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Mapping teachers' perceptions on technology use using the iTEaCH implementation model: A case study of a Singapore school

Michael Choy[1*] and Yeow Ling Ng[2]

Abstract: Schools have seen an exponential increase in the range of Information and Communications Technology (ICT) being utilised for learning and teaching over the past decade. What is exciting is not just more technology but that there are more types of technology which teachers can choose from, based on their own pedagogical preferences. Set in the context of a primary school in Singapore, the findings from the survey of the 32 teachers and senior management indicate that there is a discrepancy between the types of technology currently being used and those which the teachers actually *want* to use. Reasons for this discrepancy could be attributed to the teachers' positive desire to utilise more constructivist approaches to "Teachnology" use, to acquire more sophisticated "Technogogical" skills and to further grow the Collegiality to support the use and sustained growth of ICT in the school. The study also suggests that a granular examination of the teacher beliefs towards pedagogy, technology and collegiality may provide a more informed and targeted approach to implementing ICT in schools.

Subjects: Continuing Professional Development; Educational Change & School Reform; Educational Research; ICT; Teaching & Learning

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ABOUT THE AUTHORS

Being practitioners, both Dr Michael Choy and Yeow Ling Ng are primarily focused on getting the initiatives or projects off the ground within the context of the school or training institute. The theoretical focus is usually on how to improve implementation processes in a more strategic manner. The most important consideration in research for both of us is how to make something work. Current concerns centre round the work on Massive Open Online Courses (MOOCs) which entails researching on how to design and implement the MOOCs on different platforms to maximise the effectiveness of these e-courses. Determining the perceptions of trainers in the use of technology to facilitate blended learning is another area of interest.

PUBLIC INTEREST STATEMENT

Educational technology, just like any other teaching tool, is only useful when teachers want to use it. This is a perennial issue when school management may see much potential in a piece of technology but when it reaches the hands of teachers, the technology may be cast aside simply because it does not match the pedagogical beliefs of the teachers. Set in the context of a primary school in Singapore, the findings from the survey of the 32 teachers and senior management indicate that there is a discrepancy between the types of technology currently being used and those which the teachers actually ***want*** to use. Reasons for this discrepancy could be attributed to the teachers' positive desire to utilise more constructivist approaches to "Teachnology" use, to acquire more sophisticated "Technogogical" skills and to further grow the Collegiality to support the use and sustained growth of ICT in the school. These reasons are further examined in the context of making ICT implementation in schools more effective.

Keywords: technology implementation; pedagogical beliefs; Collegiality; Singapore school; teacher's preferences and beliefs; Teachnology; Technogogy

1. Introduction

> The introduction of new technology will change our schools. (Conlon, 2000, p. 116)

Seemingly, technology use in education has grown in an exponential manner. A compilation of statistics on schools in the USA by Synder, Dillow, and Hoffman (2009) points to a rapid upscaling of technology facilities and access in American schools in the last decade. For example, schools with Internet access jumped from 35 to 100% between 1994 and 2005. Likewise, the type of Information and Communications Technology (ICT) equipment available in schools in the UK has also increased dramatically over the years (Becta, 2009). On the other hand, according to UNESCO Institute for Statistics (2014), the ICT landscape across Asian schools is extremely diverse with developed countries such as Singapore and Korea scoring very well on equipping their students and teachers with ICT skills, while the less developed countries such as the Philippines and Myanmar are still trying to secure stable internet access for their schools. Regardless of the current state of development, one observation is clear, that almost all countries are making an attempt to incorporate ICT into their schools in order to prepare their students for an ICT-rich world.

However, one fundamental problem in educational reform, including infusing ICT into teaching, according to Fullan (2013, p. 23), is that … "school is increasingly boring for students and alienating for teachers … (while) the exploding and alluring digital world is irresistible … to students". It is important that teachers are not alienated with the impression "that technology can replace them". Fullan (2013, p. 24) added that the basic notion is to engage both "teachers and students as learning partners". Thus said, many educators may not have a clear sense how to address the forces of change brought about by technology, what they are and how to proceed. Often, the teachers who resist change are not rejecting the need for change but are resisting entering into something that they do not have the necessary knowledge and skills for.

1.1. Identifying the problem

The statistics (Becta, 2009) suggests that technology is changing the way our children are taught in schools. It also alludes to the challenges that teachers face with the intrusion of technology into the classroom as explicitly described by Fullan (2013). Teachers are expected to manage technology equipment, change their teaching approaches, integrate technological tools into their lessons and outsmart a class of technology-savvy students who may know more about technology than their teacher. It will not be surprising to find that teachers are faced with increasing levels of stress juggling technology use, redefining their roles as facilitators rather than suppliers of information and managing an ever-demanding class (Luke, Freebody, Shun, & Gopinathan, 2005; Zander, 2004). More than ever before in the history of education, teachers are required to be more flexible and skilled in managing teaching tools and students in the classroom. However, there are, as Chapman and Mahick (2004, p. 20) pointed out in their study, few "clear models of successful technology use" in schools. It would be pertinent for educators to derive more exemplars so that others can follow the pioneers in this hunt for effective technology and teaching in the classroom.

1.2. ICT implementation models

One of the earliest models (Rogers, 1995) types teachers in terms of how responsive they are to ICT implementation. According to Rogers (1995), there are five types of teachers based on their response to change (e.g. ICT initiatives):

(1) innovators (eager to try new ideas),

(2) early adopters (follow innovators and are successful users of technology),

(3) early majority (wait to see how successfully technology is implemented before following),

(4) late majority (wait till they are pressured to use before trying) and

(5) the laggards (the last to adopt change).

While commendable, Rogers' (1995) approach to typing teachers based on their responses to change may be somewhat simplistic and one-dimensional, given that teachers who are innovators may not be the most effective users of ICT and it does not show to what extent ICT is used before teachers are considered to have accepted and embraced the change. In addition, the model does not provide a comprehensive view of the ICT landscape that the teacher is in *and* the development of the teachers' professionalism and attitudes as they journey through the ICT landscape. Schussler, Poole, Whitlock, and Evertson (2007, p. 573) highlight that Rogers' (1995) Stage Theory which perceives "ICT integration as a one-dimensional incremental process" is untenable, given the complexity of the teaching process.

To capture the complexity of the teaching practice and process, Mishra and Koehler (2006) introduce the Technological Pedagogical Content Knowledge (TPCK) model which emphasises the interaction among three types of knowledge constructs:

- Pedagogy (PK)
- Technology (TK)
- Content (CK)

Together, these three constructs constitute TPCK although the focus is really on the interactions between them.

> At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context-specific, strategies and representations. (Koehler, Mishra, & Yahya, 2007, p. 741)

As a model, the TPCK (also known as TPACK) provides compelling reasons for teacher training to focus on how subject-specific ICT use ought to be carefully designed and implemented in the classroom. It differentiates general PK from TPK and TPCK. This differentiation sets the stage for the need to review how subject-specific ICT use, in conjunction with good pedagogical practice, can be further supported in schools. At the same time, the TPCK model also suggests that ICT implementation is not as straightforward or as simplistic as the models described earlier (i.e. Roger, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

There are, however, several issues with the TPCK Model. For example, according to Angeli and Valanides (2009), it is not clear if growth in TPCK is a distinct form of knowledge or whether growth in any of the related constructs will improve a teacher's TPCK, which indicates that the boundaries between the TPCK components is "fuzzy indicating a weakness in accurate knowledge categorisation ... a lack of precision in the framework" (Angeli & Valanides, 2009, p. 157).

It is also unclear how teachers can utilise the TPCK model in the classroom, other than knowing that there are these three constructs and their interactions. Does this imply that to take ICT implementation forward, schools will require detailed descriptions of how ICT ought to be used for each topic along with the pedagogical activities that accompany it? Will this be overly onerous for schools to implement, leading to a highly inflexible structure?

In addition, TPCK, as a model, seems to describe in a static manner what is actually a dynamic process concerning the use of ICT in the classroom. In the example given by Cox and Graham (2009), the history teacher could have presented the weblogs to the students using LCD projectors and have them discuss the content in groups. Instead of writing individual weblogs, the students could have recorded their comments on video and posted the clips on YouTube. Will this alternative mode

be recorded as the teacher's TPCK? If so, what value does the TPCK model add to the whole process of ICT-assisted teaching? Can the model recommend specific pedagogical approaches to the use of certain types of technology for particular subjects? For example, is presenting the blogs to the students a better alternative to getting the students to conduct the research themselves? How do teachers judge? In other words, is there a "fitness-for-purpose" between the technology used and the pedagogial approach? These questions are insufficiently addressed by a relatively static TPCK model.

In contrast, Schussler et al. (2007) propose a more dynamic five-layered "Hypertext" model which includes the teacher's familiarity with the *content* AND with *technology*. Another layer (Connectivity) focuses on the teacher's ability to integrate technology into the curriculum in an effective manner. Familiarity and Facility denote the teacher's comprehension of the pedagogical and ICT possibilities respectively. In turn, the way the teacher translates his or her thinking about ICT into practice is captured under Transparency and Connectivity which denote integration of ICT into curriculum within a topic and connecting different disciplines using ICT, respectively. Schussler et al.'s (2007, p. 580) conceptual framework of hypertextual function (operating like the links seen in webpages) "captures some of the complexity teachers face as they attempt to use technology in their classrooms."

However, there are some issues with the five dimensions. For example, if the teacher is familiar with the students' needs, does it mean that she will apply good pedagogical principles based on *those* needs in the integration of ICT? Familiarity, in the Hypertext Model, does *not* refer to how the teacher addresses the students' needs through the application of ICT. However, compared to Rogers' (1995) model which encapsulates pathways of progression for the teacher, the multidimensional Hypertext Model appears to provide a more comprehensive picture of the complex interactions which take place within and without the teacher.

1.3. Pedagogical preferences

Given that teachers are the end users of technology in the classroom, it is surprising that the models above do not address the pedagogical beliefs of teachers in a greater measure. Wells (2007) and McGrail (2005) highlight that the teacher's pedagogical beliefs could be one of the key reasons behind the lack of ICT implementation despite the available equipment. When teachers lack belief in ICT effectiveness, it results in them paying only lip service and not actually applying ICT in their teaching. On the other hand, a study by Demirci (2009) on the attitudes of 79 Geography teachers towards the use of Geographic Information systems (GIS) in Turkey revealed that though barriers such as lack of hardware and software existed, teachers' positive attitudes towards GIS contributed to the successful integration of GIS into Geography lessons.

The current thinking is that the most effective method of computer-based learning is through a range of broadly active and constructivist learner-centred approaches such as peer discussion platforms and resource sharing portals (Chapman & Mahick, 2004; Fullan, 2013) in contrast to the teacher-directed or more didactical approaches such as e-lectures or e-tutor support which results in a more passive role for the students. This implies that ICT takes on the role of a collaborative tool in addition to being a medium for transmission of content. By encouraging learning through interaction, social discourse and situated cognition, ICT as a collaborative tool enhances constructivist learning which goes beyond the mere accumulation of facts. Luke et al. (2005) noted that

> This suite of (ICT) initiatives (IT MasterPlan 2 in Singapore) is unified by at least one major policy theme: a recognition that the didactive, traditional and rote reproductive character of pedagogy needed to change. (Luke et al., 2005, p. 11)

Constructivist learner-centred approaches can occur in many forms and it is unclear if all forms of learner-centred approaches are effective. In any case, the difference between didactical and constructivist may be difficult to establish since they generally fall into a spectrum (Harasim, Hiltz, Teles, & Turoff, 1995).

Often, the studies disregard the cognitive processes involved, as long as technology was used in any part of the teaching or lesson, it would qualify as an ICT-enabled lesson. There appears to be little examination of how effective the different modes of technology use are, whether to "supplant instruction (i.e. to provide inputs) or to follow up on instruction" (i.e. to ensure mental processing and production) on the eventual learning outcomes exhibited by the students (Staples, Pugach, & Himes, 2005, p. 297). In Hattie's (2012) meta-analyses of more than 1,000 studies, two items on simulations/gaming and web-based resources showed up as having a weak impact on learning. Fullan (2013) surmised that the main reason was that the technological items were used passively with the teacher as a guide on the side. He questioned if a new pedagogy could have deepened and accelerated learning, thereby highlighting the issue of not just the types of technology being used but also how they were used to bring about effective learning among the students.

1.4. Management style

Besides pedagogical preferences, the way school leaders work with teachers also affects the level of cooperation they would get from the teachers (Gipson, 2003). While Granger, Morbey, Lotherington, Owston, and Wideman (2002) found principals with positive attitudes toward ICT use in their study are more likely to cascade these positive attitudes down to their teachers, the manner these attitudes toward change, notably, ICT use in the classroom, are transmitted would depend to a large extent on the approach the school management takes in supporting, convincing and encouraging the teachers to adopt ICT in the classroom. Underpinning this "buy-in" from the teachers is a lot of communication between the school management and teachers, a high level of trust that leads to autonomy and liberty for the teachers to try new initiatives in the classroom. Factors that can lead to increased "buy-in" by teachers, for example, strong management support and a clear vision from the principal are well-documented (e.g. Bain, 2004; Chapman & Mahick, 2004). However, the precise mechanics and processes of what the principal does with his or her staff remains an enigma. The literature is somewhat silent on the specific measures and process principals take to initiate and maintain this "buy-in".

2. The iTEaCH implementation model

To address the gaps mentioned concerning the ICT implementation models presented, a new ICT implementation model was proposed by Choy (2013). The model was developed based on a three-year research study, involving in-depth interviews and qualitative surveys with a group of teachers, school management and technical staff in a secondary school. Based on the analyses, the five primary categories of ICT use that the teachers engaged in were drawn from the pedagogical beliefs of the teachers when expressing how teaching ought to be conducted. To sustain the implementation of the ICT initiatives, support from management and teachers was needed, and this was also observed and analysed.

As a result, the **iTEaCH (ICT-Technogogy-and-Collegiality Holistic) Implementation Model** (see Figure 1) was developed based on a "goodness of fit" approach across three dimensions:

- the types of technology (Teachnology) available,
- the pedagogical preferences (Technogogy) of teachers and
- the level of teacher support (Collegiality) in the school.

Of these three dimensions (see Figure 2), two of them ("Technogogy" and "Teachnology") are new terminologies, to more accurately and elegantly capture the essence of the implementation process.

2.1. Teachnology

To facilitate the use of technology, the iTEaCH Implementation Model categorises Teachnology based on how it is used to bring about specific learning and teaching purposes. Some Teachnology involve ubiquitous resources such as mobile phones and YouTube video clips that are adapted for classroom use. By the definition given earlier, a blogsite is not Teachnology unless teachers adopt it as a discussion platform on Geography, for example. Thus, Teachnology is the educational subset of the technology available in the world today. By giving a name to this subset, educators and

Figure 1. The "iTEaCH" implementation model (Choy, 2013).

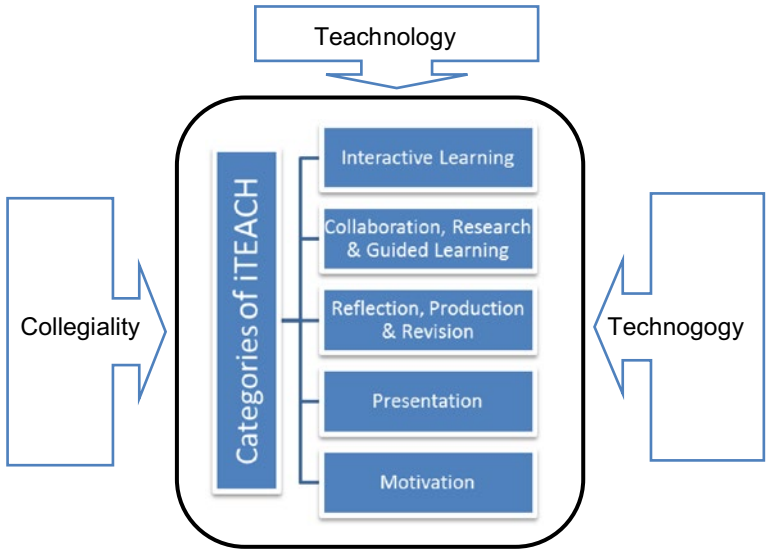


Figure 2. Definitions of "Technogogy", "Teachnology" and "Collegiality".

Teachnology
(the technology used to achieve specific teaching and learning purposes)
Technogogy
(the teacher's pedagogical skill to use ICT for learning and teaching)
Collegiality
(the support from management, colleagues and students to use ICT in teaching and learning)

technologists can now identify key characteristics of technology which can be further exploited for use in learning and teaching.

Each category of Teachnology is determined by *how* ICT is used rather than *what* is used (see Table 1). In this regard, it is possible that certain technology (e.g. video clips) can be found in different categories (for motivation and/or for presentation). Hence, each category of Teachnology is *not* a specific technology or group of technologies, but the attributes of the Teachnology category.

For example, "Motivation" Teachnology involves technology which can be used to generate students' interest in a topic. This may include technology that is widely available, requiring little redevelopment (e.g. generic resources such as commercial movies) or it can involve blogs and FaceBook discussions as platforms for teachers to give advice to students. On the other hand, Presentational Teachnology involves ICT which facilitates the injection of content. While the use of video clips can be found in both categories, the manner in which the video clips are used is different. Motivational video clips will need to be captivating while a Presentational video clip has to be relevant, clear and informational.

Specifically, if the Teachnology has already been developed, then the classroom teachers just need to be familiar with the Teachnology and apply it in the classroom. Little adaptation of ICT is expected. However, the irony is that because Teachnology is already customised for their use, some teachers may find the Teachnology ill-suited to their teaching style and their student's learning needs.

What is Teachnology?

Teachnology is characterised by the functions that the technology supports rather than the actual technology itself. By focusing on the attributes of the technology and grouping them accordingly, teachers can focus on how to use the technology to achieve the learning purpose. To fully exploit the different categories of Teachnology, matching Technogogical expertise and belief with the Teachnology available is critical for implementation success.

Table 1. iTEaCH implementation model

Category	Teachnology	Technogogy	Collegiality
Category E			
(Interactive Learning)	Interactive games/learning objects	Development and Programming skills	To support the development and use of the customised ICT which may involve external curriculum and Teachnology specialists or researchers
	Computer simulations	User application skills	
Category DC/DR	Social networking sites	Facilitation of discussions on social networking sites	To share ideas on the use of networking sites
(DC - Collaboration & Guided Learning)	Learning portals	Guiding the learning process through asking and answering questions, and correcting mistakes	To involve cross-department sharing if the same platform (e.g. Blackboard) is used
(DR – Student-based Research)	Research sites and tools	Skills in designing learning through research	Use of online research sites to share online valid data
Category C			
(Reflection, Production and Revision of Work)	Online or technology-based quizzes	Setting up of questions & quizzes	To share questions (e.g. evaluate a YouTube video clip)
	Forums for discussions and reflections	Generation of appropriate questions for web-based assessments	
Category B			
(Presentation of Information)	Teacher-made video clips	Presentation Skills Instructional design principles	To share presentation slides and ideas with each other
	PPT slides	Infusion of non-ICT enabled activities into lesson	Within-department sharing is sufficient to support this category of ICT use.
Category A		Motivational skills	
(Motivational Learning)	Commercial video or sound clips	Giving advice**/**counselling skills	To share useful ICT resources found online e.g. YouTube video clips
	Motivating online talks (e.g. Ted Talks), pictures and articles	Require skills and time to select effective resources	Sharing on an informal level within the department is most likely

2.2. Technogogy

With available Teachnology, teachers require Technogogical skills to successfully implement ICT-enabled lessons. Technogogy is a subset of pedagogy, relating specifically to the use of technology in the classroom, due to the unique skills involved in maximising learning through the use of different types of ICT. A teacher can be good at non-ICT-enabled pedagogy but poor in Technogogy due to inflexibility in using technology in a pedagogically sound manner. Experience in both classroom teaching methodologies and technology use will provide teachers with the basis to acquire Technogogical skills which are really an amalgamation of teaching methodologies and suitable technologies to bring about effective learning.

The justification for Technogogy is that it is pedagogy which is ICT-mediated. By placing Techogogy as a sub-category of pedagogy, it highlights the differences between ICT-enabled and non-ICT-enabled pedagogies and deservedly so, because of the many intricacies involved in the interplay of technology with teaching strategies. For example, the Technogogical skills involved in facilitating social interactions via social networking platforms is different from facilitating cooperative learning in class. In online collaborations, the interactions may be asynchronous with no face-to-face contact which leads one to question authenticity and user identity.

Some teachers may adapt free or low-cost commercial technology for use in the classroom, which points to the teachers' flexibility with pedagogy when applying technology to teaching and learning. These skills include the teachers' ability:

- to identify the application of new technologies to classroom teaching and learning,
- to select relevant technology that is of interest to students,
- to modify lesson plans based on the characteristics of the technology and
- to exhibit flexibility in modifying instruction in the event of technology failure.

The list of Technogogical skills may be more extensive than those listed above. Notably, the focus is on how pedagogy interfaces with technology, leading to greater interest or better learning by the students. Having described the two dimensions, Technogogy and Teachnology, the third dimension, Collegiality, is likely to be more familiar to most teachers and school management.

2.3. Collegiality

Collegiality is based on the three key actors in the school: school management, other teachers and technical staff. Given that not all schools will have the Teachnology, teachers' Technogogical preferences and the level of Collegiality aligned for each category, it may be easier to empower self-autonomous clusters of teachers or individual teachers to select the Teachnology they are comfortable with, given their own Technogogical preferences and the level of Collegiality they are receiving in their school.

Drawing together the three dimensions of Teachnology, Technogogy and Collegiality, Table 1 illustrates the details of their relationships.

3. Research methodology

3.1. Why use quantitative approaches?

Quantitative methods attempt to utilise objective measures and statistical or numerical analysis of data collected through polls, questionnaires, surveys or other tools. Usually, quantitative research focuses on gathering numerical data, and generalising it across groups of people or to explain a particular phenomenon. However, in this study, the generalisation is likely going to apply to "West School" and not beyond, given that the context is only "West School".

Using a single-case approach (Yin, 2003) with "West School" being a two-year-old new primary school presents an interesting and timely study to determine how schools can modify their approach to implementing ICT successfully. Based on the literature research, teacher perceptions and attitudes, the way in which the teachers and school leaders communicate over the ICT implementation policy and the extent to which the teachers are supported in the use of ICT seem to stand out as key issues in determining the success of ICT use in the classroom. Using the iTEaCH Implementation model (Choy, 2013) as the basis for determining the profile of teachers towards ICT in schools, a survey (see Appendix A) was developed and administered to the teachers during a 1-h workshop. The model and the categories within were explained to the teachers as part of the survey procedure.

The purpose of the study was to derive findings from the survey conducted with the teachers so as to inform the design of a working model in the school for ICT implementation. In addition, there may be useful lessons generated from the study which may be of some value to other schools looking to adopting a more evidence-based approach to ICT implementation.

As motivation is one of the key assumptions that underpins human behaviour (Demirci, 2009), an item to measure the teachers' keenness to utilise each of the six categories of Teachnology was included in the survey. The analysis will also examine the manner in which teacher motivation, Teachnology usage, Technogogical skill and Collegiality behave across the six categories.

3.2. Setting

As described, the primary school is two years old with only two cohorts of students (seven- and eight-year-olds). There are a total of 32 teachers in the school, three technology and administration support staff, and two senior management comprising the vice-principal and principal. The school is exploring how to start their ICT journey given that most of the teachers posted in from other schools have some experience with ICT usage.

The survey involved 32 respondents (including the principal and vice-principal), which is 94% of the teaching population in the school. Two teachers were exempt from workshop due to medical and other valid reasons. The workshop lasted 1 h with about 40 min for context setting on issues relating to ICT and pedagogical beliefs. The teachers were given opportunities to discuss in groups to reflect on their practice at using technology in the classroom. These activities serve to facilitate the teachers in answering the survey. They were given about 15–20 min to complete the survey (see Appendix A). Teachers were assured of confidentiality and were given the option not to indicate their names if they do not wish to do so.

3.3. Data analyses

The survey generated quantitative data which were then collated as descriptive statistics on how teachers were using ICT for teaching, especially in relation to the different categories of Teachnology (e.g. Motivational or Interactive Learning). There were a total of four questions for each of the six categories, and another three questions on general ICT use, resulting in 27 questions in total.

The initial analysis in this study was to understand the differences in the frequency across the six categories of Teachnology use in the classroom. If there were significant differences in usage frequency, then the key task would be to find out the possible reasons or factors contributing to the differences observed. The first step would be to examine the relationship between teacher motivation ("keenness to use the specific Teachnology") and the Teachnology usage. In order to examine this relationship, a correlational analysis will be most appropriate given that the study is not an experimental one. Outcomes from the correlational analysis would also facilitate the interpretation of the relationships among the remaining factors. To interpret these relationships, a set of descriptive statistics on the teachers' perceptions of Technogogical skills and Collegiality was generated to provide a profile of the teachers' perspectives toward ICT use in the classroom. Subsequent surveys may be conducted in 2–3 years, as the school progresses along on its ICT journey, as milestone checks on its ICT development. The average teacher ratings (see Table 2) for each of the three dimensions within each category were translated into bar charts for ease of interpretation of the results from the survey.

Finally, to determine possible areas the school should focus on for future teacher development or Teachnology acquisition, the question of what Teachnology the teachers really wanted to use in their teaching was addressed and compared with the earlier results on actual Teachnology usage in the classroom.

Table 2. Average scores of teachers' ratings across the six Teachnology categories

Category of Teachnology	Number of teachers expressing keenness for a particular category of Teachnology	Current usage	Teachnology	Technogogy	Collegiality
	Frequency (out of 32)		Average ratings (1–5)		
Motivation	9	4.15625	3.78125	3.90625	4.0625
Presentation	4	4.34375	4.53125	4.03125	4.25
Production of work	3	3.21875	3.9375	3.4375	3.09375
Collaboration	2	2.90625	3.15625	3.03125	3.15625
Research	7	2.9375	3.21875	2.875	3.25
Interactive learning	5	4.03125	4.0625	2.25	3.1875

Table 3. ANOVA of Teachnology usage across the six categories

Source of variation	Sum of squares	*df*	Mean squares	*F*
Between	67.65	5	13.53	14.26
Error	176.5	186	.9488	
Total	244.1	191		

Note: The probability of this result, assuming the null hypothesis, is less than .0001.

4. Results

4.1. Differences in usage across six categories of Teachnology

The findings from the survey of the 32 teachers are presented below. The first two charts depict ratings (from 1 to 5 where 1 is "strongly disagree" and 5 is "strongly agree").

Chart 1 shows that there was a healthy level of usage of ICT in the classroom across all the six categories surveyed. More specifically, teachers were currently using Teachnology more to motivate students, present content and for interactive learning than for production of student work, collaboration among students and for research by students. It is important to note that the ratings should be viewed as relative scores since they do NOT refer to actual frequencies. Hence, a low rating does not imply low frequencies. It is merely lower relative to another rating that is higher on the scale. A one-way analysis of variance revealed significant differences across the six groups, $F(5,186) = 14.26$, $p < .001$ which implied that teachers were using Teachnology in varying degrees of frequency depending on the Teachnology types (see Table 3 for detailed results).

From the chart, it could be observed that there are two clusters of behaviour in relation to Teachnology usage. Cluster 1 comprises the motivation, presentational and interactive learning categories while Cluster 2 comprises production, collaboration and research categories. It is noted that Cluster 1 (except for interactive learning) tends to include the more instructivist (or didactic) approaches to teaching, while the Cluster 2 comprises solely of constructivist teaching approaches. This arbitrary clustering of the six categories may have implications on how the results are interpreted. This is explained in Section 5.

While it was not surprising that the more didactic means of using ICT to motivate (e.g. video clips) and present content (e.g. PowerPoint slides) were prevalent as this finding corresponds with the literature (e.g. Fullan, 2013), the rating of ICT for interactive learning, on the other hand, stands out on its own with a comparatively high frequency. Given that resources for interactive learning are usually difficult to come by, it will be interesting to determine how interactive learning is conducted in the school and the reasons behind the high frequency.

Chart 1. Teachers' current usage of Teachnology in a primary school.

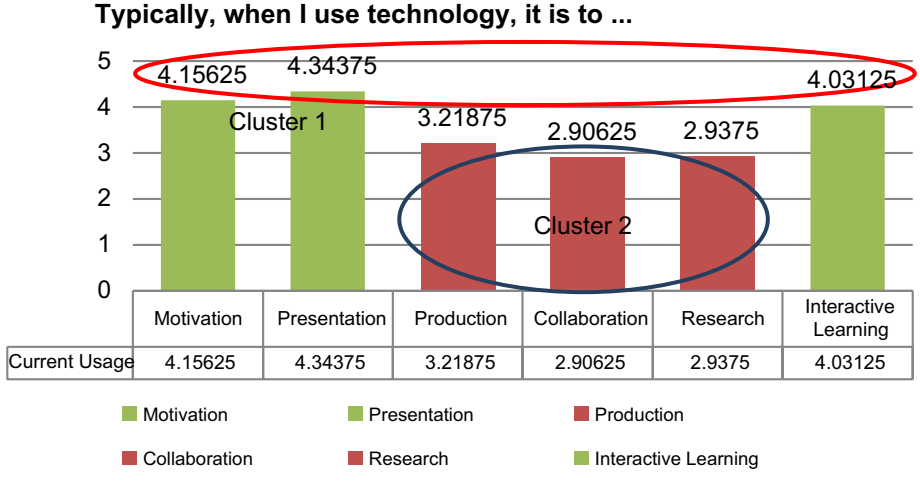
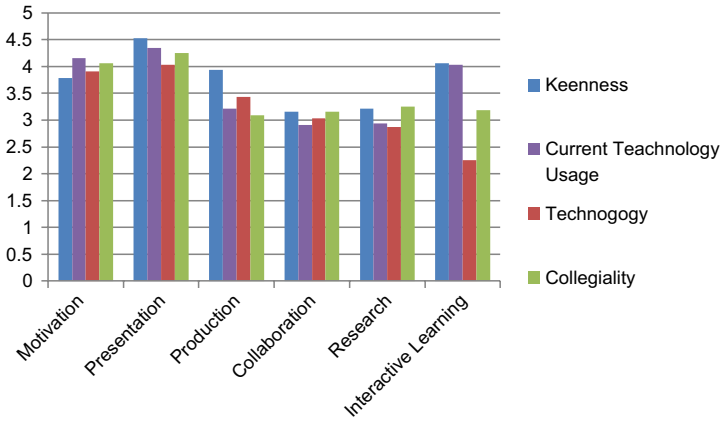


Chart 2. Average ratings of teacher keenness, actual Teachnology usage and teacher perceptions towards Technogogy and Collegiality across the six categories.



4.2. Correlation between Teachnology usage and teacher motivation

Correlational analysis of the relationship between Teachnology usage and teacher motivation ("keenness to use the specific Teachnology") was carried to investigate if the assumption that motivation did underpin teacher behaviour in this current paradigm was correct. Using Pearson's correlational analysis, there was a significant correlation between Teachnology usage and teacher motivation, (r = .181, n = 193, p < .01, two tails). Basically, higher teacher motivation across the six categories of Teachnology was associated with higher Teachnology usage scores. This relationship was also borne out in Chart 2.

The chart shows, in addition to teacher motivation ("Keenness") and Teachnology Usage ratings, the average teacher ratings towards Technogogy and Collegiality across the six categories of Teachnology. The two dimensions of Technogogy and Collegiality seemed to vary according to the cluster of Teachnology types as depicted in Chart 1. From the chart, it is observed that most of the ratings for Cluster 1 dimensions (except for interactive learning) were found to be higher than the ratings for the dimensions in Cluster 2. This seemed to also indicate that the levels of Technogogy and/or Collegiality may impact Teachnology use.

To determine the degree of impact of these two dimensions on Teachnology usage, a multiple regression analysis was conducted using Technogogy and Collegiality as variables. The results showed that Technogogy (β = .403, p < .01) and Collegiality (β = .154, p < .05) were significant predictors. The overall model fit was R^2 = .21 (see Table 4 for details).

Specifically, the following findings were observed:

- On average, teachers appeared keen to use Teachnology and actually did use it for the purposes of motivating the children, presenting content, and for interactive learning categories and less so for student work production, collaboration and research purposes.
- Further to that observation, the relatively low level of Technogogical skills associated with interactive learning does not seem to negatively affect Teachnology usage and teacher keenness. There is the possibility that with the availability of free or cheap online interactive learning resources, teachers do not need the skill to develop these learning resources, leading to easier adoption of these Teachnologies. It should also be highlighted that the item measuring Technogogical skill for interactive learning focused on the teachers' programming skill rather than applicational skill. This item could have resulted in a skewed response from the teachers.

Separately, there were also post-survey responses from the Head of Department (HOD) for Technologies for Learning and Innovation in the school which seemed to indicate that teachers

Table 4. Results from multiple regression analysis for Teachnology usage

Multiple linear regression—Estimated regression equation					
Teachnology[*t*] = + 1.7469 + .402883 Technogogy[*t*] + .154456 Collegiality[*t*] + *e*[*t*]					
Multiple linear regression—Ordinary least squares					
Variable	**Parameter**	**SD**	***t*-stat H_0: parameter = 0**	**2-tail *p*-value**	**1-tail *p*-value**
(Intercept)	1.7469	.286037	6.107	5.64971e-09	2.82486e-09
Technogogy	.402883	.0730444	5.516	1.13179e-07	5.65894e-08
Collegiality	.154456	.0748141	2.065	.0403332	.0201666
Multiple linear regression—Regression statistics					
Multiple *R*			.46235		
R^2			.213768		
Adjusted R^2			.205448		
F-test (value)			25.6935		
F-test (DF numerator)			2		
F-test (DF denominator)			189		
p-value			1.34756e-10		
Multiple linear regression—Residual statistics					
Residual standard deviation			1.00773		
Sum squared residuals			191.935		

Source: Wessa (2013).

benefited from the vendor-produced Teachnology associated with interactive learning. These resources were also available online and hence, did not require much programming or development work. Preparation could also be less tedious. The HOD responded,

> Off the shelf technology is well utilised by teachers ... We also like free online technology e.g. class dojo, Haiku Deck, Google apps, math apps, showme. In school, we do have the following: IWB (Interactive WhiteBoard) Math resources, Moo-O software for reading, Brainpop for Science ...

As such, even though teachers may not possess the programming skills to develop the learning resources, the usage level was still high. With sufficient Collegiality to support the Teachnology usage, teachers were able to effectively carry out the lesson using interactive learning materials without needing to worry about the development process. It was also reflected in the HOD's response that there is a concerted effort on the part of the ICT mentors to both source for and support teachers in their use of new Teachnology:

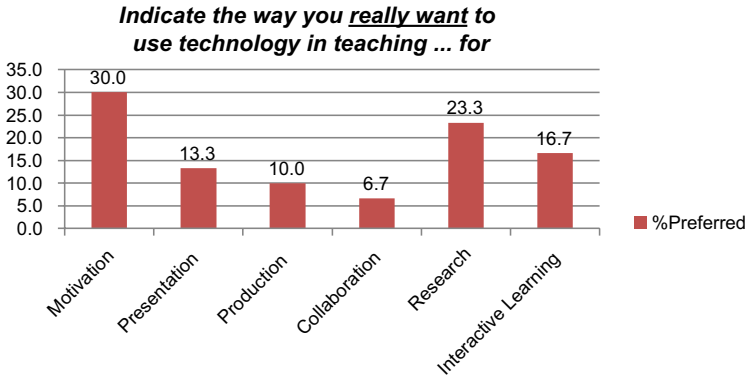
> At the moment, ICT Mentors are encouraged to explore any new ICT online tools for use in classroom.

In general, the results showed that the teachers in West School possessed the right attitude and mentality to carry out ICT lessons in class and the generally high usage rates across all six categories reflected the teachers' keenness to teach in ways which corresponded with the students' learning needs, especially where technology adoption was concerned.

4.3. Category of Teachnology teachers really wanted to use

Finally, when teachers were asked to indicate ONLY one category of Teachnology that they were really keen to use, the responses were somewhat different from the current usage of Teachnology. Chart 3 illustrates the percentage of teachers who selected the one category of Teachnology that they really want to use in teaching.

Chart 3. Percentage of teachers with preferences for specific Teachnology use.



Interestingly, the results indicated that the teachers were keen to use Teachnology as a motivational tool, to facilitate student-led research and for interactive learning. As teachers were forced to choose among the six categories which Teachnology they *really wanted to use*, the results were surprisingly different from the results in Chart 1, which showed how they were actually using Teachnology. In essence, priorisation was incumbent on the part of the teachers to pick the Teachnology that they thought would benefit the students most. Given that the three primary preferences are motivation, research and interactive learning, this set of results may provide further clarity to the school management on what they should focus on when providing staff development or conducting equipment and software acquisition. In particular, the current Teachnology usage rating for research is relatively low compared to the other categories.

In summary, the findings showed differences in teacher ratings between the two clusters of Teachnology usage:

- Cluster 1 (higher): motivation, presentation, interactive learning categories
- Cluster 2 (lower): production, collaboration, research categories

The results from the correlational analysis of Teachnology use and teacher motivation provided evidence that they were related. While causal relationship was not postulated, teacher motivation as the underpinning factor for Teachnology usage could not be ruled out. In addition, the multiple regression analysis revealed that both Technogogy and Collegiality were significant predictors of Teachnology usage. This implied that teachers tended to use the specific type of Teachnology if they possessed the Technogogical skills, and had the appropriate level of support or Collegiality provided by peers.

To validate the relationship, the descriptive statistics generated of Technogogy and Collegiality revealed some corresponding behaviour with Teachnology usage and teacher motivation except for the interactive learning category where Technogogy and to some extent, Collegiality was much lower than the other categories. On the other hand, teacher motivation was relatively higher for production but that did not seem to translate to higher Teachnology usage. It was noted that Technogogy and Collegiality were also lower, in line with the Teachnology usage for the Production Teachnology category.

Seemingly, there appeared possible reasons for the interactive learning category to be dissimilar to the other categories due to the support by vendors in producing and preparing these interactive learning resources and equipment for teaching.

5. Discussion

It is important to note that the survey only entailed one school with 32 teachers. While this satisfied basic statistical requirements concerning sample size, it was insufficient to draw generalisations

across schools in Singapore. Hence, this short study was not targeted at making substantial generalisations concerning ICT implementations, but to illustrate the use of an ICT model (the iTEaCH Implementation Model) in profiling the readiness of the teachers in a school to implement ICT. The study also showed the relationships among technology type (Teachnology), pedagogical beliefs (Technogogy) and Collegiality (peer and school support) in a school context.

5.1. Teachers' perceptions of ICT use

The workshop highlighted the different categories of Teachnology so that teachers could correctly indicate their ratings for the corresponding types of Technogogical skills and Collegiality in the survey.

The results from the ANOVA and Chart 1 seemed to show that there were two clusters of Teachnology types which differed in terms of usage ratings. Based on the needs of the children in that age group (7–8 years old) which generally required more guidance and structure, teachers could have adopted a more didactic instructional approach (Cluster 1). The notable exception in Cluster 1 was the interactive learning category, which could be due to the availability of the resources from vendors, as indicated by the HOD. This inadvertently reduced teacher preparation time while at the same time, provided a fair amount of engagement for the children. The low Technogogical skill might have been due to the skewed responses obtained due to the item angling at programming skills rather than applicational skill in the survey. Hence, it may be possible that preparation time was somewhat less for Cluster 1 Teachnology use with some resources being prepared and given to the teachers. On that note, it may be useful to determine if the lower usage ratings for Cluster 2 Teachnology types (production, collaboration and research) were due to the greater amount of preparation time needed to get the resources or the lesson plan ready. Some qualitative data would be useful to provide insights to the differences observed.

Given that Technogogy and Collegiality were rated highly for the motivation and presentation categories which showed that teachers found the Teachnology easy to use and that there was sufficient support from peers to utilise the Teachnology. On the other hand, the perceived levels of Technogogical skills and Collegiality for student-based research seemed to be low. There may be strong justification to look at addressing teachers' Technogogical skills and Collegiality for student research to determine if this intervention will lift the ratings for Research Teachnology use. Workshops or coaching targeted at research skills may be implemented to close the gaps.

Likewise, the teachers' low ratings of Collegiality in the school for facilitating students to produce work using ICT might have resulted in the low Teachnology usage despite the relatively strong keenness of the teachers in adopting production as a means to engage students. Hence, if the teachers were keen to adopt this type of ICT for use in the classroom, the school may wish to facilitate the development of teacher support mechanisms and groups so that teachers will be able to draw from the experience of other teachers or share their resources to drive the use of ICT in deriving different work products from students (e.g. quizzes, online essays, video assignments and e-portfolios)

5.2. Addressing gaps in ICT implementation using the iTEaCH model

What the previous section has shown is that through a careful examination of specific areas in each Teachnology category, the school can target gaps in either skills or peer support to improve ICT usage rates. More importantly, teachers are empowered to identify their own gaps using the iTEaCH Model.

In summary, for teachers with gaps in their Technogogial skills, teacher training is critical. The degree that Teachnology is used effectively for learning depends on how well the teacher incorporates the selected Teachnology into the curriculum. As mentioned above, targeted teacher training will address the lack of specific Technogogical skills but this also needs to be complemented by strong Collegiality (e.g. peer sharing) to provide a more contextualised approach to building Technogogical capability and expertise.

Building Teachnology, on the other hand, is slightly more resource-intensive as hardware will range from "cheap" to "customised" and hence, can be costly. Student-owned ICT, such as mobile phones and laptops, and "free" ICT resources, such as FaceBook and YouTube video clips, place a low-resource demand on the school but can require a high level of Technogogical expertise on the part of the teacher. Aligning teacher training with the types of Teachnology available in the school is probably more effective than buying all types of technology or sending teachers for training in all types of technology use, some of which teachers may not even believe in.

5.3. Informing ICT interventions

For the school management, the iTEaCH model may be perceived as a "dashboard" to decide how best to allocate resources (i.e. which category to focus on and how). With the "dashboard", schools can now be informed on how they can:

(1) target the right type of software and hardware to purchase (e.g. iPad, iPhones) based on the Technogogical skills of teachers in the school,
(2) recruit teachers with the right level of Technogogical skills for the school,
(3) develop appropriate school culture for implementation of ICT (e.g. organic growth model),
(4) empower teachers to utilise the right Teachnology based on their personal Technogogical preferences for effective teaching and learning, and
(5) encourage teachers to further their professional development by moving into other less preferred or familiar categories for ICT experimentation and implementation.

For individual teachers, locating their own Technogogical belief, the Teachnology they have at their disposal and the Collegiality that can support them in school so that there is alignment across these three dimensions can be useful to exert maximum benefit from their work. Having located their current or preferred category of ICT implementation, teachers can then determine if they wish to explore other categories and if so, develop or acquire the necessary Teachnology, Technogogical skills and Collegiality to initiate and sustain their use of ICT in the classroom.

By mapping their current strengths and gaps on the iTEaCH Implementation Model, teachers can better gauge the resources they have and minimise potential risks of failure such as damaging their confidence levels and needing to account to school management for the resources expended. Similar to using iTEaCH for the implementation of ICT for the school, applying the iTEaCH Model to individual teacher's professional practice is self-empowering. It empowers the teacher through a profiling process (either of self or school) and addressing potential gaps to ensure that the three dimensions (Teachnology, Technogogy and Collegiality) can support the necessary implementation for the selected Teachnology category.

Going forward, the school will continue to work through the ICT mentors to support teachers and source for new Teachnology resources for teachers to use. Possibly, a more targeted approach to identify Teachnology types such as for student research and to motivate students may be adopted.

6. Future research and updates

It will also be useful to determine if a targeted approach to address the gaps (e.g. building teachers' Technogogical skills on designing research questions for lower primary students) will lift the usage of Research Teachnology in the classroom. What was not explored in this study was the impact of the teachers' pedagogical beliefs on their keenness in utilising certain categories of Teachnology (e.g. the teachers with constructivist beliefs may not adopt the Presentation Teachnology). Further examination of how teachers are collaborating or supporting each other to maintain the current levels of Collegiality can also be mapped out as sociograms. This will facilitate the development of support groups and to identify teachers who are currently not within any ICT support groups or clusters. Future surveys should also include items measuring availability of Teachnology and pedagogical skills to apply interactive learning resources and not just the programming skills.

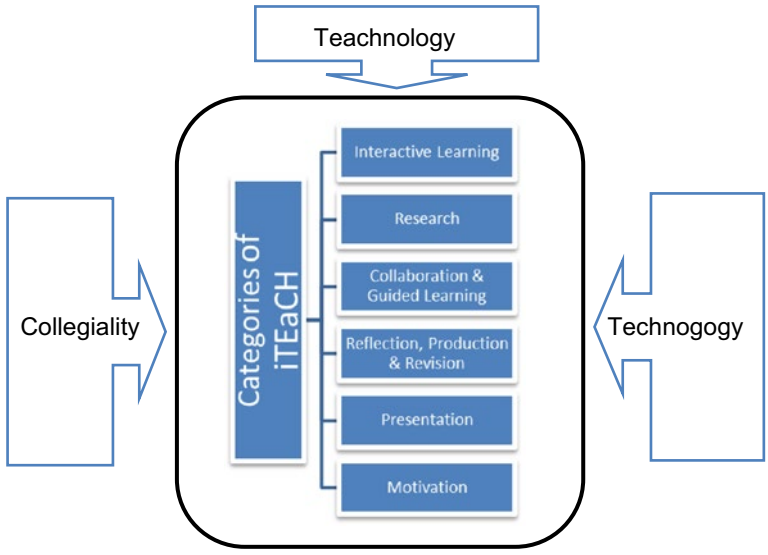


Figure 3. The expanded "iTEaCH" implementation model to comprise six categories of Teachnology.

Finally, the iTEaCH Implementation Model may have to be amended to reflect the sub-categories within the collaboration, research and guided learning category since there appears to be differences in how teachers perceived the Teachnology for collaboration and Teachnology for student-based research.

This implies that the number of categories of Teachnology ought to be presented as six categories of Teachnology instead, same as those reflected in the survey results (see Figure 3 for updated model).

7. Conclusion

The literature seems to adopt unidimensional approaches to investigating ICT implementation in schools [e.g. Roger's (1995) typology of teachers, Sandholtz et al.'s (1997) Stage Theory]. Other factors include psychological factors such as *habitus* (Belland, 2009), learning and production (Choy, 2009) and teacher resistance (Staples et al., 2005), and school factors such as lack of ICT resources and teacher training (Chapman & Mahick, 2004), culture of collaboration and support among school staff (Slay, Siebörger, & Hodgkinson-Williams, 2008). There are few studies (e.g. Mishra & Koehler, 2006; Schussler et al., 2007) which attempt to examine how these cross-dimensional factors interact and influence ICT implementation as a whole. It is unfortunate that most studies remain fixated on single-dimensional treatment when the outcomes are usually determined by the interactions of various factors (e.g. teachers' preference to employ research to engage student learning but may lack the corresponding Technogogical skills to do so).

Beyond just consideration of teacher characteristics (Rogers, 1995) and implementation phases (Sandholtz et al., 1997), this study recognises the complexity of the interactions among the key factors (Technogolgy, Teachnology and Collegiality). The iTEaCH Implementation Model is a reflection of this complexity. With iTEaCH Implementation Model, schools are now informed to craft their technology plan based on their strengths and available resources so as to target specific levels of Technogogical training for teachers and to purchase the appropriate level of Teachnology. Moving forward, the iTEaCH Implementation Model has the potential to assist school leaders in making technological inroads in their school's use of ICT in teaching.

The key tenet of the iTEaCH Implementation Model is that the alignment of the three dimensions (Technogogy, Teachnology and Collegiality) to bring about the selected purpose of the ICT use will ensure a more effective utilisation of resources for classroom teaching. Hence, by understanding the

collegial culture of the school, the pedagogical beliefs of teachers and the available Teachnology, it will inform interventions (such as customising workshops to target Technogogical skills relating to research and interactive learning) to maximise learning effectiveness through ICT use in teaching and learning.

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Appendix A

Checklist for teachers and school administrators on technology use

For each cell, give a rating from 1 (**strongly disagree**) to 5 (**strongly agree**):

	Typically, when I use technology, it is …	**I am keen to use technology that comprises …**	**I have the pedagogical skills to …**	**My colleagues/ school support me in technology use …**	**Difference (subtract lowest rating from highest rating)**
E	To promote active learning through online simulations and interactive games ☐	Interactive games/computer simulations ☐	Use authoring tools or programming to develop interactive learning objects ☐	By sending me for training to use/develop customised ICT resources (e.g. interactive games) for interactive learning ☐	
DR	To promote active learning by designing online activities for students to conduct self-directed research ☐	Research work by the students (e.g. searching for online journal articles**/** reviewing online courses for information) ☐	Design learning for students through online research ☐	By sharing best practices on how I can get students to conduct research online ☐	
DC	To facilitate online discussions and collaborations ☐	Forums or social media sites for discussions and reflections ☐	Facilitate discussions online through the use of questions and topical triggers ☐	Sharing with me how to facilitate student discussions on forums or social media sites ☐	
C	As a platform for students to produce work (e.g. write short essays, answer quizzes) and self-reflections ☐	Online or technology-based quizzes ☐	Set-up online questions and quizzes for students to check understanding ☐	Circulating online questions and quizzes that they developed for use in teaching ☐	

For each cell, give a rating from 1 (**strongly disagree**) to 5 (**strongly agree**):

	Typically, when I use technology, it is …	**I am keen to use technology that comprises …**	**I have the pedagogical skills to …**	**My colleagues/school support me in technology use …**	**Difference (subtract lowest rating from highest rating)**
B	To present information (e.g. slideshows) ☐	PPT slides**/**teacher- or student-made video clips ☐	Present information through multimedia ☐	Sharing their PowerPoint slides and teacher-made video clips with me ☐	
A	To motivate students to learn a topic ☐	Motivating online talks (e.g. Ted Talks), pictures and articles ☐	Source for and using multimedia to pique learner interest ☐	Sharing the e-resources (e.g. videos) which can stimulate interest or motivate students in a topic ☐	
	General Questions				
1	I am excited to use technology in my teaching ☐	I have access to the technology I want to use in my teaching ☐	I am happy with the way I am currently using technology in class ☐	**Other Remarks:**	

Indicate the way you *really want* to use technology in teaching by circling the respective letter (A–E) on the left.

Name: _____ (optional)

Years in Teaching: _____

Age: _____

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