

A Systematic Review of Critical Factors Regarding ICT Use in Teaching and Learning*

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Abstract

ICT use has gained currency in the realm of education for about three decades. This has led to a proliferation of ICT research studies in educational settings, which has also made it more challenging for ICT practitioners and researchers to keep up with the current trends and identify the research gaps in the literature. In regard to this, the present review aims to summarize critical factors pertinent to ICT use addressed in the reviewed papers. The paper also discusses what direction future ICT research might go. As a guideline in the current review study, the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was employed. The review results extracted from our qualitative synthesis were presented and based on the results a generic model illustrating ICT related student, teacher and school conditions was proposed. Finally, a list of implications for future research was also provided for ICT practitioners and researchers.

Keywords: ICT use; Systematic review; ICT adoption, ICT framework

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INTRODUCTION

Information and Communication Technology (ICT) use in educational settings has gained a growing reputation and concern in both developed and developing countries (Law, et al. 2008). This increasing interest for integrating ICT into teaching practices is principally associated with modern educational systems' striving for providing students with more enhanced learning opportunities (Kalolo, 2018; Pérez-Sanagustín, et al. 2017). Another reason for this growing interest is students' demand for availability and accessibility of information technologies as part of their daily lives, along with connectivity and share of e-learning contents within school learning environment (Islam, & Grönlund, 2016). With this respect, ICT is regarded as both a learning tool and a facilitator of achieving national educational goals (Baser-Gulsoy, 2011). Thus, ICT adoption into educational settings have become prominent and challenging for today's education systems.

With an attempt to address this challenge, many countries-whether located in the developed or developing part of the world-including Korea, India, Peru, Sweden, Turkey, the UK, the US, Uruguay, etc. have allocated vast amount of budgets and initiated large scale ICT integration programs, such as OLPC in Peru, Uruguay, India, G1G1 in the US, and F@tih in Turkey. This sort of initiatives is usually called as one-to-one (1:1) programs since they offer one computing device (PC, Laptop, Tablet or PDA) per student (Aydin, Gurol, & Vanderlinde, 2016). Despite large-scale investment on improving schools' ICT infrastructure and on providing students with computing devices (PC, Laptop, Tablet or PDA), previous studies acknowledge that this sort of spending does not solely ensure effective integration of ICT into teaching practices (Tay, Nair, & Lim, 2017; Wang, 2008). However, the literature on educational ICT research strongly underlines that ICT integration into education is a complex and multifaceted phenomenon. It includes many interrelated system, school and teacher level factors (Aesaert, et al. 2015; Tondeur, et al. 2008; Vanderlinde, & van Braak, 2010). Hence, effective integration of ICT into teaching practices requires careful planning and informed decisions based on learnt experiences that can be drawn from previous ICT research context.

Although there is an established literature review on ICT research in education, it is imperative to conduct periodical review studies since ICT is constantly evolving and schools, teachers and students are demanding new technologies for instructional purposes (Harper, & Milman, 2016). Given this, the current review study makes the following contributions to the realm of educational ICT research. First, it provides an update of critical factors related with ICT use in education by reviewing the most recent studies. Second, derived from the review results, it also proposes a generic model in order to illustrate critical issues regarding ICT use. Finally, the present study also identifies the current research trends and gaps, providing meaningful insights for ICT researchers and practitioners as well as ICT policy makers.

BACKGROUND

ICT Use and Related Factors

A wide array of teacher, student and school level factors were identified in the previous studies situated in the ICT literature. From a teacher-centred perspective, most researchers attributed a pivotal role to teachers for an effective ICT adoption by specifically focusing on certain ICT related teacher level factors, including teachers' ICT skills (Demirli, 2013; Tezci, 2011), their attitude towards ICT (Aslan, & Zhu, 2017; Cakiroglu, 2015; Tezci, 2011), ICT training (Hismanoglu, 2012; Tondeur, et al. 2008), and pedagogical beliefs (Baser-Gulsoy, 2011). In a similar vein, some scholars focused on student's ICT use (Agbo, 2015; Semerci, 2018; Song, & Kang, 2012) and related factors, such as their attitude towards ICT (Agbo, 2015; Aslan, & Zhu, 2017; Demirli, 2013; Semerci, & Aydin 2018; So, et al. 2012), ICT competence (Aesaert, et al. 2015; Goodwin, et al. 2015) and ICT experience (Semerci, 2018; So, et al. 2012). In addition to considering teachers' critical role in integrating ICT in class, some ICT researchers have also paid heed to school level factors, such as schools' ICT policy (Tondeur, et al. 2008, Vanderlinde, et al. 2012), ICT planning (Gulbahar, 2007; Vanderlinde, et al.

2012), schools' ICT infrastructure (Goktaset, al. 2009; Vanderlinde, & van Braak 2010; Zhong, 2011), ICT support (Chisalita, & Cretu, 2015; Karaca, et al. 2013) and technology leadership (Flanagan, & Jacobsen, 2003).

All those aforementioned studies attempted to provide a better understanding of ICT adoption in teaching and learning and ICT related factors. Yet, there are still some research gaps that need to be addressed. First, although ICT use is regarded as the heart of ICT integration in many ICT studies (Vanderlinde, et al. 2014), there is no clear understanding of how ICT use is conceptualized and examined in the literature (Hew, & Brush 2007). For example, Van Braak et al. (2004) proposed two distinctive ICT use - supportive and class use of computers. In addition, Tondeur et al., (2008) identified three types of ICT use, namely use of ICT as an information tool, as a learning tool, and learning basic ICT skills. More recently, Vanderlinde et al. (2014) introduced institutionalized ICT use encompassing factors related to students and teachers' ICT use. Considering the differences in research contexts, participants and so forth, different terms and conceptualizations pertinent to ICT use might be seen as justifiable, yet there is a need for update review studies in order to identify research trends and gaps as to ICT use and related factors. Second, a number of previous ICT research studies mostly focused on identifying critical ICT related conditions; however, a limited number of previous studies adopted or presented a comprehensive ICT adoption framework or model to formulate what specific teacher conditions facilitate or impede their uptake of ICT. Third, although student-centred curricula are in use in many contemporary educational systems, most previous studies existing in the literature focused on teachers' or student-teachers' ICT use in educational settings from a teacher-centred perspective, yet ignoring the real students' use of ICT. Thus, there is a need for review studies in order to identify critical factors pertinent to students' ICT use in teaching and learning process. In view of aforementioned research gaps, in order to summarize current state and to identify research gaps regarding ICT use and related factors, there is a need for periodical review studies (Harper, & Milman 2016) since ICT is changing and new technologies might be offering alternative learning and teaching opportunities for students and teachers.

Previous Review Studies

Educational ICT research is a dynamic research area. Hence, there is a proliferation of educational ICT research studies, particularly with the increasing popularity and prevalence of ICT integration programs (Holcomb, 2009). However, comprehensive studies like systematic reviews reflecting wider perspectives on educational use of ICT are limited in number and coverage (Islam, & Grönlund, 2016). To our knowledge, there are four papers systematically reviewing critical factors related ICT use. Most of those studies put more emphasis on just one type of computing device (usually laptop) and mainly focus on factors related with the impact of ICT use rather than ICT adoption. For example, in their review studies, Fleischer (2012), Harper and Milman (2016), Perez-Sanagustin et al. (2017) and Islam and Grönlund (2016) focused on the impact of ICT use on student level factors such as students' academic achievement, motivation or engagement, ignoring how ICT use is defined and what critical factors enable or impede instructional use of ICT. Amongst those studies, only two studies Harper and Milman (2016) and Islam and Grönlund (2016) examined enablers and barriers of ICT use in educational settings. Building on the aforementioned review studies, the present study will update the current literature on ICT adoption and related factors with a wider empirical scope.

In addition, Islam and Grönlund (2016) asserted that most previous studies examining ICT use in educational settings were conducted in the developed part of the world- mainly in the US. On this account, little is known about the global scenario of ICT adoption, particularly about the current state of ICT related issues in the developing countries. Hence, there is a need for further review studies in order to provide a wider perspective of ICT related issues with regard to geographical coverage (Islam, & Grönlund, 2016). Given this, in our review we aimed to provide a wider perspective in terms of contextual coverage, variety of computing devices (Laptop, PC, Tablet Computer etc.), various types

of ICT use and a large number of ICT related factors. Table 1 below illustrates the details about the current review and previous review studies.

Table 1. The Present and Previous Systematic Review Studies of ICT Use in Education

Review Study	Coverage			Main focus
	Years	Papers	Database(s)	
Present review	2012-2016	65	ERIC	ICT use, Teacher, student and school related factors
Islam & Grönlund, 2016	2000-2013	145	ABI/Inform, EBSCO Host	Usage patterns, Impacts on students, teachers, learning and teaching, Challenges and factors
Perez-Sanagustin et al. 2017	2011-2015	352	Computers & Education	Impact on students
Harper & Milman, 2016	2004-2014	46	ERIC	Impact on students, ICT use, Challenges to integration
Fleischer, 2012	2005-2010	18	ERIC, ASE, TRC, CS, EBSCO, ISI Web of Science	Teacher, and student related factors

Significance of the Review Study

ICT research in educational settings is proliferating due to the growing public interest and large scale investment on ICT integration into education (Islam, & Grönlund, 2016; Law, et al. 2008). Given this research context, a growing body of research studies examining issues regarding educational use of ICT is conducted in many different settings. This not only contributes to a better understanding of ICT adoption at schools, but also accounts for certain problems for ICT practitioners, ICT policy makers and even for ICT scholars since it may not be always safe to take decisions based on the results of previous studies, to build up new research on existing literature, or to catch up with the trends in the realm of ICT research (Gough, & Thomas, 2016). Thus, compared with a few decades ago, what works for similar settings, what gaps exist in the literature and what direction ICT research should go remain uncertain and much more complicated in many contexts (Islam, & Grönlund, 2016). Similarly, the diversity of research context as well as the quantity of conflicting studies existing in the literature has given rise to the need for systematic review studies in educational ICT research (Fleischer, 2012).

A systematic review is a valuable tool in collecting the critical scientific evidence necessary for developing evidence-based guidelines, making programmatic decisions, and guiding future research. (Mullins, et al. 2014). In other words, a systematic review is an essential tool for researchers, practitioners and policy makers who want to remain current with the evidence in the field. In this regard, a systematic review must adhere to strict standards, as its results can provide a more objective appraisal of evidence for making scientific decisions (Gough, & Thomas, 2016). This is the case in the ICT research realm where ICT policy makers need to take informed decisions based on the previous research. However, this is not always easy and safe to take sound decisions since ICT is not a static area, but rapidly and constantly changing, so is ICT research evolving at a similar pace. This presents some challenges for ICT policy makers to take decisions based on sometimes conflicting research results and also for ICT researchers to identify existing research gaps and build on new research. On this account, systematic reviews can serve as a fundamental and safe research tool for ICT researchers and policy makers in order for them to keep up with the latest research trends, build up new research and take sound decisions.

Another major advantage of systematic reviews is that they follow strict guidelines so as to reduce bias. These guidelines provide essential elements to include in the review process and report in the final publication for complete transparency (Gough, & Thomas, 2016; Mullins, et al. 2014). Since

they follow strict guidelines, such as QUOROM, PRISMA or AMSTAR for ensuring adherence to full transparency and reproducibility, systematic reviews can disclose profound evidence that research community can benefit in framing what has been studied, how it has been studied, and what should be studied in the future (Mullins, et al. 2014). Thus, systematic literature reviews can serve as a reliable tool for ICT researchers and policy makers to remain current with the ICT related issues and build up new research based on the existing research gaps, which illustrates the significance of the present study, as well as justifying the rationale of the current review.

Purpose of the Review and Research Questions

The present review, although it doesn't claim to be comprehensive in its coverage, aims to summarize recent research results pertinent to educational use of ICT and to provide a clear picture of status, gaps and trends in current ICT research realm. To achieve this overarching aim, the following seven research questions (RQ) were addressed in this review:

- 1: In which country/region the research was carried out?
- 2: Which subject areas were addressed?
- 3: Which educational levels were addressed?
- 4: Who were the participants included in the study?
- 5: Which methods were employed in the study?
- 6: How ICT use was defined and measured in the study?
- 7: What factors related to ICT use in educational settings were addressed?

Prior to conducting the review, a review protocol was specified in order to minimize the potential bias. The protocol included review objective and search categories generated based on the components of SPIDER method of searching electronic databases (Methley, et al. 2014). These categories were namely, publication year, title, author, SPIDER (Sample, Phenomena of Interest, Design, Experience, Research category), and quality assessment. In order to ensure transparency and inter-rater reliability by reducing researcher based bias of review, we transferred the components of our protocol into a Google Form. It is available online on: https://docs.google.com/forms/d/e/1FAIpQLScHBnnHPcCI_lq0BoVS9n-gphLZJWWdurw-OBaR5l_ckcOocQ/viewform. The data collected through Google Form transferred into a spreadsheet and undergone quantitative and qualitative synthesis.

Table 2. Review Objective and Review Protocol

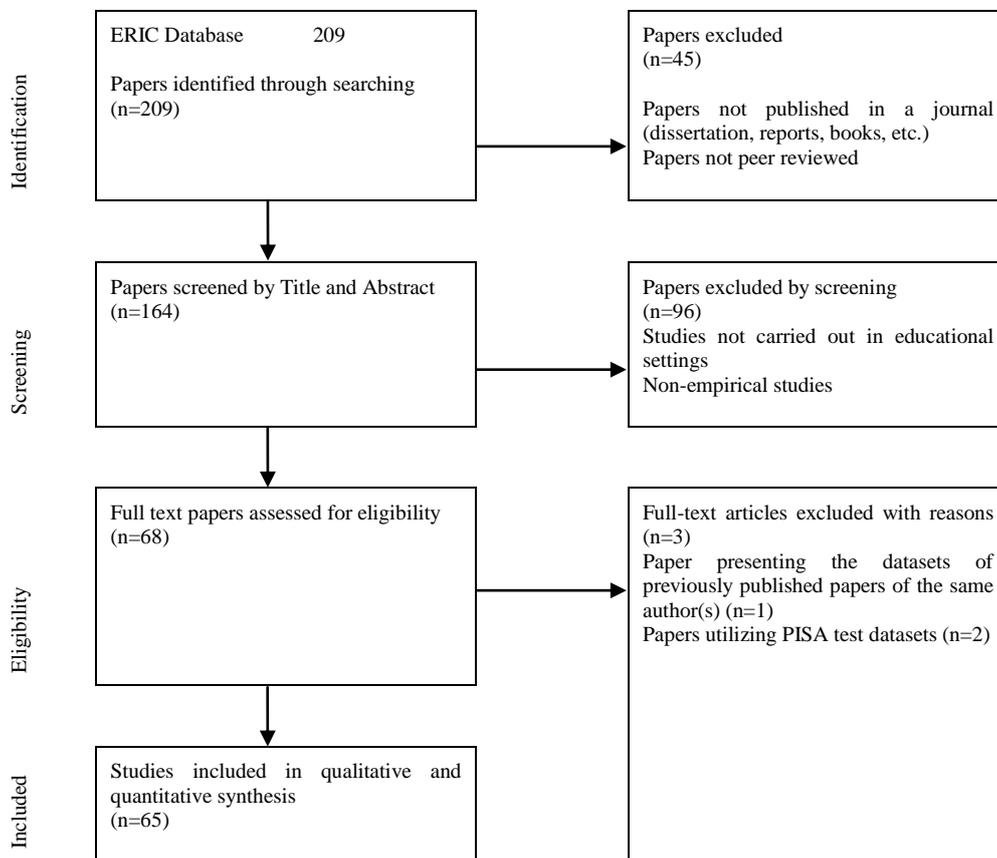
Objective	The objective of this review is to provide an overview of research on ICT use and related factors in educational settings.	
Research Questions	Review Categories	
	Pubyear	2012-2016
RQ1	Country	Affiliation of corresponding author
RQ2	Sample	Participants (Teachers/Students/School Administrators, Schools), Subject
RQ3		discipline (Mathematics, Science, Language, etc.), Educational level (Pre-school,
RQ4		Primary, Secondary, Tertiary)
RQ6	Phenomena of Interest	Studies examining ICT use and/or related factors, Frameworks applied to explain
RQ7		ICT use in teaching and learning (TAM, TPACK etc.)
	Design	Study designs (survey, correlative, experimental, focus group, grounded theory, etc.)
RQ5	Experience	N/A (Non-applicable in this review)
	Research category	Quantitative, Qualitative or Mixed Methods

Since the present study aimed at summarizing ICT adoption and related factors addressed in the reviewed studies and eventually proposing a generic ICT adoption model based on the results; hence, the experience category was omitted since it is more related with the impact of ICT use. And also the “Design” and “Research category” sections were merged into one category in the protocol since both are related with the methodological approach adopted in the studies.

METHOD

The present study is based on a systematic review of empirical studies focusing on ICT use in educational settings and of ICT related critical factors addressed in those studies. In order to ensure the rigor and quality of review process, the PRISMA Statement (Preferred reporting Items for Systematic Review and Meta-Analyses) was employed as a guideline (Moher, et al. 2009). Hence, the review process included identification, screening, eligibility, and included stages as proposed by the PRISMA guidelines. Table 3 provides an overview of review methodology by illustrating the PRISMA steps and procedures that we followed in the current review study.

Table 3. An Overview of Review Process



Source: Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement*. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

As clearly illustrated in Table 3, the steps proposed in the PRISMA statement were (1) Identification, (2) Screening, (3) Eligibility, (4) Included. Those steps were followed throughout the review process, which contributed to transparency and robustness of our review results.

In the data analysis process, we employed the constant comparative method (Glaser, & Strauss, 1999; Matavire, & Brown, 2013) in order to analyze the emergent themes. In the coding phases, open, axial and selective coding was performed iteratively on the papers included in the review (Strauss, & Corbin, 1998). Then, through further analyses, we identified properties of each category and created broad categories or themes.

Databases and Search Terms

The search strings run on the ERIC database respectively was as follows:

- “ICT use” pubyear:2012
- “ICT use” pubyear:2013
- “ICT use” pubyear:2014
- “ICT use” pubyear:2015
- “ICT use” pubyear:2016

In addition, some limiters were selected in order to eliminate the papers that wouldn't suit the research aim. These limiters were “Journal Articles” and peer reviewed only”. Given the broad perspective of overall technology use, it was beyond the scope of the current paper to include all possible technology use papers in the review. In regard to this, we didn't place a query including search term “technology use”, instead we utilized the term “ICT use” not “technology use” for practicality and feasibility means. Although this increased the transparency and reproducibility of our results, it posed a limitation regarding the coverage of our study. A few invaluable research papers might have been excluded due to this restriction.

Inclusion Criteria

In order for the inclusion of the proper studies in the review, some criteria were specified. These were:

- IC1. The study must be published between 2012 through 2016,
- IC2. The study must be an empirical study (qualitative and/or quantitative data must be collected through the study)
- IC3. The study must be carried out in formal educational settings (schools, universities etc.),
- IC4. The study should focus on exploring or explaining ICT adoption/use and/or ICT related factors (student level, teacher level or school level factors).

Quality of Studies

Since the quality of review studies is heavily dependent on the quality of the papers included, we categorized each study by rating them relevant, irrelevant or not clear. As a second round of screening, we rescreened all papers labeled as not clear in the first round. In the second round, another researcher was invited as an audit to screen all the papers. This ensured the inter-rater reliability of the included papers.

REPORTING THE REVIEW

Papers Meeting Inclusion Criteria

Prior to conducting the review, we decided to draw data from ERIC database. The rationale for choosing the ERIC database is that it is a solely educational database unlike many other multidisciplinary databases. In addition, it covers high quality journals that are also included in many other databases such as Scopus, Web of Science and Google Scholar. Another reason is its selection policy. Even if the database updates its selection policy in the future, the previously published journals are not excluded. As a consequence of this policy, the reliability and transparency of our results are safeguarded.

As a result of the preliminary query of our search terms, we identified 209 papers in the ERIC database. Table 4 below illustrates the distribution of those papers by publication years, and the number of papers meeting the inclusion criteria after screening.

Table 4. The Distribution of Papers by Years

Publication year	Papers identified	Papers screened by title and abstract	Eligible full-papers meeting inclusion criteria
2012	42	33	10
2013	42	23	6
2014	32	29	12
2015	46	38	21
2016	47	41	16
Total	209	164	65

Table 4 illustrates that there is a slightly growing interest of ICT research by years except for the year 2014. The number of ICT research studies in educational settings has shown a growth at a nearly steady pace. This can be a supporting evidence for the shared assumption in the literature that ICT use in education has gained an increasing reputation recently.

Review Results Illustrating Research Context by Regions and Countries (RQ1)

In order to answer the first review question, the country affiliation of corresponding author for each paper was reviewed. The results were given in the Table 5 and the Figure 1 below.

Table 5. The Distribution of Papers by Countries and Regions

Region	Country (f)	%
America (<i>n</i> =4)	Chile 2, Mexico 1, USA 1	6.05%
Asia (<i>n</i> =16)	China 1, India 1, Indonesia 1, Iran 2, Malaysia 4, Singapore 3, South Korea 2, Vietnam 2	24.61%
Africa (<i>n</i> =18)	Ethiopia 2, Ghana 5, Kenya 2, Malawi 1, Morocco 1, Nigeria 4, South Africa 1, Tanzania 1, Tunisia 1	27.69%
Europe (<i>n</i> =15)	Belgium 3, Finland 1, Greece 1, Ireland 1, Netherlands 1, Norway 1, Slovenia 1, Spain 2, Sweden 1, Switzerland 1, UK 2	23.07%
Middle-East (<i>n</i> =10)	Israel 3, Turkey 6, Yemen 1	15.38%
Oceania (<i>n</i> =2)	Australia 2	3.07%

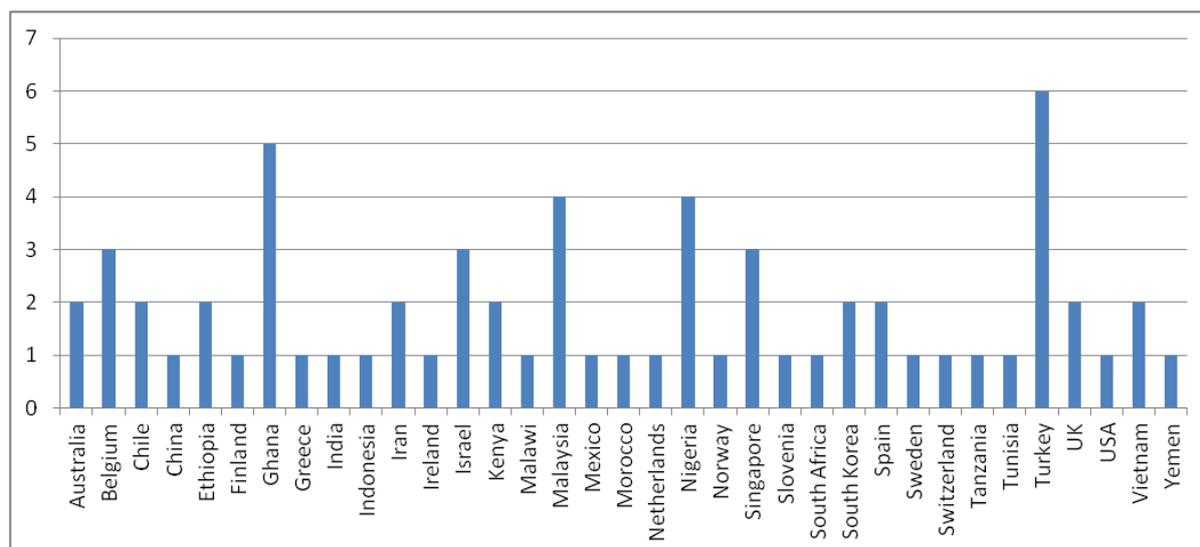


Figure 1. The Distribution of Papers by Countries.

With a closer look at the Figure 1 and Table 5, along with the limitation of inclusion and exclusion inherent to review studies, a number of countries such as Turkey, Ghana, Malaysia, Belgium, Nigeria, Israel and Singapore were the leading countries in terms of research context. Some of these countries have recently initiated their large scale ICT integration programs like Fatih in Turkey (Aydin, et al. 2016) and some others have overhauled their curricula such as Flanders in Belgium (Aesaert, et al. 2013). In line with these, this finding may resonate that ICT research community have invested some concern on the developments in the realm of educational technology in those countries. As a result, there is an increase in number of ICT studies in those countries. This may be signaling that there is a link between the presence of ICT integration programs and the volume of ICT research studies conducted in the same context.

Review Results on Subject Disciplines Addressed in the Study (RQ2)

Pertinent to the second review question, the subject discipline addressed in each paper was reviewed. The results were presented in the Table 6 below.

Table 6. The Distribution of Papers by Subject Disciplines

Subject Disciplines	(f)	%
Agriculture	1	1.49
Distance Education	1	1.49
Early Childhood Education	2	2.98
E-learning	1	1.49
Language Learning/Teaching	7	10.44
Mathematics	6	8.95
N/A	43	64.17
Science	5	7.46
Social Sciences	1	1.49
Total	67*	100

*Two papers addressed more than one subject discipline, resulting in 67 as a total.

Table 6 illustrates that in more than half of the reviewed studies (64%), the subject disciplines were not addressed or taken into consideration. In other words, those papers were not directly addressing to subject-specific use of ICT. Rather they focused on generic ICT use in teaching and

learning process than investigating subject specific use of ICT. On the other hand, the studies focusing on Language Learning/Teaching, Mathematics and Science subject areas account about 30% of overall studies included in the review. This can be an indicator of ICT use and concordantly ICT research particularly in the field of Language, Mathematics and Science is more prevalent compared with the other subject areas. This finding strongly supported the results of a previous study conducted by Tay, Nair and Lim (2017) in Singapore context. Results also illustrated that still there is a need for more research on subject specific use of ICT in educational settings.

Educational Levels and Participants in the Study (RQ3, RQ4)

The study participants were categorized as students, teachers, students and teachers, teachers and administrators and the schools. In addition, the educational levels were specified as pre-school, primary/elementary, secondary/middle, higher/tertiary education. The results were presented in Table 7.

Table 7 Study Participants and Educational Levels

	Students	Teachers	Students and Teachers	Teachers and Administrators	Schools
Pre-school	-	2	-	-	-
Primary	1	5	3	-	1
Secondary	4	15	1	1	-
Primary & Secondary	-	3	-	-	-
Tertiary	21	3	4	1	-
Total	26	28	8	2	1

In 43% of studies (N=28) included in the review, the study participants were solely teachers. Another major group of participants was students (N=26) comprising of 40% of the studies. However, the comparative analysis of the Table 7 illustrates that 80% of the student centred-studies was carried out in higher education context. A deeper investigation indicates that most of these studies targeted student teachers' ICT use along with their ICT attitude and perceptions, their ICT knowledge and skills. This also palpably illustrates that there is a research evolution towards the prospective teachers' ICT use and influencing factors on the contrary to the general consensus in the literature that teachers' ICT use is in the centre of ICT research (Vanderlinde, et al. 2014). Thus, it could be signaling that ICT research focus is shifting from a teacher-centred perspective to a more student-centred form. This finding mostly concurred with the results of a recent systematic review study (Pérez-Sanagustinet, al. 2017), supporting the sensitivity and robustness of our review results.

Review Results about Design of the Studies (RQ5)

The research design employed in each study was identified and coded based on Creswell's (2007; 2012) description of research methods. In the line of this, the distribution of research design employed in each study is presented in Table 8 below. Results illustrate that the vast majority of the papers (70%) utilized a quantitative approach to ICT research and respectively 14% of them adopted a qualitative methodology. Finally, 16% employed a mixed-methods design of inquiry.

Table 8. Design of the Studies by Publication Years

Publication Year	Quantitative	Qualitative	Mixed Methods
2012	7 (Survey 2, Correlational 5)	1 (Multiple Case 1)	2 (Exploratory 1, Explanatory 1)
2013	6 (Survey 3, Correlational 3)	-	-
2014	7 (Survey 2, Correlational 5)	1 (Single Case 1)	4 (Exploratory 1, Explanatory 2, Embedded experimental 1)
2015	15 (Survey 8, Correlational 7)	4 (Single Case 2, Multiple Case 2)	2 (Explanatory 2)
2016	10 (Survey 3, Correlational 6, Experimental 1)	3 (Single Case 2, Multiple Case 1)	3 (Explanatory 3)
Total	45	9	11

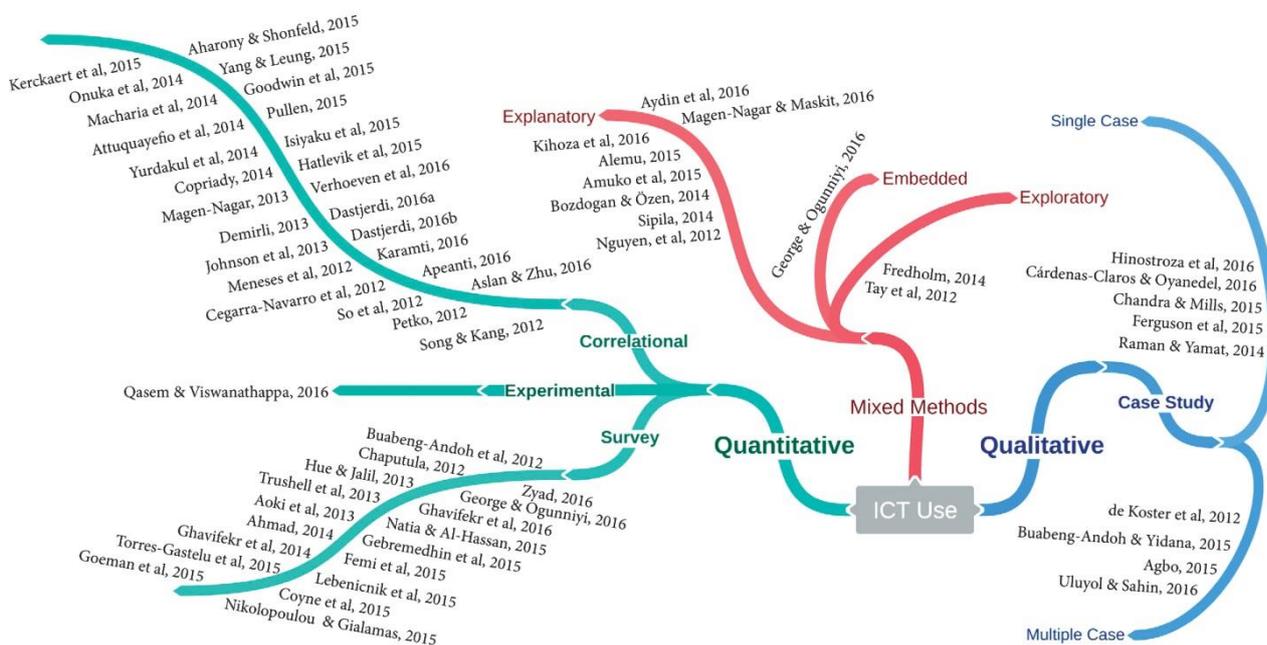


Figure 2. Illustration of Reviewed Studies by Research Design

As illustrated in Figure 2, there is a dominance of quantitative studies in the realm of ICT research. This finding overlapped with the results of a previous review study (Pérez-Sanagustín et al. 2017). Yet, most studies employed non-experimental designs of quantitative inquiry such as correlational and survey designs. In regard to experimental studies, there are only two study included in the review that utilized experimental design (one experimental paper labeled under mixed-methods since the authors). This result heralded that there is a need for more interventional studies in inquiry of ICT use and its influencing factors or its impact on students’ learning. Likewise, the number of studies adopted a qualitative or mixed-methods design is limited in number compared with the quantitative studies. Pertaining to the balance between quantitative and qualitative research designs, review results purported that there is a need for more case studies and interventional designs in ICT research.

Review Results about Typology of ICT Use (RQ6)

Regarding the RQ6, the typology of ICT use and theoretical foundations adopted in the studies were coded and categorized. Table 9 below presents these categories and qualitative synthesis of them.

Table 9. The typology of ICT use and the theoretical underpinnings

Themes	Categories	Experiential Learning	Will, skill, tool	With, from	TPACK	**Others	TAM, UTAUT	Not Specified	Overall (f)
ICT Use Competence	Digital Competence	-	-	-	-	-	-	1	1
	ICT Literacy*	-	-	-	-	-	-	1	1
	ICT Competences*	1	-	-	-	-	-	-	1
	ICT Competence and Perceived Importance	-	-	-	-	-	-	1	1
	ICT Composite Index	-	-	-	-	-	-	1	1
	ICT Usage Phase (survival, mastery, impact and innovation)	-	-	-	1	-	-	-	1
	ICT Knowledge	-	-	-	-	-	-	1	1
	TPACK	-	-	-	1	-	-	-	1
ICT Use Context	Before, during, after class	-	-	-	-	-	-	1	1
	Frequency of Use of ICT tools (Classroom Use)*	-	1	1	-	-	-	1	3
	ICT Use inside and outside Classroom	-	-	-	-	-	-	1	1
ICT Use Frequency	Actual Use of ICT	-	-	-	-	1	-	-	1
	Application of ICT	-	-	-	-	-	-	1	1
	Behavioral Intention & Use Behavior	-	-	-	-	-	5	-	5
	Frequency of Use of ICT tools	-	-	-	1	1	2	13	17
	Frequency of Use of VLE and the Internet	-	-	-	-	-	-	1	1
	Frequency of Use of ICT tools (Classroom Use)*	-	1	1	-	-	-	1	3
	Frequency of Use of ICT tools and ICT literacy*	-	-	-	-	-	-	1	1
	Frequency of Use of ICT tools and ICT competences*	1	-	-	-	-	-	-	1
ICT Use Style	Functional Use	-	-	-	-	1	-	-	1
	ICT Tools, Goals, Activities	-	-	-	-	-	-	1	1
	Organizational & Informative	-	-	-	-	-	-	1	1
	Supporting basic ICT skills and attitudes & Supporting contents and individual learning needs	-	-	-	-	-	-	1	1
	Supporting teaching and learning	-	-	-	-	-	-	1	1
	Innovative use (instructional, communicative, organizational, evaluative, supportive)	-	-	-	-	-	-	1	1
	Professional Use	-	-	-	-	1	-	-	1
	Traditional & Constructivist Use	-	-	-	-	-	-	1	1
ICT Use Tools	ICT Use at the Micro Level: Social media & Digital games	-	-	-	-	1	-	-	1
	ICT Based Instructional Activities	-	-	-	1	-	-	-	1
	Use of E-learning Portals	-	-	-	-	-	-	1	1
	Use of ICT tools	-	-	-	-	-	1	13	14
	Use of ICT tools: assimilation, transformation	-	-	-	-	-	-	1	1
	Online interaction and Access and publishing content	-	-	-	-	-	-	1	1
Overall (f)		2	2	2	4	5	8	47	70

The thematic analysis of each ICT use category yielded five themes; namely, Frequency, Tools, Style, Competence and Context of ICT use. In most papers included in the review, ICT use was formulated as frequency of use of ICT tools (43%), and respectively as ICT use tools (28%). These two conceptualizations of ICT use account for the 71 % of ICT use studies included in the review. The other formulations of ICT use included ICT use competences (11%), ICT use style (11%), and ICT use context (7%). Regarding the innovative use of ICT, only two of the papers addressed the innovative use of ICT. In one of these papers, Buabeng-Andoh and Totimeh (2012) operationalized the innovative use of ICT as instructional, communicative, organizational, evaluative, supportive use of ICT. In the second paper, Yurdakul and Coklar (2014) defined ICT use as the highest level of ICT usage phase comprising of four levels of ICT use; namely, survival, mastery, impact and innovation. Although these two papers attempted to formulate innovative use of ICT, the former focused on investigating the secondary school teachers' innovative use of ICT, yet without utilizing any theoretical framework. Unlikely, framed by the TPACK, the latter focused on the relationship between prospective teachers' ICT competences and their ICT usage. Although both studies purported promising results, they didn't present clear guidelines to formulate what innovative use of ICT in educational context is.

After examining the overall results presented in Table 9, it can be noted that there is no consensus in the literature on the definition and conceptualization of ICT use and the conceptualization of innovative use of ICT is still in its infancy. Thus, there is a need for further studies to conceptualize and measure ICT use in schools; particularly the future research focus should turn into the innovative use of ICT.

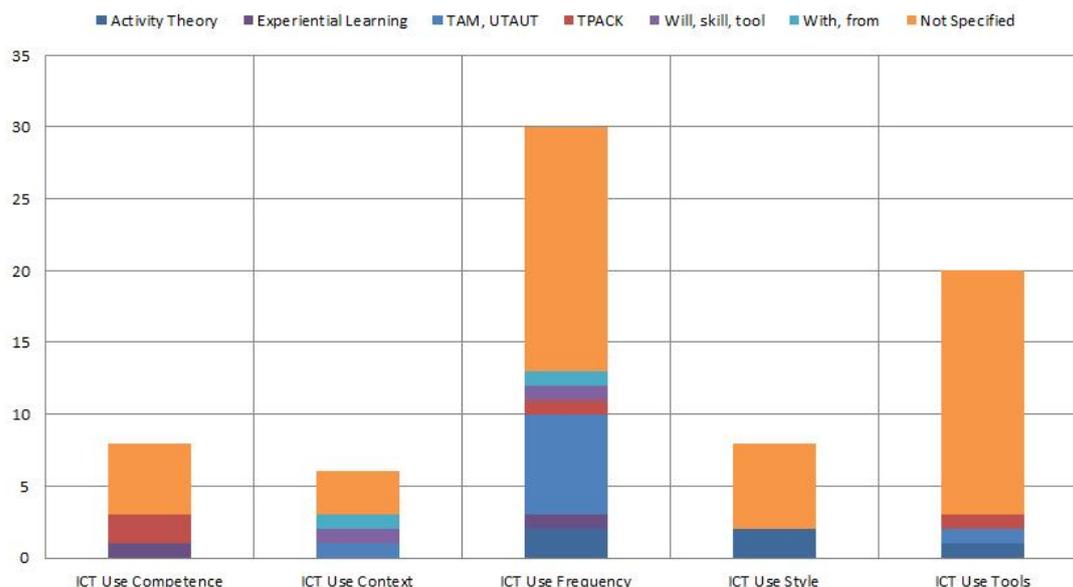


Figure 3. Typology of ICT Use and Frameworks Adopted in the Studies

Figure 3 above illustrates the theoretical foundations employed in the studies, as well as reporting the number of papers placed in each category formed as a result of thematic analysis. The Figure 3 illustrates that in most papers (66%) ICT use was not theoretically framed. Yet, a theory is an integrated set of hypotheses that has collective predictive and explanatory power (Thomas 2011). In addition, a theory helps to build up new research based on the principles and assumptions. This palpably illustrates that ICT research needs theoretical models that will guide and foreground the deeper understanding of ICT adoption phenomenon.

Amongst the studies framed by a theoretical approach to ICT adoption, Technology Acceptance Model (TAM) and Technological, Pedagogical and Content Knowledge (TPACK) were reviewed as the most frequently addressed frameworks. However, the number of these papers is not

enough in terms of representativeness. This illustrates that although TAM and TPACK are more popular frameworks in explaining ICT use in educational settings, they are limited in number, justifying that there is a need for a comprehensive theoretical framework to ICT use in teaching and learning.

Review Results about ICT Related Factors (RQ7)

As an answer to RQ7, the concepts and factors of ICT use addressed in the studies were reviewed and categorized as student level, teacher level and school level factors.

Student Level Factors

Table 10 below presents the frequency and percentage of student level factors and concepts that were under scrutiny in the studies. The concepts that were not addressed in at least two or more studies were not taken into consideration.

Table 10. Student Level Factors Addressed in the Studies

Themes	Categories	Papers	f	%
Students' ICT Use	Use of ICT Tools	Song, & Kang, 2012, Yurdakul & Coklar, 2014, Agbo, 2015, Ferguson et al, 2015, Goeman et al, 2015, Gebremedhin et al, 2015, Karamti, 2016, Magen-Nagar & Maskit, 2016, Aslan & Zhu, 2016, Cegarra-Navarro et al, 2012, Johnson et al, 2013, Lebenicnik et al, 2015	12	18
	Frequency of Use of ICT Tools	Onuka et al, 2014, Tay et al, 2012, Aharony & Shonfeld, 2015, Femi et al, 2015, Verhoeven et al, 2016, Fredholm, 2014	6	9
Critical Factors Regarding Students' ICT Use	ICT Attitude	So et al, 2012, Demirli, 2013, Agbo, 2015, Isiyaku et al, 2015, Dastjerdi, 2016b, Karamti, 2016, Aslan & Zhu, 2016, Fredholm, 2014	8	12
	Academic Achievement	Song, & Kang, 2012, Onuka et al, 2014, Karamti, 2016, Cegarra-Navarro et al, 2012	4	6
	ICT competences	Torres-Gastelu et al, 2015, Goodwin et al, 2015, Hatlevik et al, 2015, Aslan & Zhu, 2016	4	6
	Behavioral intention / Use behavior	Attuquayefio et al, 2014, Isiyaku et al, 2015, Dastjerdi, 2016b,	3	5
	Gender	Song, & Kang, 2012, Hatlevik et al, 2015, Aslan & Zhu, 2016	3	5
	ICT experience	So et al, 2012, Verhoeven et al, 2016, Aslan & Zhu, 2016	3	5
	Pedagogical beliefs,	So et al, 2012, Yang & Leung, 2015, Aslan & Zhu, 2016	3	5
	Perceived usefulness	Dastjerdi, 2016b, Apeanti, 2016, Fredholm, 2014	3	5
	Subject Discipline	Aslan & Zhu, 2016, Aoki et al, 2013 (Not students but schools)	3	5
	TPACK variables	Nguyen, et al, 2012, Yurdakul & Coklar, 2014, Apeanti, 2016	3	5
Home/School Use of ICT	Pullen, 2015, Hatlevik et al, 2015,	2	3	
ICT Knowledge	Demirli, 2013, Kharade & Peese, 2014	2	3	
ICT skills	Pullen, 2015, Verhoeven et al, 2016	2	3	

With a closer look at Table 10, there is a wide array of concepts that were examined in the reviewed studies. Amongst them, students' use of ICT tools (18%) and frequency of their use of ICT

tools (9%) are scrutinized in 18 of the studies. Secondly, in regard to the influencing conditions, students' ICT attitude (12%) and ICT competences (6%) were the most frequently employed independent variables. In four of the studies the impact of students' ICT use on their academic achievement was examined (6%). In addition, regarding students' ICT use, reviewed studies also addressed students' gender (5%), ICT experience (5%), perceived usefulness (5%), subject disciplines (5%), home/school use of ICT (3%), and ICT knowledge (3%) and skills (3%). Moreover some studies focused on student teachers' behavioral intention and use behavior (5%), pedagogical beliefs (5%), and TPACK (5%) variables.

Teacher Level Factors

Regarding teachers' ICT use and related conditions, the teacher level factors addressed in the studies were presented in Table 11.

Table 11. Teacher level factors addressed in the studies

Themes	Categories	Papers	(f)	%
Teachers' ICT Use	Use of ICT Tools	Magen-Nagar, 2013, Buabeng-Andoh & Yidana, 2015, Agbo, 2015, Nikolopoulou & Gialamas, 2015, Coyne et al, 2015, Gebremedhin et al, 2015, Amuko et al, 2015, Chandra & Mills, 2015, Uluyol & Sahin, 2016, Zyad, 2016, Chaputula, 2012, Hue & Jalil, 2013, Johnson et al, 2013	13	20
	Frequency of Use of ICT Tools	Ghavifekr et al, 2014, Tay et al, 2012, Sipila, 2014, Bozdogan & Özen, 2014, Alemu, 2015, Kihoza et al, 2016, Dastjerdi, 2016a, Ghavifekr et al, 2016, Aydin et al, 2016	9	14
Critical Factors Regarding Teachers' ICT Use	ICT Attitude	Magen-Nagar, 2013, Ahmad, 2014, Meneses et al, 2012, Agbo, 2015, Nikolopoulou & Gialamas, 2015, Alemu, 2015, Dastjerdi, 2016a, Hue & Jalil, 2013	8	12
	ICT Skills	Magen-Nagar, 2013, Raman & Yamat, 2014, Ghavifekr et al, 2014, Petko, 2012, Kihoza et al, 2016, Dastjerdi, 2016a, Ghavifekr et al, 2016, Aydin et al, 2016	8	12
	ICT Training	Buabeng-Andoh & Yidana, 2015, Meneses et al, 2012, Agbo, 2015, Nikolopoulou & Gialamas, 2015, Alemu, 2015, Ghavifekr et al, 2016, Aydin et al, 2016	6	9
	Barriers to ICT use	Ahmad, 2014, Raman & Yamat, 2014, Gebremedhin et al, 2015, Alemu, 2015, Ghavifekr et al, 2016	5	8
	ICT competences	Kerckaert et al, 2015, Petko, 2012, Sipila, 2014, Alemu, 2015, Kihoza et al, 2016, Aydin et al, 2016	5	8
	Teaching Experience	Buabeng-Andoh & Totimeh, 2012, Raman & Yamat, 2014, Nikolopoulou & Gialamas, 2015, Ghavifekr et al, 2016	4	6
	Pedagogical beliefs	Petko, 2012, Cárdenas-Claros & Oyanedel, 2016, Ghavifekr et al, 2016, Chaputula, 2012	4	6
	Gender	Buabeng-Andoh & Totimeh, 2012, Natia & Al-Hassan, 2015, Ghavifekr et al, 2016	3	5
	Home/School Use of ICT	Alemu, 2015, Cárdenas-Claros & Oyanedel, 2016, Hinostroza et al, 2016	3	5
	Professional Development	Kerckaert et al, 2015, Hatlevik et al, 2015, Aydin et al, 2016	3	5
Usage purpose/style	Natia & Al-Hassan, 2015, Hinostroza et al, 2016, de	3	5	

	Koster et al, 2012		
Blended learning	Kihoza et al, 2016, Qasem & Viswanathappa, 2016	2	3
Education levels	Song, & Kang, 2012, Kihoza et al, 2016	2	3
ICT Knowledge	Ghavifekr et al, 2014, Kihoza et al, 2016	2	3
Innovativeness	Kerckaert et al, 2015, Coyne et al, 2015	2	3
Motivation	Copriady, 2014, Uluyol & Sahin, 2016	2	3
Perceptions to use ICT	Gebremedhin et al, 2015, Goeman et al, 2015,	2	3
Self-efficacy	Kerckaert et al, 2015, Bozdogan & Özen, 2014	2	3
Supportive use of ICT	Kerckaert et al, 2015, Qasem & Viswanathappa, 2016	2	3
Teaching Style	Song, & Kang, 2012, Petko, 2012	2	3

With regard to the teachers' ICT use and influencing factors, Table 11 shows the number of papers addressing teacher level variables. Similarly, with the student level factors, the most popular ICT related teacher level factors were teachers' use of ICT tools (20%) and the frequency of their use of ICT tools (14%). As to the ICT related variables, teachers' ICT attitude (12%), ICT skills (12%), ICT training (9%), barriers to ICT use (8%), ICT competences (8%), teaching experience (6%) and their pedagogical beliefs (6%) were the most popular variables examined in the studies. Gender (5%), home/school use of ICT (5%), professional development (5%), and usage purpose (5%) were amongst the other frequently addressed variables at teacher level.

School Level Factors

Table 12 illustrates the school level factors included in the reviewed studies. The most frequently addressed school level factor is ICT infrastructure (23%). Surprisingly, ICT infrastructure yielded the most popular variable included in the reviewed studies compared with all other factors at teacher and student level. This resonates that ICT infrastructure is a critical phenomenon addressed in ICT research, which may not be supporting the claim that teacher level variables have a central role in explaining ICT use process. Yet, it should be noted that we do not underestimate the role of teacher level factors as presented in Table 11, they were still addressed in quite a number of studies in our review.

Table 12. School Level Variables Addressed in the Studies

Themes	Categories	Papers	(f)	%
School Level Factors Regarding ICT Use	ICT infrastructure	Buabeng-Andoh & Yidana, 2015, Song, & Kang, 2012, Petko, 2012, Meneses et al, 2012, Agbo, 2015, Goeman et al, 2015, Femi et al, 2015, Natia & Al-Hassan, 2015, Chandra & Mills, 2015, Dastjerdi, 2016a, Ghavifekr et al, 2016, Aydin et al, 2016, Karamti, 2016, Aoki et al, 2013, Onuka et al, 2014	15	23
	School support	Ahmad, 2014, Buabeng-Andoh & Yidana, 2015, Song, & Kang, 2012, Sipila, 2014, Chandra & Mills, 2015, Ghavifekr et al, 2016, Aydin et al, 2016	7	11
	School type	Buabeng-Andoh & Totimeh, 2012, Aslan & Zhu, 2016, Aydin et al, 2016	3	5
	ICT policy	Goeman et al, 2015, Aydin et al, 2016	2	3

Further investigation of the Table 12 shows that school support (11%), school type (5%), and ICT policy (3%) were the other factors addressed in the reviewed papers. Our overall conclusion with regard to the ICT use influencing factors is that the results we present are helpful to keep up with the trends and identifying gaps. Thus, there is a wide array of teacher level variables, yet at student and school levels; there is a need for further periodical review studies to include more research studies addressing ICT related factors at these two levels.

DISCUSSION, CONCLUSION AND IMPLICATIONS

The current study presented a systematic review of empirical studies on ICT use in teaching and learning. Time frame for the review was from 2012 to 2016. In order to minimize bias and ensure review quality, the PRISMA Statement was employed as a theoretical foundation and guideline throughout the review process. In addition, SPIDER tool of searching electronic databases was utilized in our review protocol. The ERIC database was searched for empirical papers investigating ICT use in educational settings. The initial search results yielded 209 papers. After screening and eligibility stages 65 papers met the eligibility criteria and included in the review.

Prior to presenting our major results and concluding remarks, it should be noted that certain limitations, such as a shared limitation of coverage that all review studies may subject to, are inherent to the research design we employed. On the plus side, our review results are robust and transparent since our most major findings concurred with the previous review studies (Pérez-Sanagustín, et al. 2017; Tay, et al. 2017) conducted with different electronic databases, such as ISI web of Science, and/or Scopus. Since the results of which are robust and sensitive, our review study can provide invaluable repository of evidence for ICT researchers, ICT practitioners and ICT decision-makers as such it highlights the current ICT research trends, as well as identifying research gaps in the realm of ICT research.

After qualitative and quantitative synthesis of review data, we have extracted 6 major results and concurrently we proposed some recommendations based on the implications. These are as follows:

(1) There is an increase in the volume of ICT research studies in the regions/countries that experience a large scale ICT integration program or a curriculum transformation regarding ICT adoption into teaching and learning practices. This resonates with there is a link between the prevalence of ICT use and the number of ICT research in a specific context. In other words, the more investment on ICT projects or ICT curriculum we make, the more research study we get.

(2) Most studies included in the review did not address subject specific ICT use. This may partly result from our review focus, since we put more emphasis on ICT use and influencing factors rather than its impact on students' outcomes. On the other side, out of 24 papers investigating subject specific use of ICT, 7 papers were in the Language learning area, 6 papers in the Mathematics, and 5 papers addressed the Science subject specific ICT use. This finding mostly overlapped with the results of a previous study conducted in Singapore context (Tay, Nair, & Lim, 2017), which can be an indicator of the robustness of our review results. The results also heralded that there is a limited number of papers addressing subject specific use of ICT; hence, future research should pay more heed to use of ICT in subject disciplines.

(3) Regarding educational levels addressed in the reviewed studies, there is a dominance of higher education institutions context. Yet, just 2 studies out of 65 were carried out in preschool education context, 10 in primary school settings, and 21 in secondary school settings. However, the majority of studies (29) were conducted in higher education contexts. This may result from practical reasons that ICT scholars can collect data from their own students more easily by investing less effort compared with primary and secondary school settings. Another reason could be the increasing concern on prospective teachers' ICT use and their technological and pedagogical competences. Thus, this may have an effect on ICT research paying more attention to higher education institutes with teacher

training programs. Nevertheless, this illustrates that there is a need for more research in preschool, primary and secondary school contexts.

(4) **As to the research methodology adopted in the studies, there is a dominance of non-experimental quantitative research designs such as survey design and correlational design.** The result concurred with the previous results (Pérez-Sanagustín, et al. 2017). More specifically, the review results yielded that there are just two experimental studies, 11 mixed methods designs and 8 qualitative designs. In addition, considering the results regarding theoretical underpinnings of ICT studies, most studies (65%) didn't utilize any theoretical foundations. Given this, there is a need for qualitative and mixed method design studies. Particularly for developing theory based research, qualitative studies are more effective in identifying broad concepts and categories of ICT use, then disclosing their interaction with each other. As a result, more qualitative studies needed for theoretical model building. Yet, in order to blend the strengths and neutralize the weaknesses of both methods, there is a need for more mixed methods studies, as well.

(5) **Pertaining to the conceptualization of ICT use, results purported that there is no consensus on the definition of ICT use, resulting in a wide array of ICT use conceptualizations within the papers.** Accordingly, we ran a thematic analysis in order to identify broad categories of ICT use. Qualitative synthesis yielded that ICT use nested in five broad categories namely, frequency, tools, style, context and competence. Yet there is a tendency of utilizing frequency of ICT use tools as a dependent variable in most studies in the review (46%). Only 2 papers addressed the innovative use of ICT with a number of limitations in conceptualization. These results illustrate that it is imperative for ICT researchers to generate generic ICT use models and elaborate on innovative use of ICT as a concept and finally a variable.

(6) **With regard to critical factors regarding ICT use in schools, a broad spectrum of variables examined in the studies included in the review.** As a result of qualitative synthesis of the data, we grouped these variables into three as consistent with the literature. First group is related with student level variables that consisting of students' use of ICT tools, frequency of use of ICT tools, their attitude towards ICT, and ICT competences. Second group included teacher level variables such as teachers' ICT use frequency, use of ICT tools, ICT attitude, ICT skills & knowledge, ICT training, barriers to ICT use, ICT competences, teaching experience, pedagogical beliefs, gender, and professional development. Finally, the last group consisted of school level variables, such as ICT infrastructure, ICT support and ICT policy. These results heralded that a comprehensive ICT use model should include these variables. They are illustrated in Table13 below.

Table 13. A Generic ICT Use Model Based on the Review Results

School Level Factors	Student Level Factors	Teacher Level Factors	Teachers'/Students' ICT Use
ICT infrastructure	ICT attitude	ICT attitude	Frequency
School support	ICT competence	ICT skills & knowledge	Tools
School type	Gender	ICT training	Context
ICT policy	ICT experience	Barriers to ICT use	Style
	ICT skills & knowledge	ICT competences	Competence
		Teaching experience	
		Pedagogical beliefs	
		Gender	
		Professional development	

Despite the aforementioned limitations, our results are robust and they provide invaluable insights for ICT research community, ICT practitioners and ICT policy makers. Future research should focus on innovative use of ICT, other teacher, student or school level factors pertinent to ICT use and its impact on students' learning or other school level outcomes.

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