Between School Factors and Teacher Factors: What Inhibits Malaysian Science Teachers From Using ICT?

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ABSTRACT

Despite the Malaysian government's efforts to increase the use of ICT in school, teachers' uptake of the technology remains slow and dismal. In this study, teachers' perceptions of the barriers that inhibited their use of ICT in the science classroom were explored. One hundred and fifty-one (N = 151) science teachers from selected secondary schools in Kuala Lumpur and Selangor took part in the survey. Teachers' perceptions of the barriers were captured using a self-developed questionnaire consisting of 27 Likert-type items. The questionnaires were administered with the help of school principals. Principal components analysis (PCA) with Promax rotation extracted four underlying dimensions of barriers to ICT use, namely teachers' self-handicapping thoughts, school support, attitude toward ICT use, and negative beliefs about ICT use. Three of these factors were teacher related. Self-handicapping thoughts emerged as the largest inhibitor, explaining about 38.2% of teachers' lack of ICT utilization in the science classroom. The results corroborated previous findings that teacher factors tend to outweigh school factors in hampering teachers' uptake of technology.

Keywords: *ICT utilization, science teaching, barriers to ICT use, Malaysian science teachers, Principal Components Analysis*

INTRODUCTION

In Malaysian schools where traditionalist pedagogical approaches prevail over other methods (Sharifah Maimunah, 2003), the use of Information and Communications Technology (ICT) can significantly enhance the quality of teaching and students' learning experience, especially in science subjects. Somekh (2008) argues that ICT is a powerful driver for educational change if used in the right manner, and helps to create a less stressful environment for both teachers and students. The benefits of using ICT are immense for teachers and students of science. For teachers, the Internet expands the instructional resources available to them (Bingimlas, 2009), while also allowing them to empower students to become active and skilful information seekers rather than remaining passive recipients of scientific facts (Pickersgill, 2003). Teachers can make science more engaging and comprehensible to students by employing ICT in four distinct ways as categorized by Ball (2003): as a tool, as a reference source, as a means of communication and as a means for exploration. For students, ICT can support development of science process skills and conceptual understanding, besides enhancing opportunities to engage in effective communication about science at several levels (Murphy, 2006). A comprehensive review of 557 research papers concludes that students can acquire science ideas quite successfully through ICT models and simulations (Hogarth, Bennett, Lubben, Campbell, & Robinson, 2006).

In steps that acknowledge the importance of ICT-enhanced education and mirror global trends in ICT uptake and integration, the Malaysian Ministry of Education formulated multiple strategies and plans to encourage teachers to integrate ICT into classroom teaching. The strategies included the 1997 Smart School Project, the 2003 provision of laptops to Mathematics and Science teachers and the ICT in Education policy, all of which constituted the Ministry's efforts to galvanize greater ICT use by teachers. Extensive amounts of money and resources were expended to this end, but success was marginal. Research shows that the ICT integration level in classroom science is still below the expected standards (Hamid, 2011; Lau, 2006; Shahril, 2007). By and large, science teachers reported using ICT for ancillary services and activities but not for teaching. This is despite their having the necessary equipment (Mohd Darus, 2004), skills

(Multimedia Development Corporation, 2006), and belief that ICT can improve the quality of education (Mohamed Zaki, 2013). These findings support Redecker (2009) who found that, in practice, ICT is either scarcely used or only used to supplement traditional and frontal teaching.

Literature Review

Integrating ICT into classroom learning is not as easy as it sounds. The process is indeed complex and teachers often encounter difficulties. Schoepp (2005) called these difficulties "barriers" and defined them as conditions that make it difficult for a person or organization to progress or achieve an objective. Numerous studies across contexts and cultures have identified what these barriers are among teachers, for example, mismatch between available ICT and existing curricula (Albirini, 2006); lack of institutional support (Ageel, 2011); lack of funds and budget allocation (Alwani & Soomro, 2010); insufficient training (Al-Oteawi, 2002; Taylor & Corrigan, 2007); computer anxiety, ICT efficacy, and lack of confidence (Becta, 2004); teacher beliefs and attitudes (Chen, Tan, & Lim, 2012); resistance to change (Gomes, 2005); overwhelming workload and commitment (Hennessy, Ruthven, & Brindley, 2005); overloaded curriculum and lack of subject-specific guidance for using ICT (Osborne & Hennessy, 2003); outdated hardware and Internet facilities (Ozen, 2012); time constraint and unfamiliarity with new equipment (Peralta & Costa, 2007); absence of technical support (Toprakci, 2006); and readiness as well as motivation (Ward, 2003). In a comprehensive review, Mumtaz (2000) summed up three factors that impede teachers' ICT uptake: the school/institution, resources and the teachers themselves. Although these discoveries are insightful, ICT utilization barriers can be more fully understood if they are clustered into categories or underlying dimensions.

The literature offers some useful classifications of factors impeding teachers' ICT utilization. Ertmer (1999) grouped factors related to teacher variables (e.g., attitudes, beliefs, practices, resistance, personal experience, and awareness) as intrinsic or first order barriers, while placing factors such as inadequate and/or inappropriate configuration of ICT infrastructure, access, time, technical support, resources, and training in the extrinsic or second order category. Chen et al. (2012) discovered that extrinsic barriers (i.e., time and curriculum constraints) tend to play a greater role than intrinsic barriers in hampering teachers' use of ICT in the classroom.

Becta (2004) summarized the research conducted in several different countries over a ten-year period (1993-2003) and proposed two categories of barriers, namely school-level barriers (such as lack of instructional time, access to resources, hardware, and effective training; inappropriate organization; poor quality software; and technical problems), and teacher-level barriers (such as lack of preparation time, confidence and access to ICT resources; resistance to change; negative attitudes; and no perception of benefits). According to Veen (1993), teacher-level factors (e.g., beliefs about ICT benefits and computer skills) tend to outweigh school factors in influencing ICT use. Since the nature of ICT barriers and how they operate to inhibit ICT use are highly context-specific, Becta (2004) suggested that it might be useful to further compare them between specific subjects (e.g., Science, Mathematics or English). In this study, the Becta categorization of barriers (teacher factors and school factors) was used as the conceptual framework to guide the analysis and discussion of inhibitors.

Problem Statement

An extensive body of research is available to inform us about factors inhibiting teachers in general from using ICT in teaching. Much of this body of research, however, has studied these inhibitors as single or individual indicators rather than as groups of factors, or constructs, that share a set of common attributes. Thus the approach to identifying inhibitors has largely been piecemeal. Furthermore, although the literature is replete with studies on ICT barriers, consensus is lacking regarding which factors (teacher-related or school-related) are more instrumental in impeding science teachers' utilization of ICT in the classroom. For instance, the findings of Albirini (2006), Ageel (2011), Alwani and Soomro (2010), Osborne and Hennessy (2003), and Ozen (2012) among others pointed to extrinsic or non-teacher factors, but those of Veen (1993), Becta, (2004), Ward (2003) and Gomes (2005) pinned the inhibitors down to teacher variables. This could be due in part to the piecemeal approach adopted by most studies. The lack of agreement in the findings is also understood as suggesting that ICT utilization barriers are context- and culture-specific, and often influenced by personal, sociocultural and system variables such as local policies, subjective norm, prior experience and institutional support. Furthermore, a large amount of research into ICT use inhibitors among science teachers has been conducted in non-Malaysian settings. As such, the findings may not be completely applicable to the context of Malaysian secondary science teachers. Thus, research to understand these barriers in a specific context among specific groups of teachers is much needed in order to design appropriate intervention programs to galvanize their ICT uptake.

OBJECTIVES OF THE STUDY

The objectives of this study were threefold: (i) to determine Malaysian science teachers' use of selected ICT applications; (ii) to explore if the ICT inhibitors identified from the literature and teacher interviews constituted meaningful and interpretable categories of barriers as proposed by Becta (2004); and (iii) to identify whether school factors or teacher factors were more instrumental in impeding teachers' use of ICT in the science classroom.

METHOD

Respondents

The study was a cross-sectional survey involving 151 science teachers who were purposively sampled from a number of secondary schools in Malaysia. The criteria set in identifying the respondents that befit the purpose of the study were: (i) they must be science teachers teaching in public secondary schools; and (ii) they must be teachers who were not using ICT in teaching science at the time of data collection. Science teachers who did employ ICT in teaching were excluded from the survey.

Female teachers made up 76% of the respondents (n = 115). The sample's mean age was approximately 35 years with an average teaching experience of 9.5 years. Fifty-one percent (n = 77) had received some form of ICT training at their respective schools, while the other half reported having received none. A majority were degree holders (88%), while the rest held either a master's degree (3.3%) or a diploma (8.7%).

Instrument

The data collection instrument was a self-developed questionnaire containing three parts. The first part requested demographic details, while the second required the respondents to indicate whether they used the given ICT tools or applications. Eleven were listed, namely e-mail, blogs, Skype, social networks, online libraries, e-news, Internet browsing, database, spreadsheet, presentation software, and word processor. The third section contained items on two categories of ICT barriers, namely teacher factors (such as ICT efficacy, beliefs about ICT and interest) and school factors (such as scheduling, workload and technical support). The items were drawn from a review of previous works (e.g., Becta, 2004; Mumtaz, 2000), as well as from several interviews and focus group discussions with Malaysian science teachers. The initial pool consisted of 28 Likert-type items with response categories ranging from Strongly Disagree to Strongly Agree. After content validation with five experts in the field, the questionnaire was refined and pilot tested with 31 science teachers. Results of the pilot test indicated that one item was problematic; the item was therefore removed. A reliability check was run on the remaining 27 items yielding an alpha value of .93. Therefore, the study proceeded with the 27 items for data collection. Out of the 27 items, 14 were related to school factors while the remaining 13 were teacher-related.

Data Collection and Analysis

With the help of school principals, 200 questionnaires were distributed to selected secondary schools in Kuala Lumpur and Selangor. E-mails and text messages were later sent as reminders to the respondents to return the questionnaire. Out of the 200 distributed, 152 were collected, constituting a response rate of 76%. The data were analyzed using descriptive statistics (to address research objective 1) and Principal Components Analysis (to address research objective 2).

RESULTS

Use oc ICT Applıcatıons Among The Respondents

Figure 1 presents a visual summary of the respondents' use of selected applications. Four applications turned out to be utilized by a large number of science teachers (between 66% and 79%), namely email, the Internet for browsing purposes, PowerPoint presentation software, and e-news. Just over half reported using social networking sites (55.9%) and databases (51.3%), while about one third (33.6%) used online libraries. Few reported using spreadsheet (21%), Skype (15.1%) and blogs (13.8%). The figures suggest that using ICT was common and quite widespread among the respondents, although the type of application used might vary. This was not a surprising finding considering that the sample consisted of relatively young teachers (mean age was 35) who were more likely to be familiar with ICT than older teachers.

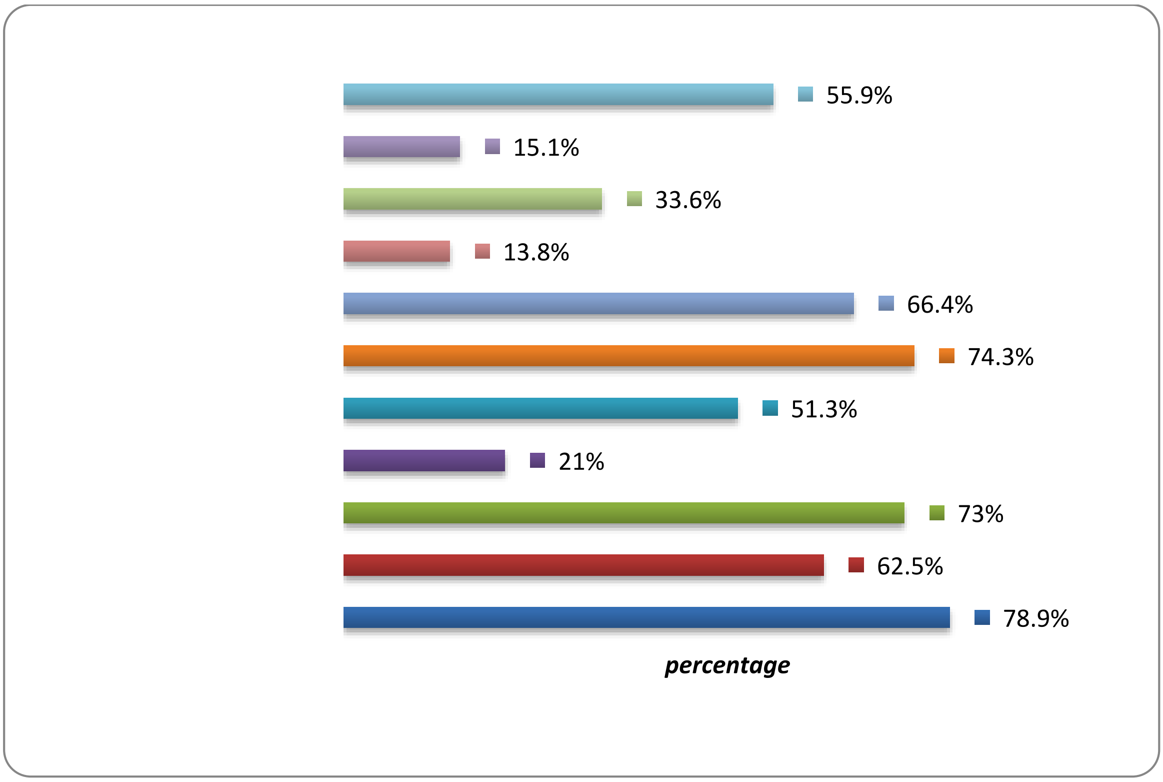

Figure 1*:* Malaysian Science Teachers' Use of Selected ICT Applications *(Percentage)*

Based on the percentage of teachers who reported using the given ICT applications, it could be inferred that most had the basic skills to enable them to use ICT in science teaching. Quite a large majority were familiar with the use of email (78.9%), the Internet (74.3%) and PowerPoint (73%). This means that most respondents could at least use PowerPoint, including its animation features, to present science concepts to the class, search the Internet for supporting materials, learning activities and reading lists, and use email to communicate with students about science ideas and homework. This information rules out lack of ICT skills as a possible barrier to ICT use.

Barrıers to ICT Use

Principal Components Analysis (PCA) with Promax rotation was applied on the data to extract underlying factors that represented barriers to the respondents' use of ICT in the science classroom. The PCA procedures would allow the study to reduce the number of items or variables in the questionnaire down to their principal components, which constituted inhibitors to ICT use. Matsunaga (2010) suggests the use of the Promax rotation technique rather than the more popular Varimax rotation as it is the most suitable and robust technique for data obtained in social science research.

The PCA procedures applied on the data produced acceptable results in terms of sampling adequacy and item correlations. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.88, indicating that the sample size relative to the number of questionnaire items was adequate for applying PCA. The Bartlett's test of sphericity was statistically significant (χ^2=2107.79, 351, p = .001), indicating that the overall correlations within the correlation matrix were adequate. Except for one item *("There are not enough ICT technicians to help"),* the communalities of the variables were acceptable at above 0.5. In summary, these results show factorability of the data, hence justifying the use of PCA in the analysis. The first run of PCA produced a six-factor structure of ICT barriers that explained close to 64.2% of the variance. However, the PCA had to be revised due to eight items that either cross loaded or failed to load on any of the factors. These items were all school-related inhibitors. The problematic items were then identified and removed from subsequent analysis.

The revised PCA after removing eight problematic items produced a clean four-factor solution with no contamination. The Kaiser-Meyer-Olkin (KMO) measure was 0.86, while the Bartlett's test of sphericity was statistically significant (χ^2=1443.56, 171, p = .001). The correlations among items were significant with communalities ranging between .324 and .797. Only three items (*"I find it troublesome to use ICT," "There aren't enough ICT technicians to help,"* and *"The school provides no ICT training for teachers"*) had a communality of less than 0.5. Table 1 shows the inter-item correlation matrix, descriptive statistics and communalities.

Table 1: Inter-Item Correlation Matrix, Descriptive Statistics and Communalities

ITEM	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19
B1	1.00																		
B2	.698	1.00																	
B3	.445	.520	1.00																
B4	.686	.483	.505	1.00															
B5	.418	.411	.495	.525	1.00														
B6	.132	.038	.104	.088	.102	1.00													
B7	.204	.137	.096	.242	.299	.539	1.00												
B8	.265	.198	.149	.291	.230	.465	.649	1.00											
B9	.197	.127	.095	.127	.214	.428	.327	.253	1.00										
B10	.365	.348	.294	.421	.268	.354	.532	.429	.324	1.00									
B11	.189	.246	.110	.172	.152	.264	.332	.302	.232	.280	1.00								
B12	.485	.421	.340	.523	.491	.066	.241	.295	.156	.284	.135	1.00							
B13	.452	.475	.498	.483	.447	.130	.242	.319	.151	.295	.167	.591	1.00						
B14	.360	.387	.303	.362	.378	.184	.402	.425	.286	.427	.178	.513	.617	1.00					
B15	.339	.341	.322	.479	.329	.168	.296	.280	.102	.369	.301	.316	.553	.380	1.00				
B16	.414	.352	.427	.514	.355	.132	.234	.207	.166	.363	.192	.377	.529	.352	.770	1.00			
B17	.401	.381	.481	.454	.411	.085	.121	.080	.105	.349	.211	.247	.393	.266	.455	.489	1.00		
B18	.315	.331	.446	.454	.482	.238	.193	.220	.182	.370	.198	.323	.407	.432	.490	.500	.553	1.00	
B19	.479	.482	.431	.509	.501	-.016	.126	.239	.068	.217	.111	.621	.662	.477	.493	.436	.307	.425	1.00
M	3.68	3.44	3.15	3.56	2.81	2.45	2.65	2.95	2.89	2.67	2.47	3.58	3.45	3.72	2.87	2.81	2.49	2.81	3.50
SD	1.04	1.07	1.04	1.16	1.15	1.12	1.25	1.43	1.03	1.19	1.15	1.16	1.08	1.05	1.02	1.04	1.10	1.13	1.03
Comm	.659	.624	.549	.725	.619	.410	.324	.676	.727	.636	.679	.578	.573	.738	.797	.728	.732	.491	.694

The Promax rotation extracted a four-factor structure of underlying ICT barriers. No item cross-loaded. The structure was represented by 19 items and explained close to 63% of the variance. The four factors are shown in Table 2 along with their representative items, factor loadings, eigenvalues, individual variance explained and internal consistency index.

Table 2: Factor Solution with Items, Factor Loadings, Eigenvalues, Variance Explained and Reliability Index

Factor and Items	Factor Loading	Eigenvalue	Variance Explained	Cronbach's alpha
Factor 1: Self-Handicapping Thoughts		7.23	38.2%	.84
I don't know how to teach using ICT	.835			
I don't have the required ICT skills	.814			
I have no time to learn ICT skills	.632			
I don't feel confident to use ICT to teach	.569			
I find it troublesome to use ICT	.478			
Factor 2: School Support		2.32	12.2%	.79
There are not enough computers for teachers	.824			
My school doesn't provide enough ICT facilities	.792			
There are no ICT facilities in the class or lab	.662			
The school provides no ICT training for teachers	.641			
Class time is too short to use ICT	.582			
There aren't enough ICT technicians to help	.499			
Factor 3: Attitude Toward ICT Use		1.29	6.8%	.85
I'm not interested in using ICT to teach	.762			
I don't see how ICT helps students to understand science	.731			
ICT doesn't improve my teaching	.687			
I think the science curriculum is inappropriate for ICT use	.671			
Factor 4: Beliefs about ICT		1.09	5.8%	.82
My students learn equally well without ICT	.878			
I teach just as well without ICT	.827			
Using ICT requires a lot of time	.663			
My workload doesn't allow me to use ICT	.648			

The factors were then labelled based on the common idea shared by the items that loaded into them. Five items empirically grouped together to create Factor 1. The items revealed debilitating ideas that the respondents had about themselves and their ability to use ICT for teaching. Thus, the factor was labelled ***Self-Handicapping Thoughts***. It alone accounted for 38.2% of the variance. The second factor consisted of six items that pointed to lack of support from the school in terms of infrastructure, technical help and scheduling; thus the factor was labelled ***School Support.*** It explained 12.2% of the variance. The empirical grouping of items that loaded on the third factor revealed the respondents' less than favorable attitude toward ICT use. This factor explained 6.8% of the variance and was named ***Attitude toward ICT Use***. The last factor which accounted for 5.8% of the variance consisted of four items that underscored the respondents' deep-seated beliefs about the necessity of using ICT and the amount of time it would require. The factor was hence labelled ***Beliefs about ICT Use***. All four underlying dimensions displayed high internal consistency indices ranging between .79 and .85 with items that loaded in the same consistent direction, resulting in a solution that was free from variable-specific factors.

DISCUSSION AND CONCLUSION

The descriptive results generally showed that the science teachers surveyed were not unfamiliar with ICT. Based on the figures that reported using the myriad applications asked, it cannot be concluded that they did not have the basic ICT skills needed for science teaching. The least ICT they could employ was PowerPoint as a content delivery tool and an aid to the explication of complex science concepts. They could also refer students to myriad science reading materials on the Internet to augment classroom teaching. However, the use of ICT in this manner should be viewed with some concern as it may lead to nothing more than ICT-supported traditional or frontal teaching as highlighted by Redecker (2009). Instead, teachers should be encouraged to use ICT in more innovative ways. The fact that these teachers actually used ICT for various purposes provides some empirical support for an earlier observation that teachers tend to use ICT for ancillary services and activities, but not so much for teaching. In this study, the science teachers surveyed reported not using ICT at all in their science classes. The reasons were indicated by the data. It appeared that they were impeded by four major barriers: their own self-handicapping thoughts; lack of school support; negative attitude toward ICT utilization; and negative beliefs. Three of these were teacher-level barriers (Becta, 2004) that stemmed from within the teachers themselves. Cumulatively they accounted for 50.7% of the reason Malaysian science teachers avoided using ICT to teach science. The results supported Veen (1993) who earlier maintained that teacher factors tend to outweigh school-related factors in influencing teachers' use of ICT. Lack of confidence and interest intertwined with insufficient ICT efficacy and negative beliefs worked their way up to become the largest inhibitors of science teachers' ICT utilization.

However, one particular finding merits further attention, and that concerns teachers' report about not knowing how to teach using ICT (the first item in Table 2). This brings to light the importance of subject-specific guidance highlighted by Osborne and Hennessy (2003) which also includes technological pedagogical content knowledge (TPCK). Providing teachers with ICT facilities and access alone is insufficient. In order to empower teachers to use ICT successfully, subject-specific ICT training must be designed and imparted with appropriate care and rigor. This effort can be taken up at the school level if necessary with the cooperation of head teachers and school principals. Teacher training programs should also take this finding into account in designing technology training for teachers. Science teachers' needs for training in ICT use may differ from those of other teachers. For example, science teachers may benefit more from skills in using screencasts, simulation and spreadsheet than other ICT applications such as database, programming or word processing. Training in all ICT applications available is not the answer to science teachers' lack of ICT uptake. Moreover, technology is only "good" insofar as teachers know how to use it in meaningful ways that encourage student learning. In this regard, future research should explore the role of TPCK and relevant ICT training in influencing science teachers' use of ICT.

Of the four categories of barriers, only one was school-related, and within this category, access to ICT facilities, technical support and scheduling of class time were discovered to be the main inhibitors. Teachers attributed their lack of ICT use to their respective schools' failure to provide enough computing facilities, access to computers, technical help when needed, adequate ICT training and sufficient class time to accommodate ICT use. The findings agreed with Ageel (2011), Al-Oteawi (2002), Taylor and Corrigan (2007) and Toprakci (2006), but the extent to which they accurately reflected the actual situation in the schools involved could not be ascertained as the study did not acquire institutional data to cross-validate the teachers' self-reports. Future studies to examine ICT utilization barriers should therefore take the cross-validation and triangulation factor into account when designing their research in order to give more weight and credibility to the data. In addition, school administration and management should identify the ICT requirements of science teachers through an ICT needs analysis. The analysis will help schools to carefully assess and identify whether the ICT facilities they wish to purchase would be relevant to what science teachers need to enhance their instructional quality.

Eight school-related items failed to load on any factor although they were included in the PCA procedures. This may be attributed to several factors. Firstly, the eight items were found to be too weakly correlated to be able to form a factor or to load on the extracted school-related category of barriers. Secondly, they did not constitute a reliable construct to represent meaningful barriers. Thirdly, each of the items could have measured different aspects of school-related barriers that did not share a common attribute, which would have been detected during the pilot test had the sample size been large enough. Fourthly, the pilot test conducted could not examine the structure of school-related barriers due to the small sample size of 31 science teachers. Further studies looking into ICT barriers should address these inadequacies and methodological concerns.

On the measurement side, given the substantial number of problematic items found in the questionnaire (i.e., items with significant cross-loadings) which affected the number of factors to be retained and the proportion of variance explained, many items had to be revised and reworded to be more closely in line with the categories of barriers established in the literature (e.g., Becta 2004). The present study could be treated as a pilot test to establish the reliability of the data and refine the items that measure ICT adoption barriers among science teachers. Upon revision and improvement of the items, new samples of science teachers could be surveyed from within and outside of Malaysia (for comparative analysis) to generate more comprehensive data that can better explain the reasons for science teachers' slow uptake of ICT.

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