounting for a teachers' ability to easily access the IWB technology in terms of whether it is located in the classroom in which they teach or accessible via other means. Overall, all indicators of model fit provide support for the proposed theoretical model (RMSEA below .05: p=.697; CFI=.934; WRMR=.952; χ^2/df=1.315). We now discuss the results relating to the final model estimates (see Figure 2).

<Insert Figure 2 about here>

4.3 Determinants of teacher IWB usage

The model estimates confirm that IWB usage is significantly affected by a teacher’s pedagogical beliefs, their concerns about the technology and their immediate access to the technology in the classroom (see Table 3). The strongest determinant of IWB usage is whether a teacher has an IWB in their classroom or not: those with immediate access to the IWB are more likely to be characterized by stronger levels of usage (γ=.425; $p<.001$). Teachers identifying more with a constructivist-oriented pedagogy are predicted to have higher levels of IWB usage in the classroom (γ=.212; $p<.01$). Secondary school teachers are found to be less likely to be aligned with constructivist pedagogy (γ=-.224; $p<.05$), whereas there is no remaining significant effect in schooling determining a teacher’s use of IWB, reinforcing the indication that usage is determined primarily by the available access to the technology. The lack of discernible difference in technology use among primary and secondary teachers parallels work by Teo (2014) who reported similarities among pre-service teaches in technology acceptance.

<Insert Table 3 about here >

Finally, technology usage was strongly predicted by how teachers are categorized with respect to the SoC model (see Figure 3). Teachers exemplified by awareness or informational concerns are predicted to have significantly lower levels of usage, whilst those concerned most by IWB related management tasks are predicted to have medium usage levels. Those teachers focused more on how the technology affects students learning or collaboration with others is predicted to have significantly higher usage levels. Finally, teachers identifying most with the final SoC (i.e., refocusing), are predicted to return to lower levels of IWB usage.

<Insert Figure 3 about here >

5. Discussion

This study found that the important determinants of technology usage include teachers' access to the technology, their Stage of Concern regarding technology adoption, and their particular pedagogical orientation. The strongest determinant of technology usage by teachers in this study was immediate and ready access. The implications of this are significant in highlighting the importance of ensuring technologies are available in classrooms for "just in time" use. Having to plan for access to technologies in particular times and places is a significant disincentive to their use in classrooms. This is consistent with Glover & Miller's (2002) observation in their own research that the degree of access can negatively affect lesson development and planning, as well as spontaneity. This finding also reinforces Ertmer et al.'s (2012) argument that to initiate and sustain effective technology-enhanced learning requires facilitating adopters to overcome first level barriers. However, this routine access to technology is not under the control of teachers. It requires actions, expenditure, support and commitment from policy makers and administrators within and beyond the school, as noted by Somekh (2008).

Teachers' Stage of Concern (SoC) was found to predict their use of technology, indicative of a hierarchical model of adoption (Rogers, 2010). As such, the findings provide evidence that a progression using technologies occurs as proficiency develops and concerns about others (e.g., colleagues; students) become more evident. The highest levels of IWB usage occurred among those more concerned about how the technology would affect students and among those with a stronger desire to collaborate with colleagues in their use. This dynamic situation indicates that policy makers in schools should assist teachers in allowing them to overcome concerns in order to move to the next stage in the model, through adequate training or supporting resources. However, after teachers become familiar and facile users of a technology, they may be ready to seek replacement technologies and pedagogies to enhance learning. Encouraging collaboration among teachers at different SoC may be beneficial not only for those teachers seeking to collaborate, but also for those looking to learn how a given technology can offer value in their teaching. In their study of IWB usage in the UK, Glover and Miller (2002; 2003) noted that this type of change, which they refer to as “peer persuasion”, successfully occurred in cases where tentative teachers were the majority.

Teachers with constructivist rather than transmission pedagogical orientations were more likely to use the IWB technology, consistent with Ravitz et al.’s (2000) study of computer use among teachers. In other research, IWBs have been viewed as a non-disruptive educational technology characterized by presentational and transmissive use (Hedberg, 2006; Kennewell & Beauchamp, 2007; Schuck & Kearney, 2007). From this viewpoint, the finding that constructivist orientations are associated with higher IWB use is surprising. However, this is entirely consistent with our hypothesized effects based on the argument that IWBs are open to teachers with less prescriptive practice, with the IWB technology more enabling of approaches where fluidity, randomness and openness in contexts and student beliefs can be supported.

It would be fruitful to investigate questions around reverse causality in the framework presented. Our research argued that pedagogical orientation was a significant driver of technology use. On the other hand, in the context of computer use in classrooms, Becker (2000) suggested that there is potential merit in also understanding whether technology use leads to changes in pedagogical orientation. As Becker (2000) argues, however, such dynamic effects require methods that allow changes within the same teacher to be observed over time rather than comparisons across teachers in different environments using cross-sectional data. As such, one avenue for future research would be to examine whether the use of interactive whiteboards and other learning technologies lead to new opportunities for a teacher and inspire self-reflection on their own practices, and whether such changes affect how they approach student learning over time.

6. Conclusion

Informed by socio-cultural perspectives, Somekh (2008) highlighted the role played by "inter-locking cultural, social and organizational contexts" (p. 450) on teachers' use of ICT, arguing that these complex factors need consideration if schooling is to be transformed by ICT. She discussed cultural drivers that might influence this adoption, such as legislative frameworks and organizational structures of schooling. Our study provides evidence that the promotion of effective use of technologies in schools requires routine access to educational technologies and that teachers are supported as they move through SoC. Furthermore, it may be that as teachers progress to the final SoC with a particular technology, opportunities should be provided for them to explore their use of another educational technology or to collaborate with other teachers in earlier stages.

The study suggests it may be more cost-effective to promote emerging technology adoption for educational purposes among constructivist-oriented teachers. However, a consequence of the exclusion of transmissive-oriented teachers may be the perpetuation of more traditional, transmissionist classes taught by this group of teachers. Alternatively, professional development with teachers could address their fundamental underlying pedagogical orientations because the needs and expectations of constructivist-oriented teachers appear to be quite different from those of transmission-oriented teachers.

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Appendix 1. Reflective measures for constructivist oriented and transmission oriented pedagogical latent construct

Item	Statements	Coding	Transmission	Constructivist
c1	Students will take more initiative to learn when they feel free to move around the room during class	C	58%	42%
c2^	Students should help establish criteria on which their work will be assessed	C	28%	72%
c3	Instruction should be built around problems with clear, correct answers, and around ideas that most students can grasp quickly	T	63%	37%
c4	Teachers know a lot more than students; they shouldn't let students muddle around when they can just explain the answers directly	T	15%	85%
c5	How much students learn depends on how much background knowledge they have - that is why teaching facts is so necessary	T	51%	49%
c6^	It is better when the teacher - not the students - decide what activities are to be done	T	45%	55%
c7	A quiet classroom is generally needed for effective learning	T	38%	62%
Item	**Paired Comparison Items**	**Coding**	**Transmission**	**Constructivist**
c8a^	I mainly see my role as a facilitator. I try to provide opportunities and resources for my students to discover or construct concepts for themselves.	C	38%	62%
c8b	That's all nice, but students really won't learn the subject unless you go over the material in a structured way. It's my job to explain, to show students how to do the work, and to assign specific practice.	T		
c9a	The most important part of instruction is that it encourages "sense-making" or thinking among students. Content is secondary.	C	21%	79%
c9b	The most important part of instruction is the content of the curriculum. That content is the community's judgment about what children need to be able to know and do.	T		
c11a	While student motivation is certainly useful, it should not drive what students study. It is more important that students learn the history, science, math and language skills in their textbooks.	T	23%	77%
c11b	It is critical for students to become interested in doing academic work - interest and effort are more important than the particular subject matter they are working on.	C		

T: Statement more aligned with transmission-oriented belief; C=more aligned with constructivist orientation; ^ Item included in final measurement model; Percentage represents proportion of respondents agreeing with perspective or selected from paired comparison.

Table 1. Reflective measures of IWB usage latent construct.

Item	**I use an IWB as part of my lessons:**	**% Respondents**
u1	Never/Rarely	42%
	Primarily as a starter activity	33%
	Throughout the whole lesson	25%

Item	**I frequently use the following applications or tools on the IWB:**	**% Agree**
u2	As a whiteboard for drawing, notes, etc.	78%
u3	Games and other activities made possible by the board	56%
u4	Prepared lessons	58%
u5	Smart resources	56%
u6	Connection to the Internet	72%
u7	Microsoft PowerPoint	63%
u8	Video playback	61%
u9	Video conferencing	7%

Item	**Please indicate whether you agree or disagree with each statement:**	**% Agree**
u10	An IWB is a regular feature in my classroom	39.1%

Table 2: Reflective model measures.

Item	**Usage of IWB (η)**	**Est. λ**	**t-val**	**R^2**	**CR**	**AVE**
u1	Use of IWB as part of lesson	0.734	11.067	0.539	0.911	0.618
u2	As a whiteboard for drawing, notes, etc.	0.807	13.756	0.651		
u3	Games and other activities made possible	0.852	21.067	0.726		
u4	Prepared lessons	0.779	13.939	0.607		
u5	Smart resources	0.768	12.835	0.590		
u6	Connection to the Internet	0.808	14.075	0.653		
u10	Regular feature in classroom	0.749	11.122	0.561		

Item	**Constructivist-Orientated Pedagogy (ξ)**	**Est. λ**	**t-val**	**R^2**	**CR**	**AVE**
c2	Students establish criteria for assessment	0.700	6.886	0.490	0.782	0.477
c6R	Teachers decide activities	0.628	5.311	0.394		
c8	Teachers facilitate opportunities to discover	0.581	5.644	0.338		
c10	Variety of activities	0.829	8.413	0.687		

Note: c6R was reverse coded to be a positive measure of constructivist approach.

Table 3: Structural measures/component.

Impact on Constructivist Pedagogy by:	**Est. γ**	**S.E.**	**t-val.**	**sig.**
Secondary School Teacher	-0.224	0.103	-2.180	**

Impact on Usage of IWB by:	**Est. γ**	**S.E.**	**t-val.**	**sig.**
Constructivist-Orientated Pedagogy	0.212	0.070	3.017	***
Access to IWB (in-class=1; bookable=-1)	0.425	0.080	5.320	***
Secondary School Teacher	-0.059	0.076	-0.784	n.s.
Stages of Concern:				
Awareness	-0.249	0.089	-2.810	***
Informational	-0.165	0.106	-1.563	n.s.
Personal	0.038	0.098	0.391	n.s.
Management	-0.013	0.091	-0.143	n.s.
Consequence	0.213	0.090	2.359	**
Collaboration	0.255	0.092	2.785	***
Refocusing	-0.079	0.090	-0.875	n.s.

*/**/*** significant at the .10/.05/.01 level;

Figure 1: Conceptual model.

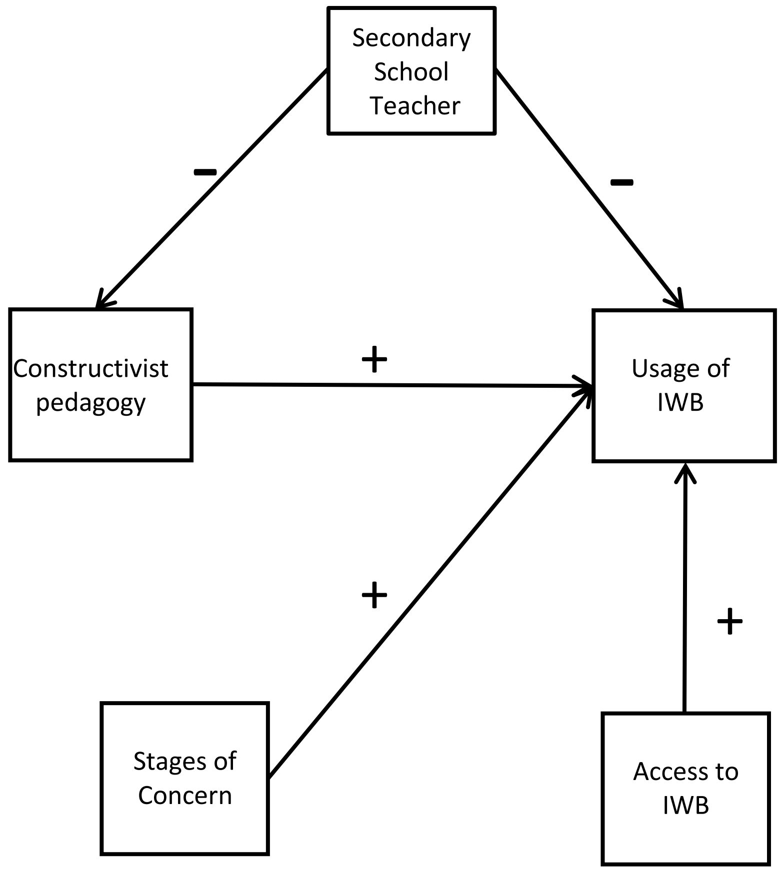


Figure 2: Results for Structural Equation Model.

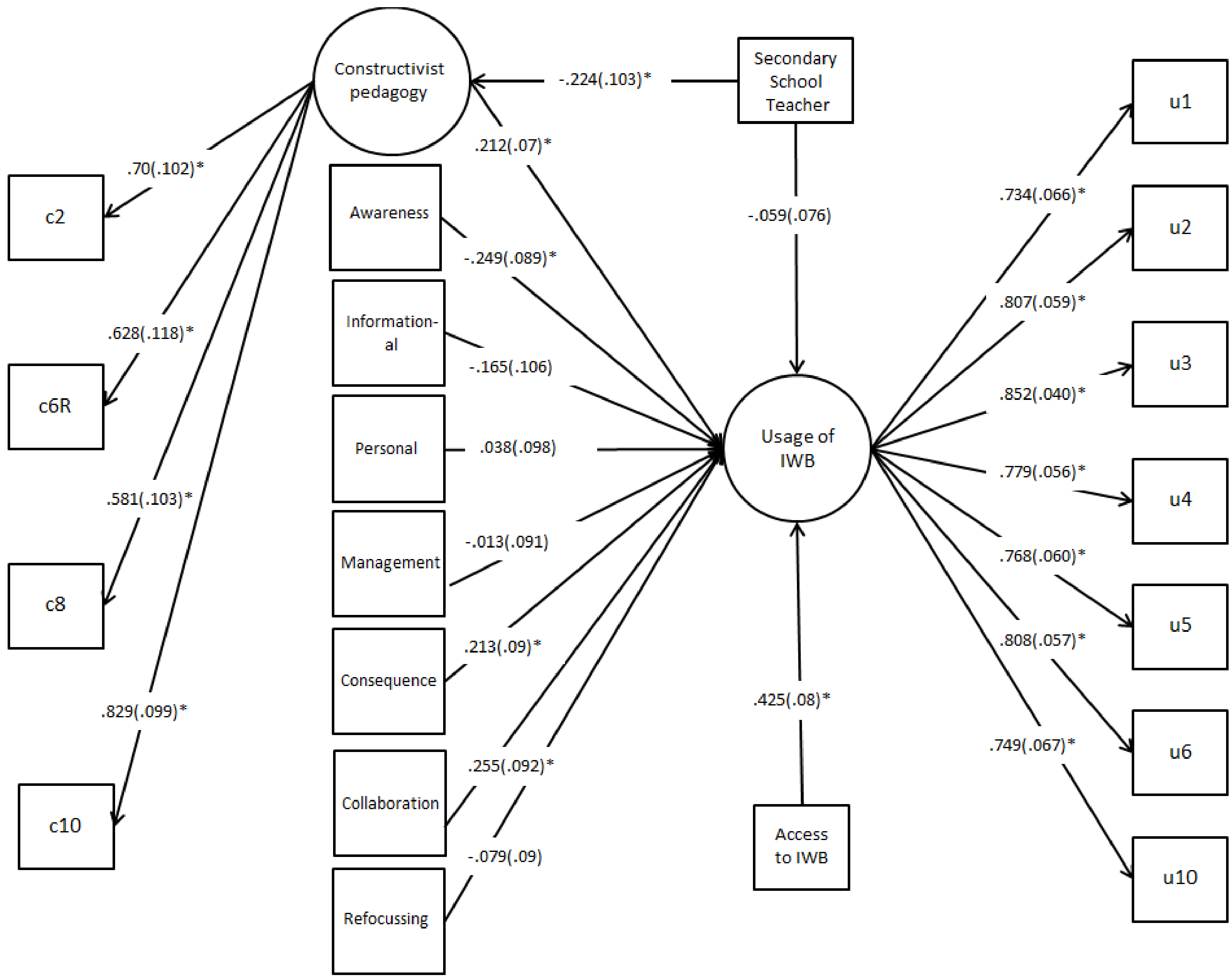
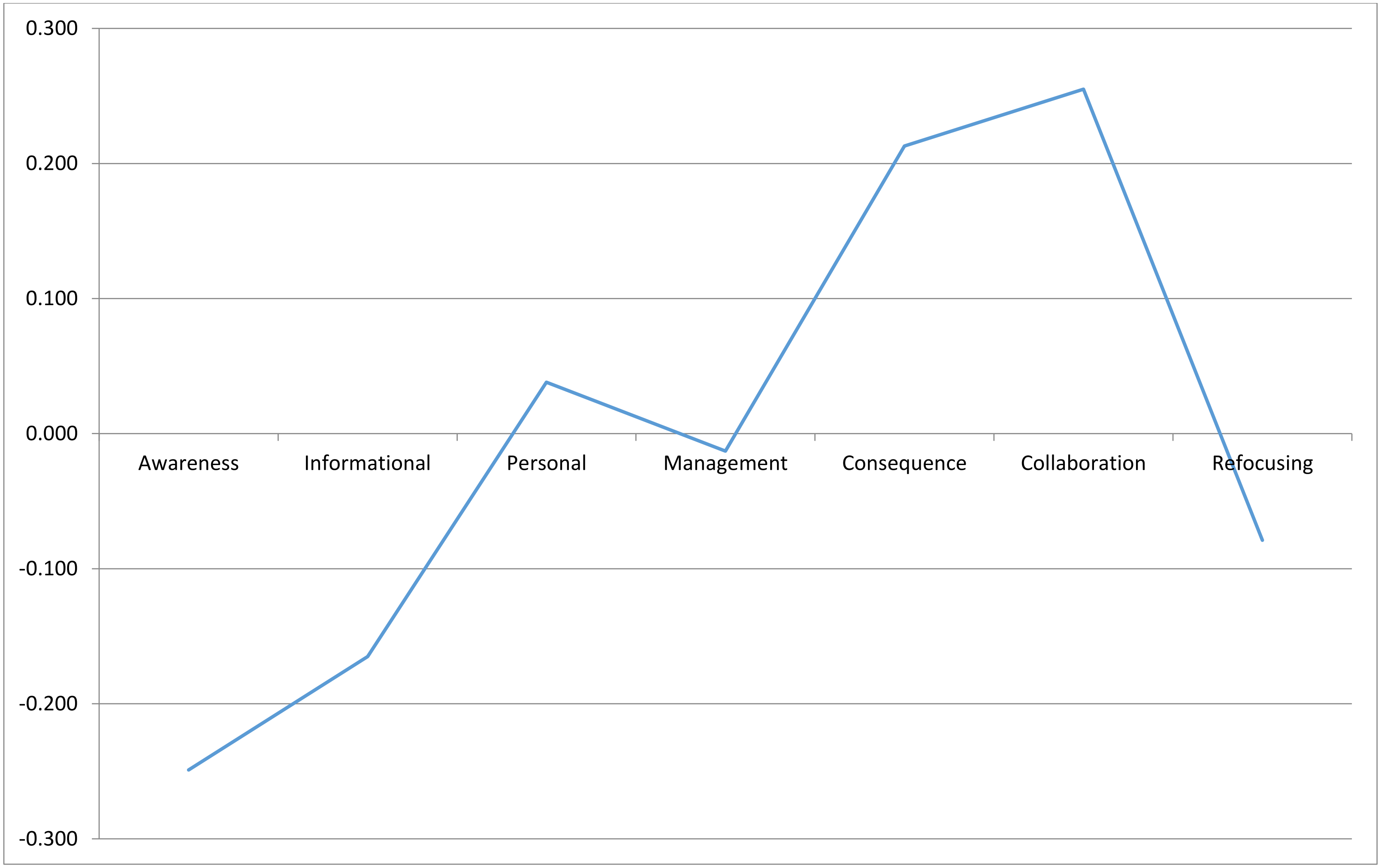


Figure 3: Predicted latent IWB usage by Stages of Concern.



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Selected other works of the authors that may be of interest to the reader:

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