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Does social capital matter? A quantitative approach to examining technology infusion in schools

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Abstract Changing teachers' perceptions about the value of technology and equipping them with appropriate knowledge and skills in pedagogical use of technology is often regarded as a key determinant of success in technology infusion in schools. However, recent studies have indicated that changing teachers' epistemological beliefs about the use of technology in teaching and learning may not necessarily bring about change in their practice, and that technology implementation in schools can be affected by other instrumental forces, such as collegial trust, support for risk taking and access to expertise within an organization. In this article, we delineate collegial trust, access to expertise, willingness to take risks, etc. as manifestations of social capital in an organization. We argue that social capital plays a pivotal role in leveraging pedagogical change in schools. To gauge teachers' self-perceived change in their pedagogical use of technology, we take a constructivist perspective to explore how technology serves as a tool for facilitating students to articulate their thoughts, to explore and construct knowledge, and to become more autonomous in learning. The results of our questionnaire survey indicate that (1) the social capital of a school had a strong direct effect on teachers' self-perceived changes in their pedagogical use of technology, and that the effect of social capital on pedagogical change outweighed that of teachers' perceived effectiveness of professional development; (2) teachers' receptivity towards technology use had a direct effect on their perceived effectiveness of professional development but a very weak effect on fostering changes in their pedagogical use of technology; and (3) the social capital of a school had a direct influence on teachers' receptivity towards technology use and their perceived effectiveness of professional development. To further unfold the complexity of technology implementation, more in-depth qualitative studies on how social forces shape the change process are deemed necessary.

Keywords educational change, social capital, structural equation modeling, technology infusion.

Introduction

Infusion of technology in education, as a global phenomenon, has become one of the top priorities on the education reform agenda in many countries (Atjonen & Li, 2006; Law, Pelgrum, & Plomp, 2008; Mioduser, Nachmias, Tubin, & Forkosh-Baruch, 2002; Pelgrum & Anderson, 1999). Technology infusion in schools is often regarded as more intricate and challenging than other system-wide initiatives. In particular, owing to the fast emergence of information and communication technology, there is often no prior pedagogical knowledge about its usage. As such, effective technology

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implementation in schools hinges on teachers' pedagogical insights and willingness to experiment with the emerging technology. Conventional models of technology infusion generally suggest that changing teachers' perceptions of the value of technology and equipping them with relevant pedagogical skills through proper teacher professional development programmes is one of the key determinants of success in integrating technology into schools (Li, 2010; Sugar, 2005). These models are premised on the belief that educational change can be effected in a rational manner. Thus, through showcasing and modeling exemplary practices, teachers will assimilate, accommodate, adopt, adapt and eventually appropriate the necessary change (Mioduser *et al*., 2002). Fung (1995) argues that teachers will adopt a new practice if they see it benefit learning and work well in classroom situations similar to theirs. Teachers' professional knowledge and skills are thus regarded as a pivotal driving force for change (Cheng, 1994; Frank, Zhao, & Borman, 2004; Law, 2000; Matzen & Edmunds, 2007; Zhao & Frank, 2003). To facilitate knowledge dissemination, system-wide training models such as the cascade model, fan model and train-the-trainer model were commonly adopted by the education authorities in various countries (Li, 2010; MOE, 2004). While these models of training are able to induce a cascade effect on knowledge dissemination in a short time frame, they have been criticized for failing to address the diverse needs of individual classrooms. The design of most professional development programmes on technology implementation in schools is underpinned by the belief that change can be effected in a rational manner. This rational approach to change management is confronted by Li (2010) and Karagiorgi (2005). They argue that changing teachers' epistemological beliefs and receptivity towards technology use does not necessarily bring about change in real practices. Notably, some teachers remain reluctant to try out new practices, though they are positively inclined towards technology or conceptually convinced of its pedagogical value, and teachers' adoption of technology can be governed by a myriad of irrational and motivational factors. Sergiovanni (1995) describes educational change as highly perishable goods and argues that their sustainability hinges on more instrumental social forces, such as collegial trust, support for risk taking, access to colleagues' expertise, collaborative culture within a school, and that change will take root only when it is inherent in the life of a school. Li (2010) and Coleman (1988) regard these social forces as the manifestations of social capital in an organization. They point out that previous research on technology infusion in schools has generally centred on the effects of three groups of factors: (1) connectivity, access to technology and technical support (Zhao & Frank, 2003); (2) time-tabling and school leadership styles (Cuban, 2001); and (3) teachers' receptiveness towards pedagogical use of technology (Bober, 2002). There have been very few empirical studies highlighting the relevance of social contexts, social forces and social support to technology infusion in schools. To bridge this gap, we conducted a questionnaire survey with a sample of 1100 teachers from 130 schools with an aim to gauge the impact of social capital as well as professional development and teachers' receptivity on technology infusion in schools. Our study set out to investigate the extent to which teachers' access to social capital of a school might affect their pedagogical use of technology in comparison with the effects of professional development and teachers' receptivity towards technology use. We argue that social capital plays a pivotal role in leveraging change in schools and has a direct effect on teachers' use of technology in their professional practice. In the following section, we will explore the theoretical underpinnings of social capital and its relationships with managing change in schools.

Social capital and organizational learning

In the discourse of technology infusion in schools, Smylie and Hart (1999), Li (2010), and Frank *et al.* (2004) redress the importance of social contexts and social capital for bringing about change in schools, and argue that teachers' informal learning through differential social processes impacts significantly on the course of educational change. Social capital is an intangible resource deriving from the relationships among individual members of an organization, and from the social structures that facilitate the development of those relationships (Smylie & Hart, 1999). Similar to other forms of capital (such as financial capital), social capital can accrue, and be drawn on, to expedite certain individual or collective actions within a social structure. Coleman (1990) describes social capital as an organizational

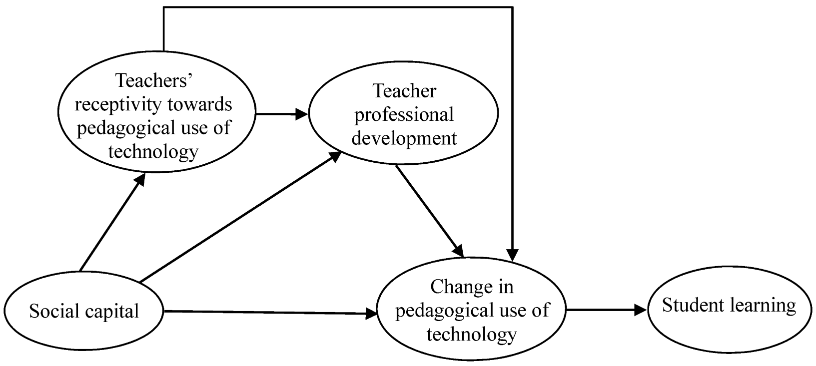

Figure 1 A Framework for Conceptualizing ICT Implementation in Schools

resource constituted by (1) social trust, norms and shared expectations; and (2) channels for new information. In a similar fashion, Hargreaves (2011) defines social capital in terms of its cultural and structural components. He associates the cultural element with the level of trust among stakeholders and the generation of norms of reciprocity, and the structural part with the networks for new information. According to Coleman (1990) and Van Maele and Van Houtte (2011), social trust provides the basis for reciprocal action, mutual support, shared accountability and collective endeavour. Further, social trust creates a context of predictability and stability for genuine, open dialogues, as well as for critical reflection and risk taking when individuals are confronted with the need for change. The second element of social capital consists of useful networks that may provide channels for new information beyond an individual's immediate community. Such channels may extend a person's access to information possessed by other members who are affiliated to multiple social structures. Smylie and Hart (1999) argue that these channels can be educative by providing new insights that help inform decisions and actions. Social capital is thus regarded as an important asset that individual members of an organization can utilize to promote change and organizational learning (Hargreaves, 2011; Van Maele & Van Houtte, 2011).

In the discussion of leadership for educational change, schools are often construed as complex and loosely coupled organizations (Li, Pow, Wong, & Fung, 2010; Uekawa, Aladjem, & Zhang, 2006). Fullan (1999) points out that educational change is a complex process, and that change is not a blueprint but a journey that entails uncertainty with positive and negative forces of change. Some teachers are reluctant to change by following top-down orders that deprive them of a sense of ownership in the implementation process. Thus, to facilitate change in a more effective way, schools are more inclined to informal social processes rather than to a bureaucratic or mechanistic chain of actions (Hew & Brush, 2007; Robertson, Grady, Fluck, & Webb, 2006). Smylie and Hart (1999) and Li (2010) argue that social capital, underpinned by human relationships and interactions, is an important resource that helps sustain change in an organization by making teacher professional learning seamlessly inherent in the life of a school. Technology infusion in schools is deemed to be a complex process governed by an array of organizational factors (Kwahk & Kim, 2008; Li, 2010; Robertson *et al*., 2006; Zhao & Frank, 2003), and yet our understanding of the interplay of these factors remains obscure (Li, 2010; Penuel, 2006). In this article, we will explore the interplay among social capital, professional development, teachers' receptivity towards technology, teachers' pedagogical use of technology, and student learning through structural equation modeling. The results were derived from a large-scale comparative study on technology implementation in schools (Wong & Li, 2011). The basic framework of our study is depicted in Figure 1. We hypothesize that (1) social capital, like teacher professional development and teachers' receptivity towards technology, plays a significant role in leveraging change in teachers' pedagogical use of technology; (2) social capital has a direct effect on teachers' receptivity towards pedagogical use of technology and on their perceived impact of professional development; and (3) change in teachers' pedagogical use of technology enhances student learning. We argue that if change is conceived as a process of organizational learning, the affective and social dimensions of teachers' capacity building should not be neglected.

Methods

Participants

To gauge teachers' views on technology infusion in their schools, a questionnaire was administered to 1076 teachers from a convenient sample of 130 schools which was about 10% of the public school population located in the 18 school districts of the entire territory of Hong Kong. Of the 130 sample schools, 53% were primary and 47% were secondary, resembling the school distribution of the wider population. In each sample school, nine to ten teachers from a variety of subject areas, such as languages, mathematics, humanities, science, technology, art and physical education, were invited to participate in the survey. Of the 1076 teachers, 61.8% were female and 38.2% were male, with ages ranging from 20 to over 50, and the majority (35.4%) at the age of 31–40. Teaching experience of the teacher sample ranged from below 3 years to over 20 years, with nearly half of the sample population (42.8%) having teaching experience of over 10 years.

Instrument

The survey instrument for this study comprises six constructs: (1) *socap1* and (2) *socap2* are associated with teachers' perceived social capital in a school; (3) *cpd* on teachers' perceived impact of continuous professional development (CPD); (4) *recep* on teachers' receptivity towards pedagogical use of technology; (5) *pedagogy* on teachers' change in pedagogical practice; and (6) *learning* on teachers' perceived changes in student learning. The instrument consists of 30 items (which were trimmed down from 37 items), with a 4-point Likert scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*) to gauge teachers' perceptions of technology infusion in schools.

Perceived social capital in a school: socap1 *and* socap2

To understand and quantify how social processes within a school affect the infusion of technology, we follow the definition of social capital as suggested by Frank *et al*. (2004), Hargreaves (2011), Smylie and Hart (1999), and Van Maele and Van Houtte (2011), as discussed earlier. The operationalized concept of social capital is taken as the potential to access information and resources through social relations. Building on the framework proposed by Hargreaves, social capital is demarcated into cultural and structural components: *socap1* and *socap2*. The first component refers to school climate and the level of trust among stakeholders, while the latter refers to the networks for accessing new information. Drawing upon the notions of school climate and social trust expounded by Sergiovanni (1995), Smylie and Hart (1999), Van Maele and Van Houtte (2011), and Hargreaves (2011), the cultural component, *socap1*, is tied in with social trust, climate for risk taking, social cohesion, shared expectations and goals, and communication with school management; for example: (i) 'Teachers in our school manifest trust and team spirit' (social trust); (ii) 'Teachers in our school are willing to experiment with new ideas in classroom practice' (climate for risk taking); (iii) 'I have a sense of belonging to my school' (social cohesion); (iv) 'My educational beliefs align with the school goals' (shared expectations and goals); and (v) 'My opinions can be conveyed to the school management effectively' (communication with the school management). The structural component, *socap2*, is construed as the internal and external networks for new information within a school; for example: (i) 'Colleagues in my school share experiences of using information technology (IT) in education' (internal); and (ii) 'My school organizes sharing sessions for exchanging experiences of using IT in education with teachers from other schools' (external).

Perceived impact of teacher professional development: cpd

To measure the impact of professional development on teachers' pedagogical use of technology, *cpd* is associated with teachers' confidence, motivation and skills in using technology in their practice as suggested by Matzen and Edmunds (2007); for example: (i) 'My confidence in using IT in teaching and learning has increased after attending staff development programmes' (confidence); (ii) 'My motivation in using IT in teaching and learning has increased after attending staff development programmes' (motivation); and (iii) 'The IT policy on staff development of my school strengthens my classroom practice' (skills).

Teachers' receptivity: recep

To probe into teachers' receptivity towards pedagogical use of technology, *recep* is associated with teachers' willingness to enrich their pedagogical knowledge and skills in using technology to enhance their practice; for example: (i) 'I am eager to know how using IT can improve my current practice'; (ii) 'I am eager to know how my role will change when using IT in classroom'; and (iii) 'I am eager to know how other teachers use IT in teaching and learning'.

Perceived change in pedagogical use of technology: pedagogy

To track teachers' changes in pedagogical use of technology through a constructivist lens, technology is seen as a tool for facilitating students to articulate their thoughts, to explore and construct knowledge, and to achieve a greater sense of autonomy in learning (Jonassen, Peck, & Wilson, 1999). This new paradigm of learning has been one of the key objectives of the system-wide policy on technology infusion in Hong Kong schools. In our study, teachers' changes in pedagogical use of technology were not measured in terms of what or how technology was used (as it could be idiosyncratic and diverse), but in terms of whether technology integration helped enhance articulation of thoughts, knowledge exploration, knowledge construction and learner autonomy as exemplified by the construct of *pedagogy*; for example: (i) 'The use of IT in teaching and learning has enabled me to create more opportunities for students to express their thoughts and analyze information in the past two years' (articulation of thoughts); (ii) 'The use of IT in teaching and learning has enabled me to create more opportunities for students to determine their learning activities in the past two years' (learner autonomy); and (iii) 'The use of IT in teaching and learning has enabled me to create more opportunities for students to explore and to construct knowledge in the past two years' (knowledge exploration and construction).

Perceived student learning: learning

To probe into teachers' perceptions of the affective and cognitive dimensions of student learning, the construct of *learning* is associated with teachers' perceptions of students' learning motivations, enjoyment in learning, knowledge construction and mastery of generic skills; for example: (i) My students are motivated and enjoy learning (motivation and enjoyment); (ii) My students are active in constructing knowledge and have courage to express ideas in class (knowledge construction); and (iii) My students are able to master various generic skills (mastery of skills).

School-level variables

To examine the school-level effect on teachers' perceived changes in pedagogical use of technology, we further defined a set of school-level variables, *socap1*, *socap2* and *cpd*, to measure the respective average scores of *socap1*, *socap2* and *cpd* within a school. In other words, each participating school was regarded as a unit, and *socap1*, *socap2* and *cpd* were calculated by averaging the respective aggregated scores of *socap1*, *socap2* and *cpd* for all participating teachers within a school. Through a multi-level analysis, we examined the school-level effect by comparing the explanatory power of the school-level predictors: *socap1*, *socap2* and *cpd* with that of the teacher-level predictors: *socap1*, *socap2* and *cpd* in accounting for the total variance of the outcome variable of *pedagogy*.

Results

For the purpose of data reduction and examination of the instrument validity, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted using *IBM SPSS 19.0* and *LISREL 8.8*, respectively. Structural equation models were constructed to elucidate the interplay among various latent factors. To study the school-level effect on the outcome variables, a set of two-level linear regression models was built and analysed with *HLM 6.0*.

Exploratory factor analysis

A principal component analysis with *varimax* rotation technique was adopted to analyse the 37 items. Based upon the EFA results, items with a cross-loading greater than 0.3 or a factor loading less than 0.4 were removed. The instrument was ultimately trimmed down to 30 (see Table 1). This analysis resulted in six latent factors: *socap1*, *socap2*, *learning*, *pedagogy recep*, and *cpd*, with an average factor loading of 0.64, 0.72, 0.69, 0.79, 0.72 and 0.63, respectively.

Confirmatory factor analysis

A CFA was conducted to provide quantitative measures for assessing the factor structures as well as the validity

Table 1. *FL*, *M* and *SD* for Selected Items

	Item	Statement	*FL*	*M*	*SD*
socap1	b10_i	I can communicate freely with the principal about school matters.	.724	2.74	0.70
	b10_j	My opinions can be conveyed to the school management effectively.	.722	2.64	0.64
	b10_b	The school goals are reflected in school plans.	.721	2.87	0.46
	b10_k	I have a sense of belonging to my school.	.699	3.11	0.59
	b10_c	The principal trusts me with school matters.	.696	3.02	0.50
	b10_a	My educational beliefs align with the school goals.	.687	3.00	0.47
	b10_l	Teachers in our school manifest trust and team spirit.	.578	2.85	0.64
	b10_m	Teachers in our school are willing to experiment with new ideas in classroom practice.	.498	2.83	0.54
	c20_l	The principal encourages me to experiment with new IT practices.	.419	2.84	0.51
socap2	c21_di	I participate in sharing sessions for exchanging experiences of using IT to enhance teaching and learning with teachers from other schools.	.796	1.81	0.69
	c21_cii	My school organizes sharing sessions for exchanging experiences of using IT in education with educators from tertiary institutions.	.794	1.62	0.68
	c21_dii	I participate in sharing sessions for exchanging experiences of using IT in education with educators from tertiary institutions.	.780	1.63	0.68
	c21_ci	My school organizes sharing sessions for exchanging experiences of using IT in education with teachers from other schools.	.757	1.86	0.68
	c21_a	I collaborate with colleagues to develop curriculum resources for using IT in teaching and learning.	.631	2.15	0.62
	c21_b	Colleagues in my school share experiences of using IT in education.	.561	2.30	0.55
learning	d28_ni	My students are motivated in their learning.	.786	2.59	0.61
	d28_ji	My students are independent in their learning.	.765	2.38	0.60
	d28_ki	My students are active in constructing knowledge.	.716	2.35	0.57
	d28_oi	My students enjoy learning.	.671	2.68	0.57
	d28_mi	My students have courage to express ideas in class.	.609	2.73	0.59
	d28_ii	My students are able to master various generic skills.	.607	2.55	0.56
pedagogy	d28_fiii	The use of IT in teaching and learning has enabled me to create more opportunities for students to express their thoughts and analyse information in the past 2 years.	.809	2.60	0.58
	d28_hiii	The use of IT in teaching and learning has enabled me to create more opportunities for students to determine their learning activities in the past 2 years.	.787	2.58	0.60
	d28_giii	The use of IT in teaching and learning has enabled me to create more opportunity for students to explore and to construct knowledge in the past 2 years.	.769	2.74	0.58
recep	c20_c	I am eager to know how my role will change in using IT in classroom.	.819	3.05	0.45
	c20_b	I am eager to know how using IT can improve my current practice.	.804	3.07	0.44
	c20_f	I am eager to know how other teachers use IT in teaching and learning.	.531	2.96	0.49
cpd	c20_q	My motivation in using IT in teaching and learning has increased after attending staff development programmes.	.664	2.94	0.46
	c20_r	My confidence in using IT in teaching and learning has increased after attending staff development programmes.	.628	2.94	0.45
	c20_n	The IT policy on staff development of my school strengthens my classroom practice.	.582	2.78	0.52

FL = factor loading; *M* = mean; *SD* = standard deviation.

and reliability of the instrument. The full information maximum likelihood technique was employed in model fitting and estimation of model parameters. The parameter estimates for the CFA measurement model are depicted in Table 2.

The average factor loading of each factor is above 0.7. The composite reliability (CR) of the factors and the average variance explained (AVE) range from 0.71 to 0.92 and 0.46 to 0.65, respectively. The squared correlation coefficients between factors are given in Table 3. The correlations among the six latent factors are significant with *p*-values ranging from 0.005 to 0.05. The fitting indices given in Table 4 indicate that the CFA measurement model is a good-fit model: (1) the value of Satorra–Bentler χ^2 is 1058 with a corresponding *p*-value less than 0.0001; (2) the root mean

Table 2. Parameter Estimates for the CFA Measurement Model

		Parameter estimate			
Factor	Item	*FL*	$(FL)^2$	CR	AVE
socap1	b10_a	0.781*	0.610	0.896	0.49
	b10_i	0.705+	0.497		
	b10_m	0.637+	0.406		
	b10_l	0.627+	0.393		
	b10_k	0.724+	0.524		
	b10_j	0.745*	0.555		
	b10_b	0.758+	0.575		
	b10_c	0.644+	0.415		
	c20_l	0.658#	0.433		
socap2	c21_ci	0.716*	0.513	0.879	0.55
	c21_cii	0.711*	0.506		
	c21_di	0.675*	0.456		
	c21_dii	0.672*	0.452		
	c21_a	0.916*	0.839		
	c21_b	0.738*	0.545		
learning	d28_ji	0.877*	0.769	0.905	0.617
	d28_ii	0.761*	0.579		
	d28_ki	0.819*	0.671		
	d28_mi	0.595+	0.354		
	d28_ni	0.801*	0.642		
	d28_oi	0.830*	0.689		
pedagogy	d28_diii	0.840*	0.706	0.846	0.647
	d28_fiii	0.756*	0.572		
	d28_giii	0.814*	0.663		
recep	c20_f	0.734*	0.539	0.713	0.456
	c20_b	0.576*	0.332		
	c20_c	0.705*	0.497		
cpd	c20_n	0.733*	0.537	0.740	0.488
	c20_q	0.718*	0.516		
	c20_r	0.641*	0.411		

FL = factor loading; CR = composite reliability; AVE = average variance extracted; CFA = confirmatory factor analysis.
#$p < 0.005$; +$p < 0.01$; *$p < 0.05$.

square error of approximation (RMSEA) value is 0.046, which is less than the 0.05 criterion; and (3) the fitting indices that include the normed fit index (NFI), non-normed fit index, comparative fit index (CFI), incremental fit index, relative fit index (RFI), goodness of fit index (GFI) and adjusted goodness of fit index (AGFI) are well above 0.9.

Convergent validity

To examine the convergent validity, that is, the extent to which the indicators of a specific construct converge or share a high proportion of variance in common, we assessed the factor loadings, the AVE and the CR of each construct. The results given in Table 2 indicate that (1) all factor loadings are significant; (2) the average factor loadings are well above the threshold value of 0.5; (3) the CR ranges from the threshold value of 0.7 to 0.9; and (4) the AVE from each construct is either close to or above 0.5. Hence, according to Hair (1998), the factor loadings, composite reliabilities, and the AVE confirm that the convergent validity of the constructs is established.

Discriminant validity

To examine the extent to which a construct is distinct from other constructs, we compared the AVE and squared inter-construct correlation (SIC) estimates. In Tables 2 and 3, the AVE estimate of each construct is larger than their corresponding SIC estimates. This means the indicator variables have more in common with the construct they are associated with than they do with other constructs, and that the discriminant validity of the model is adequate.

Structural equation models

To scrutinize the interplay among social capital, CPD, teachers' receptivity to technology, change in pedagogical use of technology and new modes of student learning, three six-factor recursive structural equation models with different levels of complexity were constructed. The three models are the direct model, capital-mediating model and CPD-mediating model as shown in Figure 2, Figure 3 and Figure 4, respectively. As depicted in Table 4, the RMSEA indices of the three

Table 3. Squared Correlation Coefficient Matrix

	socap1	*socap2*	*learning*	*pedagogy*	*recep*	*cpd*
socap1	1	0.096#	0.208+	0.150*	0.049#	0.257*
socap2	0.096#	1.000	0.138+	0.281*	0.026#	0.204*
learning	0.208+	0.138+	1.000	0.146*	0.004#	0.122*
pedagogy	0.150*	0.281*	0.146*	1.000	0.086*	0.343*
recep	0.049#	0.026#	0.004#	0.086*	1.000	0.340*
cpd	0.257*	0.204*	0.122*	0.343*	0.340*	1.000

#$p < 0.005$; +$p < 0.01$; *$p < 0.05$.

Table 4. A Summary of Fitting Indices of the SEM Models

Goodness of fit index	CFA measurement model	Direct model	Capital-mediating model	CPD-mediating model
Satorra–Bentler chi-square (d.f.)	1058 (390)	1130 (394)	1172 (398)	1129 (395)
p-value of chi-square test	0.000	0.000	0.000	0.000
Root mean square error of approximation	0.046	0.048	0.049	0.048
Normed fit index	1.00	0.999	0.999	0.999
Non-normed fit index	1.00	1.00	1.00	1.00
Parsimony normed fit index	0.896	0.905	0.914	0.907
Comparative fit index	1.00	1.00	1.00	1.00
Incremental fit index	1.00	1.00	1.00	1.00
Relative fit index	0.999	0.999	0.999	0.999
Standardized RMR	0.071	0.082	0.084	0.082
Goodness of fit index	0.998	0.995	0.995	0.995
Adjusted goodness of fit index	0.997	0.994	0.994	0.994
Cross-validation index	1.484	1.562	1.604	1.559
Akaike's information criterion	1208	1272	1306	1269
Consistent Akaike's information criterion	1636	1677	1688	1669

SEM = structural equation modeling; CFA = confirmatory factor analysis; CPD = continuous professional development; RMR = root mean square residual.

models are less than 0.05 and all other fit indices such as NFI, parsimony normed fit index, CFI, RFI and GFI are well above 0.9, indicating that the three models are good-fit models.

The direct model

The direct model was used to examine the direct effects of teachers' perceptions on social capital, teacher professional development, teachers' receptivity towards technology on teachers' changes in pedagogical use of technology, and how teachers' pedagogical changes subsequently impacted on student learning (see Figure 2). As shown in Table 5, all the parameter estimates are significant at $p < 0.05$ level. The R^2 of the first structural equation of the direct model is 0.849, indicating that *socap1*, *socap2*, *cpd* and *recep* account for 85% of the total variance of *pedagogy*. The R^2 of the second structural equation of the direct model is 0.324, indicating that *pedagogy* accounts for 32% of the total variance of *learning*, and that teachers' changes in pedagogical use of technology have significant impact on student learning. As suggested by Joreskog and Sorborm (2001), the direct effect of *socap1* on *pedagogy* can be estimated by the coefficient associated with the path between the two latent factors concerned. As indicated in Figure 2, the direct effects of *socap1* (0.53) and *socap2* (0.47) outweigh that of *cpd* (0.24) and *recep* (−0.12). Both professional development and teachers' receptivity towards pedagogical use of technology play a relatively small role in bringing about change in teachers' pedagogical practices. To examine the explanatory power of *recep*, we constructed the direct (II) model in which *socap1*, *socap2* and *cpd* were removed from the original direct model. As depicted in Table 5, the R^2 of the structural equation of the direct (II) model is 0.032, indicating that *recep* accounts for only 3% of the total variance of *pedagogy*. Further, we constructed the direct (III) model in which *recep* and *cpd* were removed from the original direct model. As shown in Table 5, the removal of *recep* and *cpd* from the original direct model causes a drop in R^2 from 0.849 to 0.786. This indicates that *recep* and *cpd* together only account for about $(0.849 - 0.786)*100\% = 6.3\%$ of the total variance in *pedagogy*, and that teachers' perceived social capital within a school seem to play a dominating role in effecting change in pedagogical use of technology, accounting for 78.6% of the total variance of *pedagogy*.

The capital-mediating model

The capital-mediating model was constructed to examine the mediation of social capital over teacher professional development and teachers' changes in pedagogical use of technology (see Figure 3). As shown in Table 5, all the parameter estimates for the capital-mediating model are significant at a level of $p < 0.05$ or 0.01. The R^2 of the first structural equation is 0.809, indicating that *socap1*, *socap2* and *cpd*

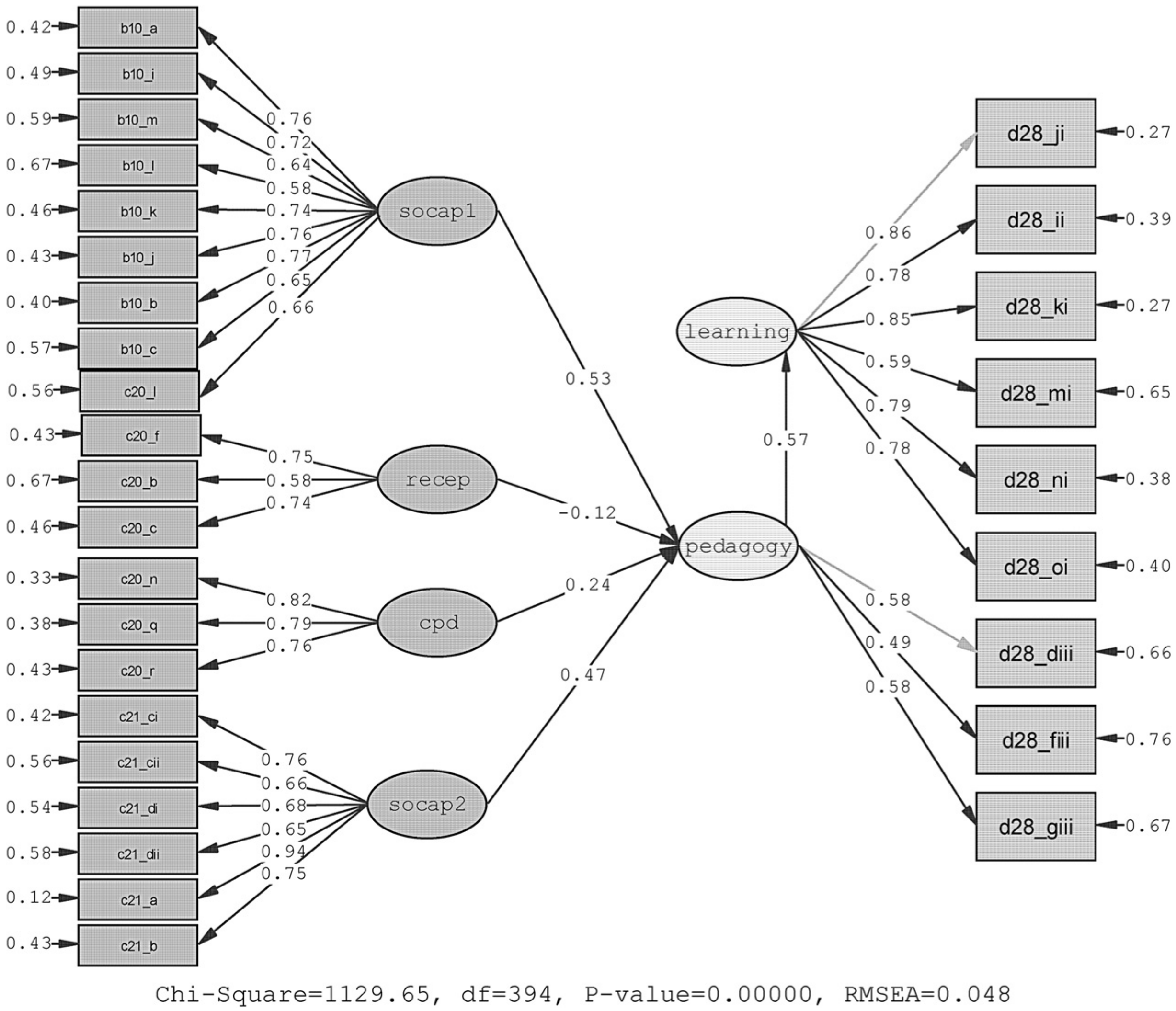

Figure 2 The Direct Model – A Structural Equation Model Used to Examine the Direct Effects of *socap1*, *socap2*, *cpd* and *recep* on *pedagogy*, and the Direct Effect of *pedagogy* on *learning*

account for 81% of the total variance of *pedagogy*. When comparing with the first equation of the direct model, the addition of *recep* only recorded an increase of (84.9 − 80.9)% = 4% of variance explained for *pedagogy*. This re-confirmed that teachers' receptivity towards technology plays a minimal role in effecting change in teachers' pedagogical practices.

As shown in Figure 3, the direct effects of *socap1* (0.58) and *socap2* (0.51) on *pedagogy* are over ten times that of *cpd* (0.05), indicating that social capital has a much stronger influence on teachers' changes in pedagogical use of technology than professional development. According to Joreskog and Sorborm (2001), the indirect effects of *cpd* on *pedagogy* mediated by *socap1* can be estimated by multiplying the path coefficient between *cpd* and *socap1* with the path coefficient between *socap1* and *pedagogy*. The indirect effects of *cpd*, as mediated by *socap1* and *socap2*, are 0.29 and 0.26, respectively, which is two times of its direct effect. Thus, social capital mediates the effect of teacher professional development on teachers' changes in pedagogical use of technology. The fourth structural equation indicates that *recep* has a direct effect (0.41) on *cpd*, implying that teachers' receptivity towards technology has positive influence on their perceived impact of professional development. Similar to the results derived from the direct model, the fifth structural equation indicates that *pedagogy* has a positive

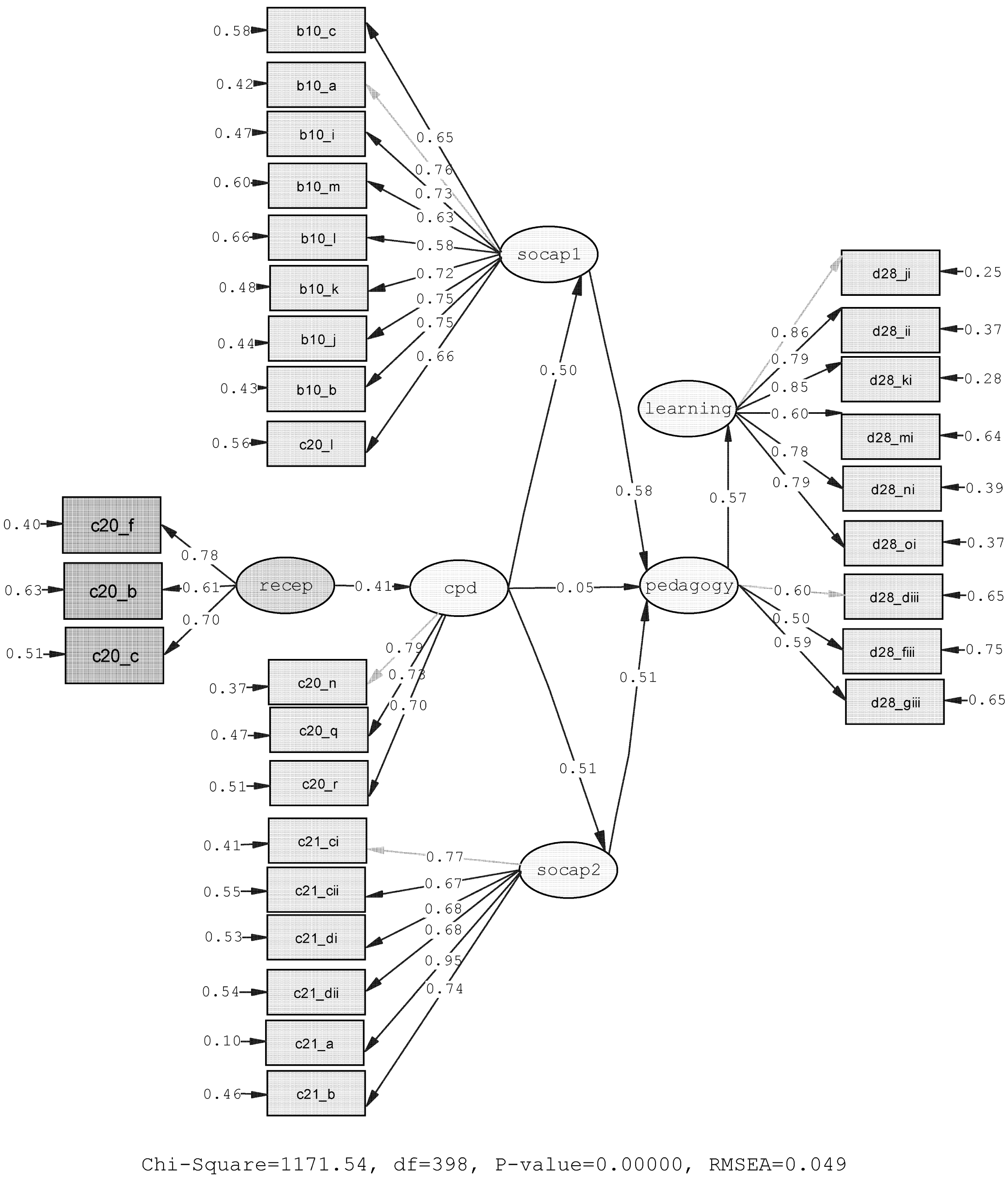

Figure 3 The Capital-Mediating Model – A Structural Equation Model Used to Examine the Mediation of Social Capital over Continuous Professional Development and Teachers' Perceived Changes in Pedagogical Use of Technology

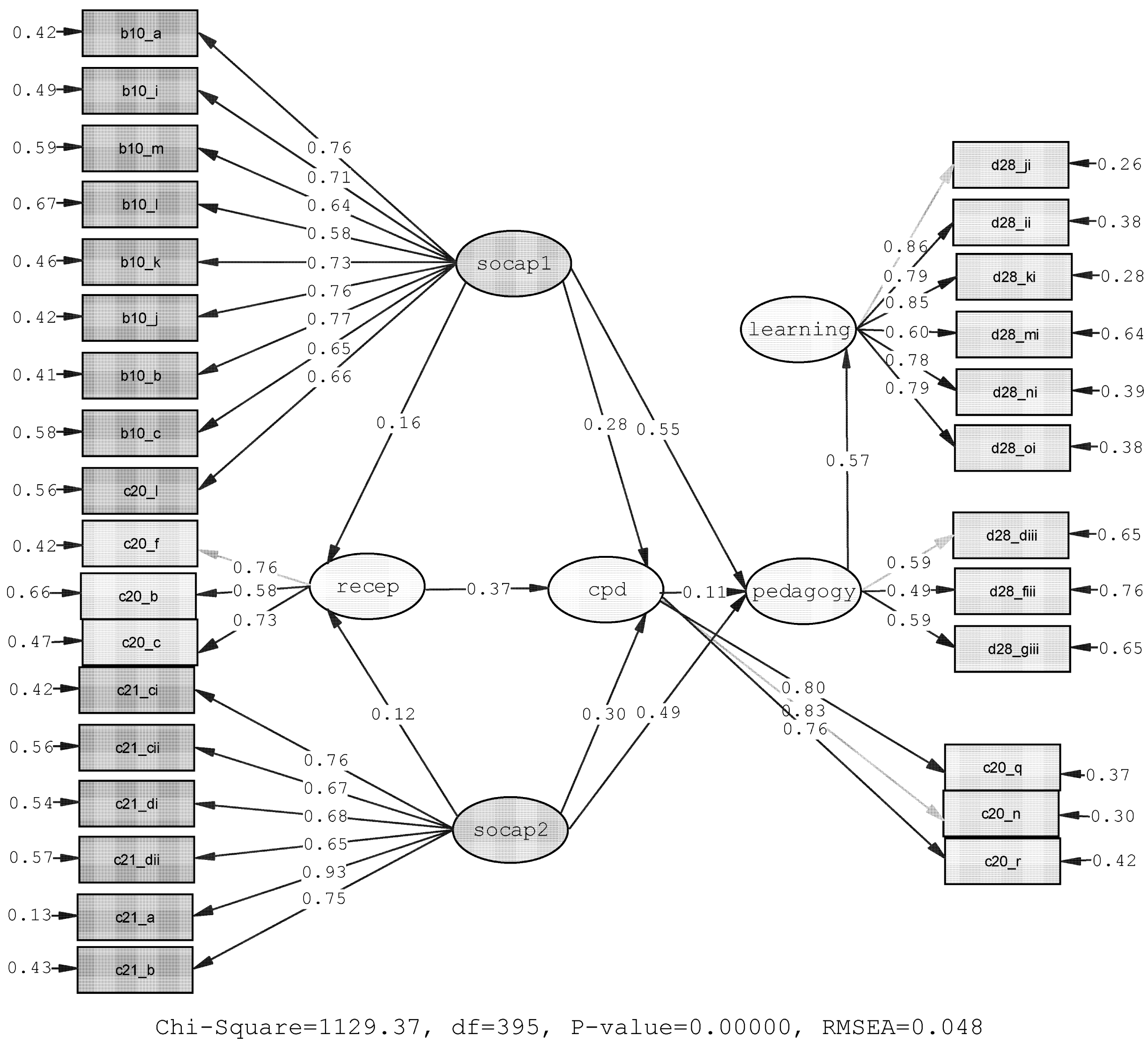

Figure 4 The CPD-Mediating Model – A Structural Equation Model Used to Examine the Mediation of Continuous Professional Development over Social Capital and Teachers' Self-Perceived Changes in Pedagogical Use of Technology

influence on learning with a R^2 of 0.324, accounting for 32% variance of *learning*.

The CPD-mediating model

The CPD-mediating model was devised to examine the mediation of teacher professional development over social capital and teachers' changes in pedagogical use of technology (see Figure 4). As shown in Table 5, all the parameter estimates for the CPD-mediating model are significant at a level of $p < 0.05$ or 0.01 or 0.005. Similar to the previous two models, the R^2 of the first structural equation of the model is 0.805, indicating that *socap1*, *socap2* and *cpd* account for 81% of the total variance of *pedagogy*. Again, the direct effects of *socap1* (0.55) and *socap2* (0.49) on *pedagogy* are about five times that of *cpd* (0.11). Social capital continues to be a dominating factor in effecting change in teachers' pedagogical use of technology in schools. As shown in Figure 4, the estimates for the indirect effects of *socap1* and *socap2* on pedagogy as mediated by *cpd* are 0.030 and 0.033, respectively. The results indicate that the mediation of *cpd* between *socap1* and

Table 5. Parameter Estimates of Structural Equation Models

Model	No.	Structural equations					R^2
Direct	1	*pedagogy*	=0.53⁺ *socap1*	+0.47* *socap2*	–0.12* *recep*	+0.24* *cpd*	0.849
		(t)	*(40.031)*	*(24.246)*	*(–4.737)*	*(6.385)*	
	2	*learning*	=0.57* *pedagogy*				0.324
		(t)	*(24.79)*				
Direct (II)	1	*pedagogy*	=0.18⁺ *recep*				0.032
		(t)	*(4.738)*				
Direct (III)	1	*pedagogy*	=0.55⁺ *socap1*	+0.54* *socap2*			0.786
		(t)	*(148.96)*	*(45.330)*			
Capital-mediating	1	*pedagogy*	=0.59⁺ *socap1*	+0.51* *socap2*	+0.05⁺ *cpd*		0.809
		(t)	*(63.137)*	*(19.021)*	*(4.629)*		
	2	*socap1*	=0.50⁺ *cpd*				0.249
		(t)	*(51.074)*				
	3	*socap2*	=0.51* *cpd*				0.264
		(t)	*(30.483)*				
	4	*cpd*	=0.41⁺ *recep*				0.167
		(t)	*39.506*				
	5	*learning*	=0.57* *pedagogy*				0.324
		(t)	*(22.738)*				
CPD-mediating	1	*pedagogy*	=0.11* *cpd*	+0.55⁺ *socap1*	+0.49* *socap2*		0.805
		(t)	*(8.873)*	*(88.314)*	*(29.327)*		
	2	*recep*	=0.16⁺ *socap1*	+0.12# *socap2*			0.051
		(t)	*31.657*	*32.351*			
	3	*cpd*	=0.37* *recep*	+0.28# *socap1*	+0.28# *socap2*		0.429
		(t)	*(17.01 1)*	*(54.199)*	*(63.436)*		
	4	*learning*	=0.57* *pedagogy*				0.327
		(t)	*(23.673)*				

#$p < 0.005$; ⁺$p < 0.01$; *$p < 0.05$. CPD = continuous professional development.

pedagogy and between *socap2* and *pedagogy* is relatively small compared with the direct effects of *socap1* and *socap2* on *pedagogy*.

As shown in Table 5, the R^2 of the third structural equation of the CPD-mediating model is about 0.429, indicating that *socap* and *socap2* together with *recep* account for almost 43% of the total variance of *cpd*.

School-level effect

To examine the school-level effect on the outcome variable, *pedagogy*, a set of two-level linear regression models, as shown in Table 6, was constructed using the statistical package *HLM 6.08*. Model 1 is a fully unconditional two-level model, in which the total variation in the outcome variable, *pedagogy*, is divided into variation over individual teachers and variation over individual schools. In Table 6, r_{ij} represents the total variance in the outcome variable within a school that can be explained by level-1 predictors while μ_{0j} is the total explainable variation at level-2 (school-level) predictors. As such, the unconditional model serves as a baseline for comparison with subsequent, more complex models. The unconditional intra-class correlation coefficient $\hat{\rho}_0$ of the unconditional model (model 1) is 0.079, indicating that about 8% of the total variance of the outcome variable can be attributed to the school-level effect while the remaining 92% to the teacher-level effect. To examine the school-level effect, Model 2a, Model 2b and Model 2c with no level-1 predictors but only level-2 predictors were constructed. The three models can be used to evaluate the difference between the unconditional variance in the outcome variable over schools and the variance over schools after taking into account each school's mean scores of *socap1*, *socap2* and *cpd*. As illustrated in Table 6, the three level-2 (school-level) predictors of model 2c account for $[(0.018 - 0.006) \div 0.018] \times 100\% \approx 67\%$ of the total level-2 variance. The relative percentage variances explained by *socap*1, *socap*2 and *cpd* are 17%, 44% and 6%, respectively, indicating that social capital remains a dominating factor that helps explain the variation in pedagogical use of technology among schools.

Table 6. A List of Two-Level Models with '*pedagogy*' Chosen as the Outcome Variable

Two-level models		Residual variance r_{ij}	Residual variance μ_{0j}
1	L1: $pedagogy_{ij} = \beta_{0j} + r_{ij}$ L2: $\beta_{0j} = \gamma_{00} + \mu_{0j}$	0.210†	0.018†
2a	L1: $pedagogy_{ij} = \beta_{0j} + r_{ij}$ L2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\overline{socap1}_j + \mu_{0j}$	0.209†	0.015†
2b	L1: $pedagogy_{ij} = \beta_{0j} + r_{ij}$ L2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\overline{socap1}_j + \gamma_{02}\overline{socap2}_j + \mu_{0j}$	0.209+	0.007+
2c	L1: $pedagogy_{ij} = \beta_{0j} + r_{ij}$ L2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\overline{socap1}_j + \gamma_{02}\overline{socap2}_j + \gamma_{03}\overline{cpd}_j + \mu_{0j}$	0.209*	0.006*

Note. Variables with a top bar line are school-level mean scores.
†$p < 0.001$; +$p < 0.01$; *$p < 0.05$.

In sum, the results of the three structural equation models and multi-level analysis indicate that social capital within a school seems to play a predominant role in facilitating change in pedagogical use of technology, as well as enhancing teachers' receptivity towards the use of technology in teaching and learning, and their engagement in professional development.

Discussion and implications

The results of this study indicate that (1) the social capital (*socap1* and *socap2*) of a school and teachers' perceived effectiveness of professional development (*cpd*) had direct effect on changes in their pedagogical use of technology (*pedagogy*); (2) the effect of *socap1* and *socap2* on *pedagogy* outweighed that of *cpd*; (3) teachers' receptivity towards technology use (*recep*) had a direct effect on their perceived effectiveness of professional development (*cpd*) but a very weak influence on effecting changes in their pedagogical use of technology; (4) the social capital of a school had a direct influence on teachers' receptivity towards technology use and their perceived effectiveness of professional development; (5) teachers' self-perceived changes in pedagogical use of technology had a strong direct effect on their perceived student learning (*learning*); and (6) the average scores of *socap1* and *socap2* of a school explained respectively 17% and 44% of the school-level variance of *pedagogy*. In gist, the social capital of a school plays a pivotal role in effecting changes in pedagogical use of technology in teaching and learning. The social capital of a school can be used to engender a culture that helps drive the implementation of change and reinforce teachers' receptivity as well as responsiveness towards educational change. The social capital of a school, as illustrated in the study, is constituted by a myriad of ingredients that include (1) mutual trust between the principal and teachers; (2) effective communication channels between senior management and teachers; (3) shared beliefs; (4) goal alignment; (5) sense of belonging; (5) willingness to take risks; and (6) willingness to collaborate and share experience. Social capital helps establish the formal and informal social support structures that provide novice teachers with necessary scaffolding and impetus to experiment with new technologies and pedagogies.

The findings of this study pose challenges to the rationality assumed by conventional models of technology infusion. These models suggest that the success of technology implementation hinges mainly on teachers' epistemological beliefs about the pedagogical value of technology and professional development (Law *et al.*, 2008). However, as Frank *et al*. (2004) maintain, teachers, regardless of their own perceptions or beliefs, are more likely to implement change under social pressure, and with appropriate social support or access to expertise. In a similar vein, we argue that effecting change in teachers' practices may depend on rational factors as well as a myriad of affective and social factors, and that social capital fuels the informal and formal social processes through which teachers' readiness to take risks and experiment with novel ideas may be enhanced.

Social relations not only help develop teachers' knowledge and skills, but also shape teachers' behaviours and bring about change in classroom contexts. This echoes the findings elucidated by Li (2010) that teachers, with a sense of trust, are more willing to step out of their comfort zone and try out new pedagogies, provided that collegial support is readily available out there. Social capital thus plays a vital role in inculcating a supportive social structure that helps leverage teachers' receptivity towards change.

As expounded in the previous section, conventional models of infusion are underpinned by the notion that teachers will eagerly respond to educational change when they can see how exemplary practices work and benefit student learning. However, changing teachers' epistemological beliefs may not exert an influence on their pedagogical practice. Some teachers remain reluctant to take risks with inadequate social support or with limited access to expertise. Further, the fast-evolving and short-lived nature of learning technology may restrain the availability of exemplary practices as prior knowledge of the pedagogical use of technology is often scarce. Thus, to ensure the sustainability of change, fostering a school's social capital and internal capacity to try out novel ideas and reflect on their pedagogical use of technology is of paramount importance. The distribution of social capital in a given school thus shapes the implementation of change. The findings of this study call into question those technology infusion policies that centre merely on the structural aspects of a school organization or skill-driven teacher development programmes, without due attention to building schools' social processes and social contexts for change. As Li (2010) argues, social capital cannot be infused nor can it be enacted from external authorities; rather, it can only be nurtured over time from within the school organization. On the other hand, it is noteworthy that social capital, as a kind of ubiquitous and intangible resource, can be overdrawn against competing initiatives. Reformers should be aware of the symbiotic relationships among reforms that may exhaust the social capital of an organization in the fluid context of change.

Conclusion

The results of this study indicate that (a) social capital of a school had a strong direct effect on teachers' changes in pedagogical use of technology, and that the effect of the social capital outweighed that of teacher professional development; (b) teachers' receptivity towards technology use had a direct effect on their perceived effectiveness of CPD but a very weak effect on changes in pedagogical use of technology; and (c) the social capital of a school had a direct influence on teachers' receptivity towards technology use and their perceived effectiveness of CPD. The results of this study provide insights into technology implementation in schools, suggesting that social capital provides the impetus for teachers to adopt new pedagogy and that conventional models of technology infusion may not be adequate to address the social and affective dimensions of change management.

Limitations and suggestions

Our findings were grounded on teachers' perspectives and their perceptions in assessing social capital in school, change in pedagogical use of technology, student learning, etc. While acknowledging the usefulness of teachers' perceptions in gauging the social relations and social processes within a school, the perspectives of other stakeholders, such as students, should be taken into account in order to delineate a fuller picture of teachers' pedagogical uses of technology, student learning and the classroom reality. To this end, the sampling strategy needs to be modified, for example, the teacher sample of each school can be stratified on a classroom basis. Thus, teachers' self-perceived change in pedagogical use of technology and student learning can be triangulated with the feedback from their respective students. Further, the operational definition for social capital can be broadened to encompass student–teacher and parent–teacher relations as well as the linkage between school and the wider community. To unfold the complexity of technology implementation, in-depth qualitative studies on how formal and informal social forces help shape the process of change are deemed necessary.

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