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Gender and ICT:
Meta-Analysis and Systematic Review

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1.0 EXECUTIVE SUMMARY

This project addresses the intersection of gender and information and communication technologies (ICT) as reflected in the primary research literature and in educational practices and policies of the Commonwealth, the USA and Scandinavian countries. The present final report on the project summarises the methodology and outcomes of two large-scale systematic reviews, namely:

1. a meta-analysis of empirical research on gender-based differences in perception and actual use of ICT in education; and
2. a systematic review of policy documents that address issues and solutions related to gender and ICT.

Gender-based differences in various attitudes toward ICT in education belong to an area of special research interest for a reason. The importance of educational technology for the learning outcomes of students across academic levels and fields of study has been vastly documented in primary empirical research and meta-analyses alike. Technological tools and applications are constantly advancing in functionality and interactivity. Increasingly sophisticated ICT can: boost access to education through distance, blended and mobile learning; support students' cognition; facilitate interactions of all kinds; promote more meaningful science education by employing computer simulations, serious games and intelligent tutoring systems; enable more control for learners; and engage them in critical discourse, thus laying a foundation for further success in life, both professionally and socially.

In these circumstances, it is critical to make sure that ICT tools and applications are equally beneficial for all students, regardless of grade level, race, ethnicity, cultural background, socio-economic status and especially gender.

Men's and women's different attitudes toward using ICT play a key role during learning and when making career decisions. Uncovering the dynamics between gender and students' ICT usage and perceptions is vital, particularly because there is a long-standing impression that fewer women enroll in ICT educational programmes and seek professional careers in ICT-related fields. The research summarised in this report is intended to contribute to our understanding of the origins of this issue and hopefully to assist in overcoming the undesirable consequences of that gender gap.

The report consists of two major parts, each reflecting one of the abovementioned systematic reviews. First, we present the research objectives of the meta-analysis of primary research on gender-based differences in ICT perception and use, followed by an overview of previous meta-analyses conducted on the topic since the 1990s, the method and procedure of the current meta-analysis, its results (organised by outcome type and by moderator variables) and a discussion of the findings. Second, and similar to the meta-analysis part, the systematic review of policy documents opens with a statement of its purposes and an introductory review of the literature. We then briefly describe our method and present summaries of the findings (organised by region and by coded document characteristics), followed by a discussion of the most prevalent and/or interesting observations. An overall introductory literature review on the topic of gender and ICT precedes both parts of the report.

META-ANALYSIS

Our meta-analysis covers primary research conducted since 2000 that reported (separately for female and male students) four major outcome categories with respect to ICT, namely:

- general ICT attitudes (subsumes positive and negative attitudes and satisfaction with ICT learning experiences);
- confidence about ICT (subsumes confidence, computer self-efficacy, perceived ease of use, and computer anxiety);
- motivation for and intent to use ICT, and its perceived usefulness; and
- actual ICT use (including learners' self-reported frequency and time spent)

Extensive systematic literature searches identified over 2,000 potentially suitable primary studies. With thorough abstract screening and review of full-text documents, that number was reduced to 363 studies included in the final set of analyses. Together they produced 554 individual effect sizes that were distributed by outcome category in independent sets as follows:

1. General Attitudes toward ICT ($k = 153$)
2. ICT Confidence and Self-Efficacy ($k = 163$)
3. ICT Motivation and Interest ($k = 121$)
4. Actual Use of ICT ($k = 117$)

All the corresponding weighted average effect sizes (Hedges' g) were positive (i.e., in favour of male students) but differed in magnitude. Specifically, calculated according to the random-effects analytical model, they were:

$g^+ = 0.066$ ($p < 0.05$) for General Attitudes

$g^+ = 0.228$ ($p < 0.01$) for ICT Confidence

$g^+ = 0.079$ ($p < 0.01$) for ICT Motivation

$g^+ = 0.048$ ($p = 0.054$) for Actual Use

In other words, the first three of the above four effect sizes were statistically significant. The effect size $g^+ = 0.048$ in the outcome category of actual ICT use statistically was no different from zero, indicating that female and male students had access to and utilised educational ICT to a relatively equal extent.

Collections of effect sizes in all four categories of outcome were also significantly heterogeneous, warranting a further search for systematic variations through a series of moderator variable analyses. Implemented according to the mixed model, these analyses detected some interesting patterns of results within each category (though just a handful of them reached the level of statistical significance), but more importantly found patterns that were relatively consistent across collections of outcome types. Specifically, we observed a tendency for lower effect sizes (to the point of reversal in valence — i.e., in favour of women) in graduate students. Also, effect sizes tended to be lower in magnitude in studies conducted in the USA and Scandinavian countries. Though infrequent, studies conducted in the field of education produced consistently smaller effect sizes across outcome types as well. Finally, effect sizes for data collected within the context of specific educational interventions (either prior to or after their delivery) also reflected smaller differences between male and female students in their perception and use of ICT for learning.

We organised the discussion of the meta-analysis findings around its major research questions, briefly summarised as follows.

Does a gender gap in ICT perception and use exist?

We found that female and male students on average are comparable in their access to and educational use of computer-based and online technologies (i.e., that a "primary" digital divide with respect to gender may no longer be of any serious concern), whereas a gender-based "secondary" digital divide still persists, as reflected by differences in ICT-related attitude, confidence and motivation measures.

How big is the magnitude of that gap?

Considering the entire population of learners in need of various degrees of ICT exposure and mastery, effect sizes discovered in our meta-analysis should not be perceived as negligibly small, but neither do they represent an insurmountable obstacle preventing a society from achieving gender balance in ICT outcomes if equality of opportunity is assured.

Is the gap closing (narrowing down or even reversing its poles)?

According to the findings of this meta-analysis, taken in conjunction with some earlier observations by primary researchers, reviewers and meta-analysts, a tendency for the gap to tighten (if not close) seems quite evident, an observation also indirectly supported by the noticeably higher proportion of female students among the respondents accounted for in our review.

How much do we know about what moderates (increases or decreases) the gap size?

As the patterns of results of the moderator variable analyses suggest, the lower effect sizes (reflecting lesser degrees of gender-based differences in the respective outcomes) mostly resulted from studies conducted in the USA and Scandinavian countries, and represented samples of graduate university students and more definitive contexts of data collection (i.e., directly linked to specific educational interventions). Hopefully, other upcoming research efforts will further advance our understanding of the factors that influence gender differences in ICT perception and use.

Does education matter? Can it exert sufficient influence to facilitate closing the gap and/or overcoming its undesirable consequences?

The field of education emerged in our meta-analysis as a strong moderator towards narrowing the gap between male and female students in several outcome categories. Taking into consideration some earlier research findings and a large number of primary studies targeting professional educators, we suggest that the field of education may be ahead of the curve in addressing gender differences with respect to ICT perception and use. Education can anticipate and test the corresponding trends and contribute substantially to shaping the attitudes and skills of future students, better informing the general public and helping policy makers devise viable solutions for successfully overcoming the undesirable consequences of the ICT-related gender gap.

What are the points of special interest on which future research into the issue of gender-related differences in ICT perception and use should focus?

The results of the current meta-analysis point in several directions for future research on the intersection of gender and ICT. These include (though are not limited to): more closely studying specific educational contexts and samples of educators; improving the quality of the assessment tools used in this line of research; and paying special attention to gender stereotypes that not only exist in the general population but persist in the research community as well. This last area would allow for higher objectivity and transparency in research on gender-based differences in ICT perception and use in education and beyond.

To wrap up the meta-analysis portion of this report, Appendix A provides a more detailed description of the methodology of meta-analytical research in general for those readers who are interested in better understanding its conceptual foundation, procedural techniques, and the extent of its implications for research and practice.

SYSTEMATIC REVIEW OF POLICY DOCUMENTS

Our systematic review of governmental policy documents of the Commonwealth, the USA and Scandinavian countries aimed to explore the following research questions with respect to gender and ICT:

1. What policies regarding gender and ICT in education are in effect (and/or being planned) in Commonwealth countries, the USA or one of the Scandinavian countries (as reference points)?
2. Do action plans exist, and are specific policies implemented to bridge the gender gap, to empower women through ICT educational practices?
3. What differences and/or similarities in educational policies with respect to the issue of gender and ICT exist among Commonwealth countries in various regions (i.e., Europe, Asia, etc.)?

To address these questions, we conducted a systematic search of the relevant government websites, along with any subsidiary departmental or ministerial websites in related domains, and followed links in them to potentially relevant programmes and reports. We were searching specifically for:

- policies/plans to encourage girls/women to study in ICT-related fields;
- policies meant to ensure gender equity in ICT education; and
- policies/plans meant to assess any gender gaps in the ICT domain.

It was notably difficult at times to search/browse government websites due to varying quality and sophistication. Nevertheless, 87 documents were identified for further review. Of these, 56 reports passed initial screening and underwent a more detailed examination; only those documents that contained information about both target topics (gender and ICT, though represented in various proportions) were retained for inclusion in the review. The final collection was subsequently coded to account for the following policy content and characteristics:

- Policy focus: Whether the policy primarily addresses gender or ICT or offers some balanced approach to both.
- Policy status: In effect / Planned (announced or under development) / Reflection of the current state (e.g., relevant data on policy/practice evaluation, when available).
- Educational level: Kindergarten and elementary school / High school / Undergraduate / Vocational education / Specific forms of adult education (e.g., on-the-job training, professional improvement, remediation, workforce reintegration, etc.).
- Outcome type: Data available on expectations, targets and focus of attention of each particular policy or practice, matched whenever possible to the four major outcome types of the meta-analysis. Monitoring (effectiveness evaluation, feedback): Reflects whether this kind of information is provided and describes what criteria the monitoring/evaluation is based upon. Support for policy implementation: Infrastructure, training, dedicated professionals, financial resources, etc.

- Policy time frame: When the policy was initiated, what dates were set for preliminary and final target actions/goals and by what time the effects of implementation are expected to show.

Drawing firm conclusions from a collection so diverse in scope and focus as the one in our systematic review of policy documents presented a serious challenge. Nevertheless, some worthwhile observations were made. We summarise them as follows.

Very few policies were balanced with respect to the main areas of interest for our review—i.e., addressed more or less equally the issues of gender and ICT. Most of the reviewed documents presented general ICT policies and practices, with some attention to gender equity concerns or, vice versa, were devoted to gender equality policies in general, with some reference to ICT as a field of study and/or employment for women.

Another concern was the lack of details about the means of achieving policy goals and evaluating policy effects. For example, specifics about funding and budget allocations, agencies working to support or maintain goals, and evaluation criteria were rarely mentioned. More documents described plans for future programmes/policies, with a much smaller number reporting on policies in effect. Policies also tended to target older populations, addressing employment needs but not basic educational levels.

The review identified a number of outstanding (i.e., balanced, comprehensive and well-described) policies. For instance, the United Kingdom's UK Digital Strategy 2017 not only addressed the issues of infrastructure and skills training but also focused on achieving a higher level of digital business, cloud computing and virtual reality, while acknowledging that women lack representation in "digital roles," and subsequently offering a number of specific programmes to address this issue.

In terms of comparing the policies of Commonwealth members to those of Scandinavian countries, our review noted that the latter policies, though few in number, did seem to originate from a more progressive baseline — for example, by assuming gender equity in a push for more general inclusion, or by addressing the digital divide and promoting equity values as a foreign policy in other countries.

In our view, all countries could do a better job of formulating more concrete policies — including by providing specific deliverables, support mechanisms, and assessment criteria — to facilitate the meaningful reception of these policies by researchers and the general public, thereby knowingly contributing to their successful implementation.

2.0 INTRODUCTION

Information and communications technology (ICT) is the key to meeting the demands and expectations of the 21st-century globalised economy and increasingly digitalised society in all its aspects, including the promotion of political accountability and changes in educational opportunities for younger generations (Information Technology Association of Canada, 2013; Sanders and George, 2017). As Korunka and Hoonakker (2014) state: "There is no doubt that the development and implementation of information and communication technology during the last decades has had — and still has — a major impact on all levels of society" (p. 1). Not only have the media, manufacturing industries and commerce become increasingly technology oriented (Turban, Outland, King, Lee, Liang, & Turban, 2018), but public education, responding to challenges of the new millennium, strives to integrate ICT into educational settings to the point where it is increasingly hard to envision classrooms completely free of at least some form of modern digital technology.

Several meta-analyses[1] conducted on these premises largely confirm the positive effect of ICT on learning outcomes. As a very illustrative comprehensive summary, a second-order meta-analysis (Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011) investigated 25 meta-analyses with a combined examination of more than 1,050 primary studies on the effect of computer technology use on academic achievement. Its findings attest that computer-assisted instruction improves students' academic achievement, especially when technology is used to assist and support learning and not as a source of direct instruction. These results are in line with Ross, Morrison and Lowther (2010), who claim that "educational technology is not a homogeneous 'intervention' but a broad variety of modalities, tools, and strategies for learning" (p. 51). Therefore, successful use of ICT is dependent on how well it assists instructors and, especially, students in achieving learning objectives. It is about the proper usage and integration of technological tools to facilitate learning. It is also a significant challenge to integrate tools into educational settings, which emphasises Kozma's (1994) argument that the use of computer technology is highly effective when it supports "active engagement with the curriculum" (Schmid et al., 2009, p. 97). Schmid et al. (2014) then conducted a large-scale meta-analysis on the effectiveness of technology integration in post-secondary education and found that technological tools and applications that provide "cognitive support" for learners (e.g., computer simulations) significantly outperformed their use just for content delivery (e.g., PowerPoint).

What is critical then with respect to advances in educational technology is to make sure that they are equally beneficial for all students, regardless of grade level, race, ethnicity, cultural background, socio-economic status and gender. Girls and boys may differ in their various predispositions for the successful employment of ICT practices in education, but this should not become a ground for yet another gender-determined form of "digital divide." Not surprisingly, many scholars' attention is focused on the issue of gender differences as it relates to attitudes towards and usage of technologies in learning environments (e.g., Barker & Aspray, 2006; Hargittai & Shafer, 2006; Saleem, Beaudry, & Croteau, 2011; Venkatesh, Crouteau, & Rabah, 2014, among many others). In fact, the intersection between gender and ICT in educational settings has proven to be a complex issue. On the one hand, there is a body of evidence supporting gender-based

[1] For a brief overview on meta-analysis, see Appendix A.

differences within post-secondary settings (e.g., Huang, Hood, & Yoo, 2013; Jones, Johnson-Yale, Millermaier, & Pérez, 2009; Kay & Lauricella, 2011; Selwyn, 2007). Researchers have found that male university learners report higher levels of experience and competency in utilising computers (e.g., Bunz, Curry, & Voon, 2007; Gardner, Sheridan, & Tian, 2014; Kay & Lauricella, 2011) and are more positive about using them for learning than are their female counterparts (Alon & Herath, 2014; Li & Kirkup, 2007). On the other hand, studies document no gender-related difference in perceptions of digital technology (e.g., Ghatty, 2014; Morris, & Chikwa, 2014) or even report female undergraduate students as having higher self-efficacy in using technology (e.g., Joiner et al., 2011). Some researchers claim that gender differences relating to higher education students' perceptions and usage of technology are diminishing (e.g., Zhou, 2014). Others report minor differences, still reflecting that male students perceive themselves to be more proficient and confident and less anxious when it comes to dealing with technological tools in education (Barker & Aspray, 2006; Kay, 2008; Sanders, 2006). Ono and Zavodny (2003) go so far as to indicate that the gender-based digital divide no longer exists in the USA. To somewhat reconcile these rather ambiguous patterns of findings, some scholars suggest that digital inequalities among students are shifting from unequal access to differentiated use (Stewart & Beaney, 2015).

However, various manifestations of a gender-related digital divide are still the focus of public attention, especially when it comes to differences between men and women in: enrollment in educational programmes associated with ICT; ease of computer use in learning, professional life and daily life; choosing career paths in technology-reliant fields; and other areas. Hargittai and Shaffer (2006) provide quite a detailed account of different manifestations of the digital divide based on gender. Joiner et al. (2015) identify at least two types of digital divide: a primary one that relates to disparities in access to technology, and a secondary one attributable to differences in a broad class of cognitive and affective phenomena, subsumed under an umbrella category of attitudes towards ICT.

Much research has revolved around the primary digital divide, which indeed seems to be disappearing, at least in developed countries. According to US-based surveys undertaken between 2000 and 2013 (Pew Internet & American Life Project, 2014), males and females have overall enjoyed equal access to technology since 2007. Similar findings came out of surveys in the UK between 2003 and 2013 (Oxford Internet Institute, Dutton, & Blank, 2011).

Although disparities in access may no longer be an issue, the same is hardly true about the secondary digital divide. For example, according to Cheong (2007), offering a society equal access to technology does not automatically guarantee equal levels of technological self-efficacy or ICT use. Based on data collected from 716 male and female students in higher-education settings, the researcher found that both ICT-related self-efficacy and technology use were lower among female students. The secondary digital divide extends far beyond the issue of access to ICT — and due to its more diverse underpinnings, partly rooted in individual psychological characteristics, it may be a factor enabling and/or exacerbating the primary divide.

Gender-based differences surrounding attitudes toward technology and the perceived efficacy and benefits of the tools used within learning environments therefore remain critical areas for research (Hargittai & Shafer, 2006). Men's and women's different attitudes toward using ICT tools and applications play a key role during learning and when making career choices (e.g., Buche, Davis, & Vician, 2007; Huang, Cotten, & Ball, 2015). Therefore, it is critical that scholars keep on investigating gender-based differences surrounding attitudes toward ICT (Hargittai &

Shafer, 2006). Uncovering the dynamics between gender and students' ICT usage and perceptions is vital because there is an impression of the persistent pattern of fewer women enrolling in educational programmes and seeking professional careers in ICT-related fields (OECD, 2017). Indeed, there is still an enormous amount of work to be done to understand the origins of and overcome the undesirable consequences of that gender gap.

To address this need and ascertain what might be done about it, it is important to base decisions on what is already known about attempts to close the gap, in terms of what existing research has found and what steps governments and policy makers have already taken.

The following report will investigate this issue along two tracks. First, we will review the evidence on gender perceptions of, attitudes towards and use of ICT to learn what several decades of research tell us about it, by conducting a meta-analysis of the empirical research. Second, to examine what governments and policy makers are doing to promote the use of ICT among female populations, we will conduct a systematic review of policy documents planned and/or implemented by the Member States of the Commonwealth of Nations,[2] as well as the USA and Scandinavian countries. Each of these two major sections of the report is preceded by a literature review to capture the respective state of the field.

[2] https://col.org/member-countries

3.0 META-ANALYSIS OF RESEARCH ON ICT AND GENDER

Statement of Purpose

The major objective of this report is to inform its readership (including the research community, educators, policy makers and the general public) about the current status of research on the issues of gender and ICT perception and use. To that end, we conducted a large-scale meta-analysis of primary empirical research that reports major attitudinal outcomes with respect to ICT separately for male and female students, to address the following research questions:

- Is there a gender gap (i.e., quantifiable difference, also referred to as a "digital divide," between male and female students) in attitudinal outcomes (i.e., satisfaction with ICT-related courses, willingness to engage in ICT-based learning activities, etc.)?
- How substantial is such a gap (i.e., what are the directions and the magnitudes of the corresponding effect sizes)?
- Does the gap change over time or depending on various circumstances (i.e., what moderators can explain variability in effect sizes)?

3.1. Previous Meta-Analyses on the Topic

This meta-analysis is one of the most recent and comprehensive reviews to address the issue of gender-based differences in ICT-related attitudinal and behavioural outcomes, but it is by no means the first. Our review covers studies published since 2000 and encompasses four major outcome types across educational subject fields, grade (academic) levels, and geographic areas. It aggregates independent effect sizes from primary research to derive reliable estimates of how the overall population of learners: (1) perceives modern ICT; (2) is confident about their ICT skills and competencies; (3) expresses interest in ICT; and (4) actually uses different forms of ICT in various educational contexts.

Since the beginning of the 21st century, several prominent studies, including systematic reviews and meta-analyses, have addressed the issue of gender-based differences in outcomes related to ICT from different perspectives and for various populations. They also have utilised a variety of methodological approaches. For example, Kay (2008) conducted what would most precisely be described as a "vote count" systematic review by documenting the number of primary comparative studies that showed significant findings in favour of men as compared to those in favour of women, and the number of studies that did not detect any significant gender difference. Such an approach does not allow for actual effect-size extraction and aggregation but instead paints a broad picture of what tendencies are more or less prevalent in the related research literature (Bushman, 1994). After reviewing 71 studies from 17 different countries featuring 644 comparison points based on various individual measures, Kay (2008) reported findings relatively balanced with respect to gender, with men having moderately positive attitudes toward computers (33% of the times versus 15% in women, with 52% of the reviewed comparisons showing no significant gender differences) and a higher degree of self-efficacy (men rated their computer abilities higher than women did 47% of the time, in contrast with 9% higher self-rating by women, while 44% of reviewed comparisons reported equal ratings by men and women). Women held more positive attitudes towards online learning and tended to be more successful in completing computer-related tasks (24% versus just 5% in men, with 71% having no difference in performance). Men also reported more frequent computer use, though the author noticed an obvious narrowing of this gender gap over time. Although from 1997 to 2000, male participants indicated more frequent computer use than their female counterparts (by a solid 62%), the difference then decreased to 37% from 2001 to 2004, and then to 29% from 2005 to 2007.

Several studies used data collected by means of typical surveys to go beyond just detecting gender differences, also exploring complex relationships among ICT-related outcomes by using structural equation modeling (SEM) methodology (e.g., Bazelais, Doleck, & Lemay, 2018; Ong & Lai, 2006; Tondeur, Van de Velde, Vermeersch, & Van Houtte, 2016; Yu, Kim, & Roh, 2001). Among the most interesting findings of these studies was a tendency for men to be more influenced in their decisions to use computers by the perceived usefulness of eLearning, whereas women relied more on perceived computer self-efficacy (Ong & Lai, 2006). The influence of, so to speak, applied context on attitudinal outcomes was also observed (e.g., Tondeur et al., 2016). While general attitudes towards computers were predominantly more favourable in men, the difference tended to disappear when computers and computer-based practices were rated in study-related contexts (that is, using computers for educational purposes). Studies based on the SEM methodology have also been used to explain and refine the Technology Acceptance Model (TAM) (e.g., Davis, Bagozzi, & Warshaw, 1989) by testing multidirectional relationships among its components.

Of course, of primary interest for the current review were true meta-analytical studies that addressed gender differences in ICT attitudes and behaviours. Among those we will briefly discuss below are: Huang (2013); Cam, Yarar, Toraman, and Erdamar (2016); Cai, Fan, and Du (2017); and Rabah et al. (2017). However, before summarising their major findings, it is important to remind readers that these more recent meta-analyses were preceded by a series of quite influential meta-analyses of the 1990s that actually helped to shape the existing framework for research on ICT-related gender differences.

A meta-analysis of correlates of computer anxiety, undertaken by Rosen and Maguire (1990), put in question several common beliefs about "computer-phobia," including gender bias. It summarised data from 81 studies published between 1966 and 1989 that reported various computer anxiety measures for participants representing samples of school and college students, school and post-secondary teachers, and adult professionals. Though the authors did find that women were more prone to experience computer anxiety, this tendency was not strong enough for conclusive assertion: mean effect sizes (gender-to-anxiety correlations) varied from 0.112 in elementary and secondary school students to 0.165 in college students and were markedly moderated by experience with computers. The authors concluded that the reality does not always support the common belief that women had substantially higher vulnerability to computer anxiety. Later Chua, Chen, and Wong (1999) addressed a similar question in their more limited meta-analysis (just ten gender-related studies, predominantly on data collected from undergraduate students) and found low but statistically significant ($Z = 0.077$, $p < .01$) support for higher computer anxiety in female participants). Liao (1999) reviewed and summarised data from 106 primary studies on gender differences with respect to computer attitudes. The meta-analysis reported an overall weighted average effect size of 0.192 (with the range of individual effects from –0.85 to 0.88). None of the moderator variables considered (e.g., country where study was conducted, publication type, sample size, reliability of the measures used) except for attitude type was statistically significant.

It is probably important to note different approaches for handling the aggregation of effect size based on related but still different outcomes. Collapsing together several types may complicate the interpretation of findings. Specifically, in the case of Liao (1999), the interpretation of the overall effect size somewhat shifts when measures of attitudes (a generic term) are classified in more specific categories and then analysed and reported separately. Out of seven such categories, only sex-related stereotypes produced truly outstanding results (significantly different from other categories — liking computers, anxiety, confidence to use, and especially ability-related stereotype, the last actually being in favour of female participants). In other words, what really made the difference in this meta-analysis was participants' belief in the existence of bias rather than any real ICT gender bias itself.

Probably the most heavily cited meta-analysis was conducted by Whitley (1997) and summarised empirical data on the issue available by the mid 1990s, more specifically from 1973 to 1993. It established the existence of a gender bias in computer-related outcomes (that is, affective and cognitive attitudes, computer self-efficacy and actual computer use). With various degrees of magnitude of the respective effect sizes, men demonstrated higher scores than women across outcome types. Whitley's meta-analysis was based on the data collected from over 40,000 respondents from the USA and Canada and made several additional important observations. Affective computer attitudes manifested a trend of increasing effect-size magnitude with age — from 0.08 in grammar school students to 0.61 in high school students — with a subsequent reduction to 0.22 and 0.24 in college students and adults, respectively. Computer self-efficacy was also higher for older male learners (up to 0.66 for students beyond high school). Conversely, cognitive computer attitudes were more balanced for men and women, with the effect size not exceeding 0.20 in younger learners, while college students showed an effect size close to zero, albeit still in favour of men. Actual use of computer technologies was higher in men across age groups. Overall, it seems that Whitley (1997) documented an indisputable gender gap in computer attitudes and activities, thereby establishing a reference point for all subsequent research on the issue, including the above-mentioned meta-analyses of the 2000s.

Specifically, Cam et al. (2016) meta-analysed 36 primary studies conducted in Turkey on pre-service and in-service teachers, which reported students' attitudes towards computer-assisted instruction separately for male learners (total sample of 3,297) and female learners (total sample of 4,029), thus enabling gender-based comparisons. The overall effect size of 0.031 (according to the random-effects model) in favour of men was, however, statistically non-significant (p = .51, with 19 studies reporting positive individual effects and 17 studies negative ones) but significantly heterogeneous. What is especially interesting about this (rather limited in scope and geography) meta-analysis is not only that, unlike many previous ones, it did not confirm the gender bias in ICT perception, but also that its sample was entirely composed of actual and future educators, possibly suggesting that overcoming the so-called technological gender gap (Canada & Brusca, 1993) begins and unfolds with balancing the computer attitudes of male and female teachers.

Cai et al. (2016) conducted a meta-analysis of several outcome types (including affects, cognitive beliefs, self-efficacy, sex-role stereotypes and combined ones — 92 individual independent effects in total) reported in 51 studies published between 1997 and 2014. They found a statistically significant positive (i.e., favouring men) effect size ($g^{+} = 0.159$) for computer attitudes (i.e., cognitive beliefs) but no statistically significant differences in affective outcomes. The authors concluded that with the increasing integration of computer-based technologies and particularly of the Internet in everybody's daily life, the gender gap with respect to ICT perceptions and use is now narrowing.

Though the meta-analysis conducted in 2013 by Huang focuses on academic self-efficacy (not specifically connected to computer-based educational activities), it may be important to mention its findings in the context of the current review, as the two concepts (academic and computer self-efficacy) are closely related. Derived from 187 primary studies, with a total sample of 68,429 students, 247 independent effect sizes resulted in an overall point estimate of 0.08 (indicating higher academic self-efficacy in men). Though statistically significant ($p < .05$), this effect was in actuality small and varied substantially with participants' age (higher effect sizes for older learners) and the subject matter they learned (male students revealed more self-efficacy for mathematics, computer science and social sciences, whereas female students were more confident in language arts). Such domain-specific academic self-efficacy may substantially mediate computer self-efficacy when educational technology either compliments the content area (e.g., computer science) or presents an additional challenge (e.g., language arts). When compared to Whitley's (1997) effect size of 0.41for computer self-efficacy, the findings of Huang (2013) indeed seem to indicate that the gender gap is gradually being overcome.

Most recently, Rabah et al. (2017) undertook a large-scale meta-analysis of gender differences with respect to ICT. Their meta-analysis included 213 primary studies published between 2006 and 2016. It was based on a total sample of over 37,000 students from around the world, limited only by the context — technology was considered solely when used for educational purposes. The authors approached their review with a more fine-grained gradation of outcome types that distinguished among such specific measures as: computer anxiety; negative, positive and mixed attitudes towards ICT and ICT satisfaction; computer confidence and self-efficacy; perceived ease of ICT use; perceived usefulness of ICT; motivation; and intent to use ICT. The largest effect size was documented for the measures of computer confidence, with male students scoring on average 0.38 standard deviation units higher than female students. The smallest effects size ($g^{+} = 0.05$, still in favour of men, though statistically non-significant) characterised the ICT satisfaction outcome type. Distributions of all outcome types were significantly heterogeneous, indicating that substantial fluctuations in individual effect sizes could be explained by systematic variations in specific study characteristics. Subsequently, several moderators (including participants' age and academic level, publication date, country in which study was conducted, etc.) were analysed, revealing some interesting patterns in their influence on effect sizes. For example, with respect to computer confidence and motivation to use ICT, effect sizes were significantly higher for university students than for school students. Another consistent trend observed for several outcome types (specifically motivation to use ICT and actual ICT use) was that more recent studies produced lower-magnitude effect sizes, indicating higher involvement of women with technology in later years. Rabah et al. (2017) also underlined the impact of culture (as judged by the country under study) on gender differences across several outcome types.

SUMMARY OF THE PREVIOUS RESEARCH

To summarise the findings from previous systematic reviews, they largely agreed that there is a gender gap in outcomes related to ICT perception and use. However, when comparing meta-analyses conducted in the 1990s and after 2000, the latter tended to produce effect sizes somewhat lower than the corresponding findings of the former. Also, not all outcome types are equally susceptible to the gender bias; variability in effect sizes reported by meta-analyses even from the same time frame accounts for effects as low as ~0.05 (e.g., in Rabah et al., 2017, for ICT satisfaction) and as high as above 0.60 (e.g., in Whitley, 1997, for computer self-efficacy). Though the above-mentioned meta-analyses did not use the same moderator variables, it is quite clear that systematic variation in effect sizes due to particular study characteristics, especially learners' age and the content area of the study, is a reality demanding careful attention. As much as some may be tempted to declare the existence of a gender bias (or the lack thereof) across the entire population, stopping at such an assertion would be trivialising and muddling the issue. Of much greater interest for researchers should be questions such as, in what age groups and educational contexts does the gap between men and women in ICT perceptions and behavioural outcomes tend to widen or close, even up to the point of reversal, when female students are more satisfied, confident and fluent with technological tools and applications than their male peers? The upcoming sections present the results of our take on these issues.

3.2 Methodology

In conducting this meta-analysis we followed the standards recommended by the Campbell Collaboration (C2), the major international body for supporting, coordinating, and promoting systematic reviews of research evidence in the social sciences. Typically, the design and implementation of a systematic review (with minor modifications for meta-analyses and qualitative syntheses) consists of the following seven steps, as outlined by Cooper (2017).

Step 1 — Formulating the problem

In addition to an overview of the state of the research in the area of interest, this includes the critical task of stating specific research questions, developing operational definitions of the main concepts and outcomes, determining key words that will guide subsequent literature searches, and formulating comprehensive inclusion criteria for admitting relevant studies to the review.

Step 2 — Searching the literature

Such search efforts necessarily should be systematic and as exhaustive as possible, including not only targeted (adaptive but consistent) searches of relevant electronic databases and manual searches of tables of content of major journals in the respective field of research, but also attention to so-called "grey literature" by consulting conference proceedings, unpublished dissertations, reference lists "branching" from previous major reviews, etc.

Step 3 — Gathering information from studies

In this step, the actual review of retained documents proceeds, including effect-size extraction and coding of moderator variables; all these require some form of consistency check among coders to ensure sufficient reliability of the review process and outcomes.

Step 4 — Evaluating the quality of studies

Conducted in parallel with Step 3, review activities include assessing the methodological quality of the studies under review and addressing the issue of potential dependencies and confounding factors among samples, treatment conditions and outcome measures.

Step 5 — Analysing and integrating the outcomes of research

Specifically for meta-analyses, this step presents the challenges of (1) selecting and applying a proper analytical model to aggregate effect sizes from individual independent samples and (2) implementing the necessary procedures for sensitivity and publication bias analyses, whereas qualitative syntheses require meaningful and consistent categorisation and cross-referencing of the data.

Step 6 — Interpreting the evidence

The key component of this step is relating findings to the main research questions and to the context outlined prior to undertaking the review, to emphasise its unique contribution to the field and implications for practice.

Step 7 — Presenting the results

This step, though it may be perceived as pretty straightforward, requires clarity and transparency in describing not only the findings but also the review procedures.

INCLUSION/EXCLUSION CRITERIA

For a study under review to be retained for further analysis, it should meet the following inclusion criteria:

1. It should report any direct measure of learners' attitudinal outcomes (usage, satisfaction, confidence, etc.) separately for male and female students. See the list of relevant outcomes below.
2. It should be published within the time frame of 2000 onward.
3. It should be conducted within an educational context at any grade level (from kindergarten to postgraduate).
4. It should contain sufficient statistical information to enable effect-size extraction.
5. It should sufficiently describe research methodology, setting and procedures to inform at least some moderator variables (see the list below).

Failure to meet any of these criteria should result in study exclusion, at either the abstract screening or full-text review level. The reason for rejection should be documented. The major categories of reasons for study exclusion are as follows:

- Non-educational context (e.g., recreational video gaming, use of social media for non-educational purposes)
- Irrelevant outcomes (e.g., academic achievement that cannot be explained by gender differences but results from various instructional interventions, subject matter attitudes and satisfaction)
- No comparison is possible (i.e., relevant outcomes are not disaggregated by gender)
- Insufficient statistical data (i.e., effect-size extraction is not possible)
- Outside of the predetermined time frame (i.e., published prior to 2000)
- Inappropriate unit of analysis (e.g., gender groups are not compatible with respect to relevant outcomes — male and female students, whose outcomes are to be compared, represent different age groups, learning contexts, etc., or outcomes are reported for teachers, parents)

- Insufficient description of the study characteristics (i.e., no coding of moderator variables is possible)

SEARCH STRATEGY

The strategy to locate research literature that answered our research questions had two main components: (1) electronic searches of the bibliographic databases for formally published research and (2) manual searches (browsing) for grey literature (e.g., conference papers, reports, theses) using Google and other online resources (e.g., OpenGrey.eu, LearnTechLib digital library), as well as checking the reference lists of previous reviews and meta-analyses in the subject area.

Electronic searches. The following bibliographic databases have been searched for literature: Academic Search Complete, Communication Abstracts, Communication & Mass Media Complete, Education Source, ERIC, Gender Studies Database (EBSCO), ProQuest Dissertations & Theses Global, and PsycINFO. Search strategies were tailored to the available fields, controlled vocabulary, and filters of each database to make maximum use of their capacities. The following is an example from the ERIC database:

> ((DE "Gender Differences" OR DE "Gender Issues") OR (DE "Females" AND DE "Males"))
>
> AND ((perception OR attitude OR efficacy OR anxiety OR usage) OR (DE "Computer Attitudes"))
>
> AND (DE "Educational Technology" OR DE "Asynchronous Communication" OR DE "Audiovisual Communications" OR DE "Audiovisual Instruction" OR DE "Computer Uses in Education" OR DE "Computer Assisted Instruction" OR DE "Online Courses" OR DE "Courseware" OR DE "Virtual Classrooms" OR DE "Web Based Instruction" OR DE "Laptop Computers" OR DE "Information Technology" OR DE "Technology Integration" OR DE "Technology Uses in Education" OR DE "Handheld Devices" OR DE "Electronic Equipment" OR DE "Computer Games" OR DE "Electronic Learning" OR DE "Computer Mediated Communication" OR DE "Computer Peripherals")
>
> NOT ("professional development" OR "teacher training")
>
> Limiters Date Published: 20000101-;
>
> Publication Type: Reports - Descriptive, Reports - Evaluative, Reports - Research

Manual searches. The primary tool used to locate grey literature was the Google search engine. Owing to Google's lack of advanced search features, a series of searches combining different keywords were run to locate nonstandard literature (local reports, government reports, conference papers, theses and dissertations). Some examples are:

> "gender differences" "use of technology"
>
> "gender differences" perception ICT
>
> "gender differences" "attitude towards" "information technology"

In addition, several online resources were used to find additional grey literature, most notably the LearnTechLib digital library of the Association for the Advancement of Computing in Education, which curates content from numerous academic conferences and e-journals. The reference lists of previous reviews in the subject area (e.g., Cai et al., 2016; Cam et al., 2016; Huang, 2013) were manually scanned for additional relevant studies that might be included. The outcomes of the whole complex of conducted systematic searches are summarised in Table 1 below.

Table 1

Search Results by Source

Source	Number of Results*
Academic Search Complete	15
Communication Abstracts	37
Communication & Mass Media Complete	67
Education Source	19
ERIC	849
Gender Studies Database	87
LearnTechLib	480
Manual Searches (Google & branching)	110
ProQuest Dissertations & Theses Global	169
PsycINFO	219
TOTAL	**2,052**

*After duplicate results (i.e., found previously in another database) were removed.

OUTCOME TYPES

As noted previously, meta-analyses on gender differences with regard to ICT have used a wide variety of outcomes, often organised in broader (more inclusive) or sometimes very focused, narrow categories, to the point where negative and positive computer attitudes were studied and aggregated separately (Rabah et al., 2017). Researchers typically collected and summarised data according to the TAM framework (Davis et al., 1989) for computer self-efficacy, perceived ease of use and usefulness, and behavioural intentions to use ICT, alongside various forms of computer attitudes, with studies often distinguishing between cognitive and affective (computer anxiety occasionally was among the latter or served as an independent construct to be assessed). The list above names just the most frequently used outcome types, predominantly in meta-analytical research, whereas individual primary studies produced an even higher variety of outcome types and measures, substantially overlapping among themselves and of different scope and psychometric quality. The latter issue, first underscored by Kay (1992), may present a serious challenge to the reliability of findings, as standardised scales (e.g., for computer anxiety), individual items (e.g., selected satisfaction survey questions) and various forms of experience-based self-reports (e.g., frequencies of Internet access) are largely accounted for indiscriminately in quantitative syntheses. Though obviously this is a reason for more cautious interpretation, including measures of uneven methodological quality is the reality of the current state of research in the field, overwhelmingly represented by survey techniques of various degrees of depth and extent.

For the purposes of the current meta-analysis we considered the following four major categories of outcome (composed of individual measures that in our view complemented each other the most, reflecting similar core aspects of ICT perception and use):

1. **General ICT attitudes** (subsumes positive and negative attitudes and perceived satisfaction with ICT learning experiences)
2. **Confidence about ICT** (subsumes confidence, computer self-efficacy, perceived ease of use, and computer anxiety — opposite of the other three in effect-size valence)
3. **Motivation/intent to use ICT, and its perceived usefulness**
4. **Actual ICT use** (including learners' self-reported frequency and time spent)

Please note that we did not address those studies whose primary area of interest was in comparing computer abilities and academic performance between genders, as this line of research is beyond the mandate of the current review, though it may be of equal interest for educators. Only attitudinal and behavioral outcomes were of concern.

MODERATOR VARIABLES (STUDY FEATURES)

Moderator variable analysis is intended to explain variability in effect sizes in a given meta-analysis. In other words, it seeks to identify those conditions that systematically influence the magnitude and direction of effect sizes (i.e., under what circumstances they tend to be positive or negative, larger or smaller).

Moderator variables are systematically coded study characteristics: methodological (e.g., research design of included primary studies), substantive (e.g., major functionality of technology, as in Schmid et al., 2014), or demographic (e.g., learners' grade level). In this review, the following study characteristics (study features) were coded and analysed to explore differences in effect sizes due to their respective levels:

1. **Outcome type** (as outlined in the previous section)
   Technically, this item separated data sets into four independent collections (meta-analysed separately) to produce population estimates for each respective outcome category.
2. **Measure source**
   We distinguished among: (a) whole instruments (though of varying psychometric quality); (b) selected individual survey items; and (c) composites, created by us by averaging several measures of the same type and compatible representativeness (e.g., frequencies of use of different software applications equally important for achieving the learning objective of a given course). This methodological study feature was introduced to at least partly account for potential bias associated with uneven reliability of the measures used in included primary studies.
3. **Effect size extraction procedure**
   As with the previous study feature, this one belongs to the methodological type and was used to make sure that the degree of precision of statistical procedures did not differentially affect the magnitude of the corresponding effect sizes. Specifically, we distinguished among: (a) effect sizes precisely calculated from reported descriptive statistics; (b) effect sizes estimated from reported inferential statistics without additional assumptions; (c) effect sizes estimated with necessary assumptions (e.g., of sample size equivalence when individual group sizes were not reported); and (d) effect sizes reported by the authors of included primary studies without providing any additional information.

4. **Study publication date**
The publication year of each study was documented and used in subsequent moderator variable analysis as a continuous-scale predictor in a meta-regression. Additionally, we performed analyses of publication date as a categorical variable in two different ways. First, studies were separated into groups based on whether they were published before or after 2010. They were then split into four categories of roughly five-year periods: from 2000 to 2004 (inclusive), from 2005 to 2009, from 2010 to 2014, and from 2015 to 2018 (from one to four effect sizes were available in each outcome category for this time period).

5. **Country (region) of study**
Each country of origin was documented individually (i.e., it is possible to look at the magnitude of effect sizes coming from the same geographical location), but for the purposes of moderator variable analyses, additional categorisation was carried out. First, we dichotomised countries into Commonwealth members and non-members, then we further split the former into five Commonwealth regions and the latter into studies conducted in the USA, Scandinavian countries, and the rest of the world (organised in groups by continent).

6. **Study context with respect to ICT** (technological context)
Accounting for the entire spectrum of technological tools and applications encompassed in the collection of included primary studies would not be feasible for any meta-analysis. Instead, we decided to consider the specificity of the technological environment in terms of its connection to the corresponding effect sizes. We distinguished between generic and specific technological contexts. The former category included a broad variety of ICT tools and applications, usually addressed in large-scale surveys without specifying their precise composition and circumstances of use (e.g., "online learning" or "computer use for studying"), whereas the latter dealt with only specific educational technologies (e.g., "simulations for science classes" or "mobile educational games").

7. **Educational context**
Similar to the technological context above, this study characteristic dealt with the specificity of educational environments in which ICT perception and use were evaluated. We also distinguished among specific and generic educational environments (the latter characterised by multiple fields of studies, e.g., university-wide surveys). Whenever possible, we accounted for specific subject matters being studied, at least to the extent of separating STEM, non-STEM and educational disciplines and programmes.

8. **Time of data collection**
We hypothesised that one influence might be whether the data with regards to ICT use/attitudes were collected over an unspecified time period (e.g., surveys sent to all students in an educational programme and/or institution with uncertain/varying return rate or time), or gathered prior to or upon completion of a specific educational experience. So we carried out coding of the time of data collection as follows: (a) pre-intervention data collection; (b) mid-term data collection (for analysis purposes, this could be combined with the next option as representing at least a part of some structured educational experience); (c) post-intervention data collection; and (d) unspecified time of data collection.

3.3 Results

OVERVIEW OF THE STRUCTURE OF THE FINDINGS

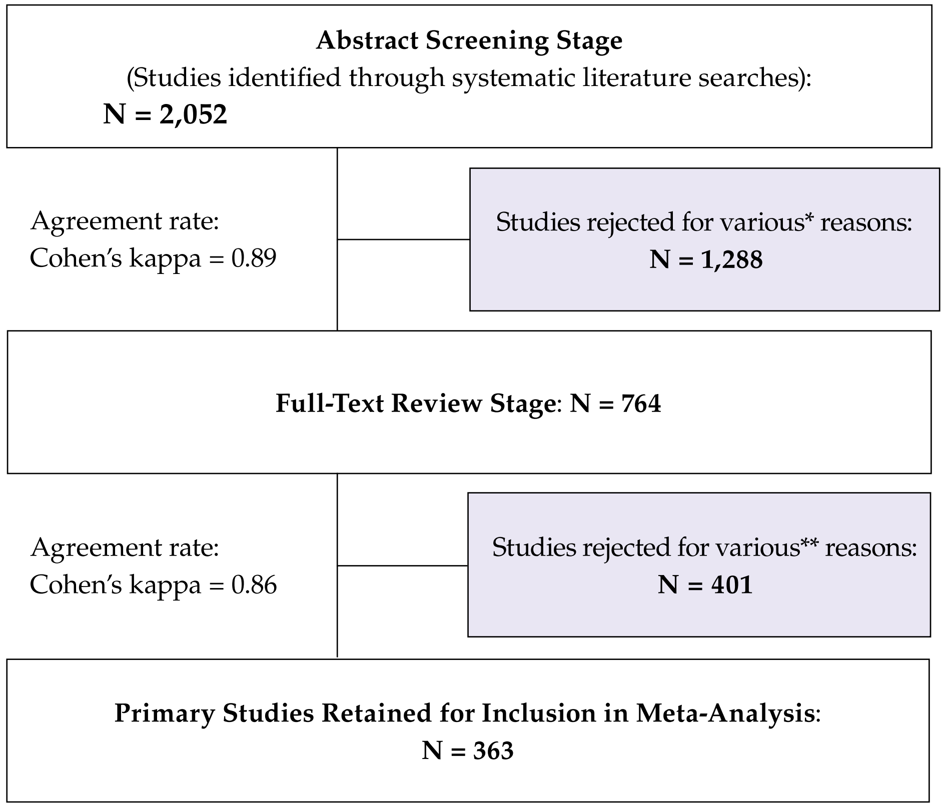
In the subsequent sections, we will:

1. briefly outline the review process and decisions made along the way;
2. present the overall findings of the meta-analysis organised by outcome category, both in terms of descriptive statistics of the respective effect sizes' origins, samples and contexts, and the weighted averages;
3. describe the outcomes of the publication bias and sensitivity analyses;
4. report the results of the moderator variable analyses by outcome category, with the emphasis on statistically significant findings; and
5. summarise interesting patterns of results organised by moderator variables across outcome types.

REVIEW PROCESS DESCRIPTION

The flow chart in Figure 1 reflects the key points of the review procedure. First, all studies identified through systematic literature searches (N = 2,052) were screened at the abstract level. Applying the inclusion/exclusion criteria presented earlier allowed us to narrow the list of potentially suitable studies down to 764 primary studies marked for full-text document retrieval and review, which in turn resulted in 363 studies[3] retained for inclusion in the meta-analysis. At both stages, the reviewing process was as follows. Two researchers independently reviewed approximately 15% of the respective collections, compared notes, established sufficient reliability, and advanced further with the rest of the studies evenly split between them. Agreement rates reached through independent portions of screening abstracts and reviewing full-text documents, expressed as Cohen's kappa, are presented on the left side of the flow chart.

[3] http://hdl.handle.net/11599/3089



* Among the most prevalent reasons for excluding studies at the abstract screening level were:

- irrelevant outcomes (mostly reflecting academic achievements) – 24.4%
- inappropriate sample/population (mostly data coming from teachers, not students) – 13.1%
- non-educational context (e.g., recreational use of ICT) – 8.4%

There was a relatively small group of studies (n = 9) in which the issue of gender and ICT was addressed for samples of female students only. Not admissible to the meta-analysis, these studies later on may provide insights into a more nuanced picture of that population's ICT perceptions and use. Qualitative studies, review and opinion articles, and studies published in languages other than English were also rejected, together accounting for over 22% of the studies. The rest were excluded for combinations of several reasons.

** Among the most prevalent reasons for excluding studies at the full-text review level were:

- irrelevant outcomes (mostly reflecting academic achievements) – 57.5%
- no comparison point (i.e., data reported without gender split) – 14.9%
- non-educational context – 10.6%

Other categories of reasons included insufficiency of reported statistical data (for effect size extraction) and explained the rest of the excluded studies.

THE OVERALL EFFECT SIZES

Table 2 summarises the meta-analysis findings with respect to four major outcome types: (1) General Attitudes toward ICT (k = 153); (2) ICT Confidence and Self-Efficacy (k = 163); (3) ICT Motivation and Interest (k = 121); and (4) Actual Use of ICT (k = 117). The corresponding weighted average effect sizes are reported there according to both the random-effects model and the fixed-effect model. Given the apparent non-uniformity of studies in our collection, the former provides more accurate estimates of the population effects, while the latter serves primarily to estimate the degree of heterogeneity of the respective effect-size distributions; these statistics are reported in the last line of each subsection of the table.

Table 2

Overall Weighted Average Effect Size for All Four Outcome Types and Associated Heterogeneity Statistics

Population Estimates	k	g^+	SE	Lower 95th	Upper 95th
General ICT/Computer Attitudes/Satisfaction					
Fixed-effect model	153	0.098***	0.01	0.08	0.11
Random-effects model	153	0.066**	0.02	0.02	0.11
Heterogeneity analysis	Q_T = 1321.02 (df = 152), p < .001, I^2 = 88.49				
ICT/Computer Confidence					
Fixed-effect model	163	0.185***	0.01	0.17	0.20
Random-effects model	163	0.228***	0.02	0.18	0.27
Heterogeneity analysis	Q_T = 1063.47 (df = 162), p = .001, I^2 = 84.77				
ICT/Computer Motivation/Interest					
Fixed-effect model	121	0.106***	0.01	0.09	0.12
Random-effects model	121	0.079***	0.03	0.03	0.13
Heterogeneity analysis	Q_T = 888.06 (df = 120), p < .001, I^2 = 86.49				
ICT/Computer Actual Use					
Fixed-effect model	117	0.071***	0.01	0.06	0.09
Random-effects model	117	0.048*	0.02	0.00	0.10
Heterogeneity analysis	Q_T = 1075.82 (df = 116), p < .001, I^2 = 89.22				

* p = .054; ** p < .05; *** p < 0.01

Weighted average effect sizes in all outcome categories were positive and statistically significant (with the exception of g^+ = 0.048 in the Actual ICT Use outcome category, with its p-value at 0.054), though quite low in magnitude, thus reflecting the existence of gender difference in perception of, confidence in, motivation for, and actual use of ICT in education in favour of male students. It is worth noting that the effect size in the last outcome category, actual ICT use, though nearly meeting the criterion of statistical significance (with a p-value at 0.054), was very small and should be interpreted with caution.

Also, all four respective distributions were highly heterogeneous, which suggests that this direction of the difference does not persist across the included studies but varies substantially and may be reversed under specific conditions that could be identified through subsequent analyses of coded moderator variables.

More specifically, with respect to each of the outcome type data collections, the following result patterns have been observed.

1. **General Attitudes**
   The category of general attitudes toward ICT and/or satisfaction with using computers, Internet, and specific computer tools and applications for learning produced 153 independent effect sizes based on a total sample of 77,977 students (34,937 males and 43,040 females) from 37 different countries (including 15 Commonwealth states, predominantly Canada and the UK — seven and five effect sizes, respectively) that ranged in magnitude from –1.032 to 1.564. There were 90 effects in favour of men versus 62 effects in favour of women, with one "zero" effect reflecting no gender difference. The vast majority (k = 118) of the effect sizes in this outcome category would be considered low and low-to-moderate (in Cohen's terms) in magnitude (i.e., not exceeding 0.4 standard deviation units in either direction). The distribution of participants by age or grade level was quite uneven: eleven effect sizes came from kindergarteners and elementary school students, 33 from secondary and high school students, whereas the vast majority of participants were college and undergraduate students (k = 95). There were only three effects based on data collected from graduate students, and a few cases of adult learners (e.g., continuing education or vocational students) and of mixed-level samples, two of which were combinations of undergraduate and graduate students. In terms of the contexts of data collection, with respect to both technology type and educational environments, most of the studies were non-specific. One hundred thirteen effects represented differences in opinion about generic ICT without specifying particular tools and applications. Similarly, 114 effects were derived from generic educational contexts — i.e., either across disciplines and subject matters or without specifying them. Time of data collection was also specified quite rarely; we identified five cases of pre-intervention surveys, three instances when attitudinal data were collected around mid-term exams and 48 cases of post-intervention data collection.

2. **Confidence**
   This outcome category included a great diversity of measures that reflected ICT confidence and perceived ease of use (also opposite to computer anxiety), as well as ICT self-efficacy, with a total of 163 independent effect sizes. They were derived from 65,501 students, 46.3% men and 53.7% women. These students represented 33 different countries from around the world, including 13 Commonwealth states, mostly the UK (k = 7), Canada (k = 6) and the Pacific region (k = 6, Australia and New Zealand each contributing three effects). Outside the Commonwealth, the most frequent effects were from studies conducted in the USA (k = 53), Taiwan (k = 26) and Turkey (k = 16). After removal of one outlier (see the section on Publication Bias and Sensitivity analyses below), effect sizes in this category were relatively low in magnitude, ranging from –0.730 to 2.055, with 109 effect sizes clustering within the interval from –0.40 to 0.40. Thirty-eight effects were negative (i.e., favouring female students), whereas 122 were positive (i.e., reflecting higher scores

for male students) and three comparisons detected no gender difference (i.e., "zero" effect) in outcomes related to ICT confidence, self-efficacy and perceived ease of use. Time of data collection was not specified in 111 cases. Pre-intervention survey administration was documented for 14 effect sizes, mid-term for five effects, while end-of-course data collection occurred in 34 cases. Questions about specific educational technology were much less frequent (k = 32) than those about confidence with ICT in general (k = 131). Educational contexts were also predominantly non-specific, basically coinciding with cases of generic technologies (k = 131). The absolute majority of the effect sizes were based on data collected from university undergraduate students (k = 102), while other categories of participants' age/grade level counted 12 cases of kindergarteners and elementary school students, 35 cases of secondary and high school students, six cases of university graduate students, four cases of adult learners and four cases of various mixed samples.

3. **Motivation and Interest**

   One hundred and twenty-one independent effect sizes reflected gender differences in interest about and motivation to use ICT (also often presented as perceived usefulness). They were based on data collected from 30,939 female students and 25,775 male students, for a total sample of 56,714 participants. These effect sizes ranged from –1.318 to 1.564 with no outliers detected. The distribution of effect sizes in this category of outcomes was the most balanced in terms of the frequencies of positive and negative effects (k = 64 and k = 57, respectively). Studies in this category originated in 39 different countries (making it the most geographically diverse collection in this meta-analysis, though rather low in number of effects, i.e., a smaller number of effects per country). Twenty-three effect sizes were derived from 14 Commonwealth countries in all five regions, and 97 effect sizes came from 25 countries in the rest of the world, with the USA and Taiwan being the most represented (k = 30 and k = 20, respectively). Participants provided their responses about motivation/interest for specific technological tools and applications in 33 cases. Much more often they were asked to rate ICT usefulness in general (k = 88). A similar pattern characterised the educational contexts of data collection: specific courses and other types of educational interventions were represented in only 24 cases, while 95 effect sizes dealt with participants' responses outside of or across individual courses and subjects. The time of data collection was for the most part unspecified (k = 88); seven surveys were administered at the beginning of various educational experiences and four at the mid-term exam time, while 22 represented post-intervention data collection. Participants' age varied as follows: kindergarten and elementary school — 10 effect sizes; secondary and high school — 25 effect sizes; college and university undergraduates — 76 effect sizes. Only four effect sizes represented university graduate level, and there were four combined samples (two between elementary and secondary school and two between secondary school and undergraduates) as well as two cases of adult learners.

4. **Actual Use**

   Finally, the category of actual use of ICT programmes, tools and applications contains 117 independent effect sizes encompassing the total sample of 74,743 students (47.7% men and 52.3% women). This collection is characterised by reliance on relatively large-scale surveys, often conducted beyond the context of specific educational course. As a result, the smallest number of effect sizes in this outcome type category is based on a higher number of students (compatible with the number of respondents in the General ICT Attitudes category). Also, this collection appears to be relatively balanced in terms of the number of positive and negative effect sizes. Out of 117 effects, 48 favour female students and 67 favour male students, with two "zero" effects reflecting no gender difference. The range of magnitude is from –1.135 to 1.951, well within two standard deviation boundaries on either side of the distribution, with the overwhelming majority of 100 effects not exceeding +/– 0.4 standard deviation units. Studies in this collection originated in eight Commonwealth countries and 26 non-member countries from all regions of the globe. Among the latter, similar to all other outcome categories, the most representation was from the USA (k = 36), followed by Taiwan (k = 9) and Turkey (k = 7), while the Commonwealth's most represented states were the UK (k = 7), Australia and Canada (four effect sizes per country). Data on actual ICT use were collected from the following categories of learners: kindergarten and elementary school students (k = 9); secondary and high school students (k = 33); college students and university undergraduates (k = 66); graduate students (k = 4); and adult learners (k = 5). Ninety-one effect sizes represented participants' use of unspecified educational technology, whereas 26 effects reflected participants' experience with particular tools and/or applications. Educational contexts were also rather non-specific; data for 103 effects were collected across learning disciplines and subject matters, and in only 14 cases was educational context identified and described. Data were collected at various points in time with respect to some educational intervention: at the beginning (k = 8), in the middle (k = 3) or at the conclusion (k = 25). But for the most part, this information was not specified in reports (k = 81).

PUBLICATION BIAS ANALYSIS

Publication bias analyses include several procedures designed to determine whether a substantial number of effect sizes might have been overlooked in a search for relevant studies and their non-inclusion in a meta-analysis might have distorted its findings. Usually, the literature refers to publication bias with respect to the tendency of journals to publish statistically significant results at the expense of inconclusive ones, which may lead to overestimating the magnitude of the effect in a population. We employed several tools to assess publication bias, including the examination of a funnel plot (depicting the distribution of effect sizes as a function of their associated standard errors) and Duval and Tweedie's (2004) analytical technique, as well as the statistical procedures of Classic Failsafe analysis and Orwin's fail-safe analysis for each of the four outcome type categories.

All but one of the funnel plots were balanced, showing nearly symmetrical distribution of effect sizes on both sides of the respective mean and suggesting no potentially "missing" studies that would bias the findings of our meta-analysis (see Figures 2–5 for the funnel plots of the Attitudes, Confidence, Motivation and Use outcomes, respectively). As Figure 3 shows, the only exception was the distribution of the effect sizes in the ICT Confidence outcome category, which was skewed towards positive effects and would require the imputation of 24 potentially "missing" effects (blackened circles on the plot) on its negative side to be properly balanced.

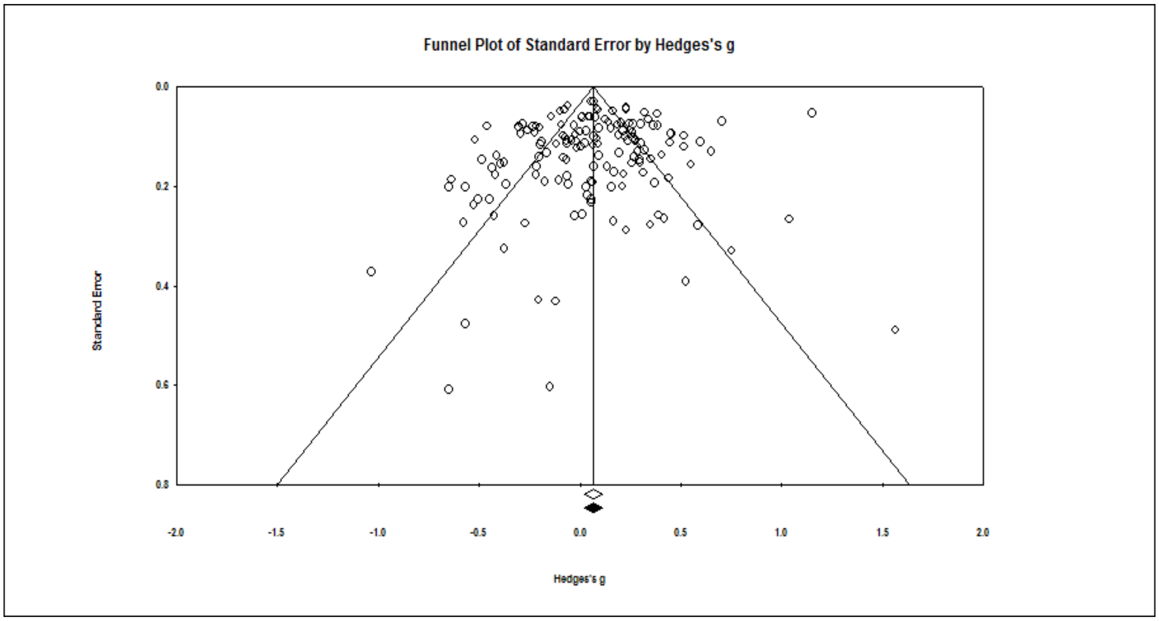


Figure 2. Funnel plot (effect size by standard error) for ICT General Attitudes.

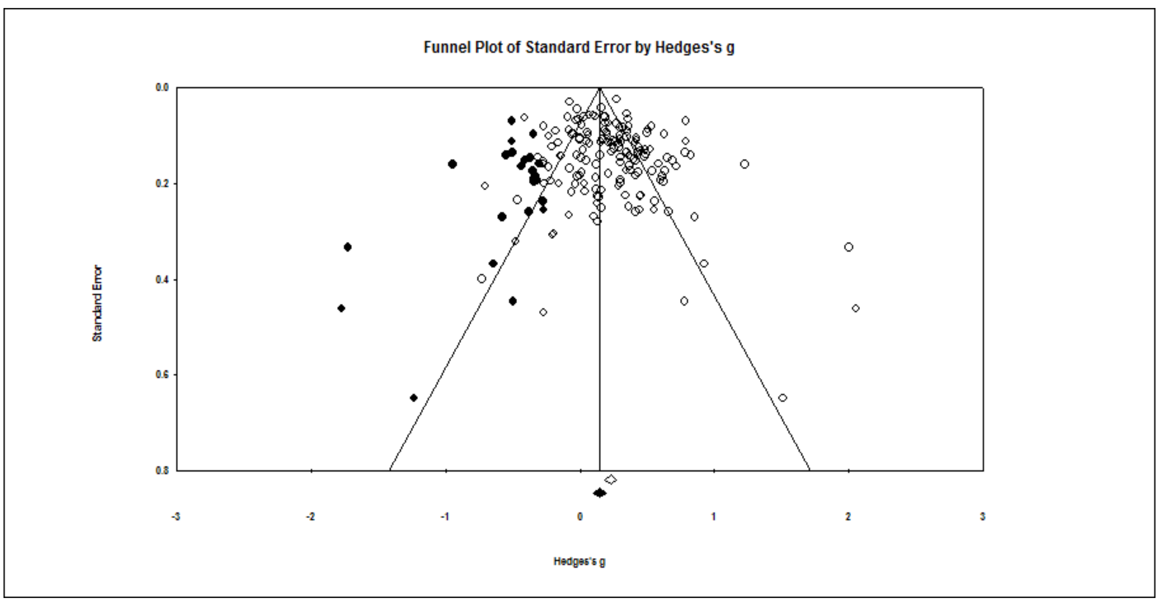


Figure 3. Funnel plot (effect size by standard error) for ICT Confidence.

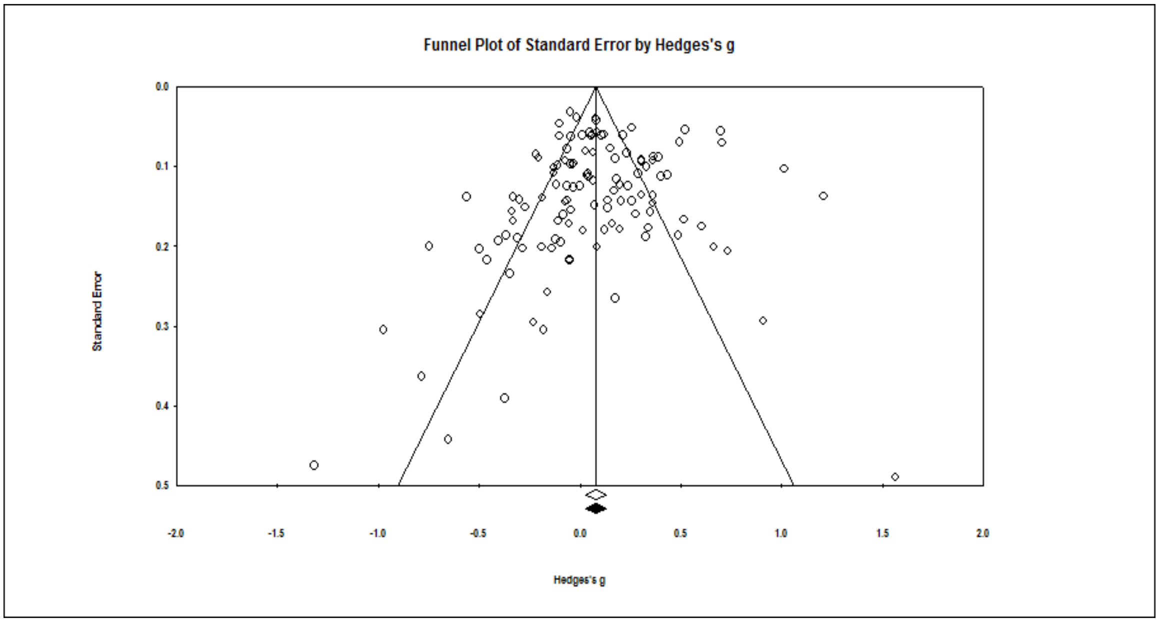


Figure 4. Funnel plot (effect size by standard error) for ICT Motivation.

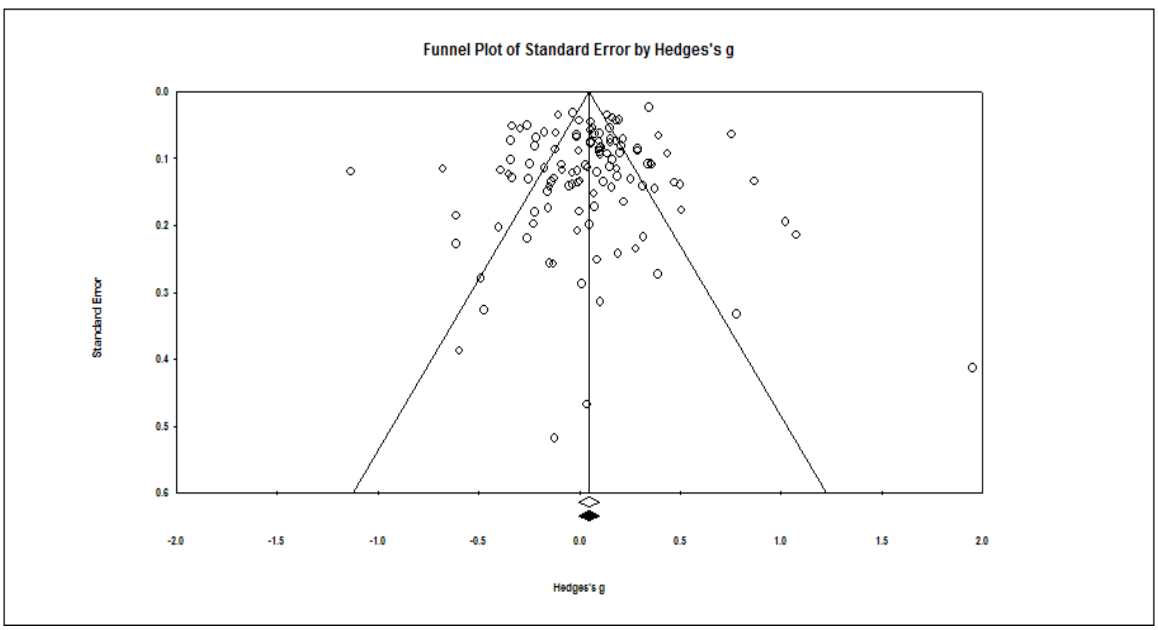


Figure 5. Funnel plot (effect size by standard error) for ICT Actual Use.

Associated "trim-and-fill" procedures by Duval and Tweedie (2004) confirmed the impression derived from a visual examination of the funnel plots: no "missing studies" were detected, and no subsequent imputations were suggested for three out of four categories of outcomes. When calculated within the random-effects model, the respective weighted average effect sizes stayed unchanged. For the ICT Confidence category, the analysis suggested the imputation of 24 effect sizes on the left side of the distribution to achieve symmetry. This kind of adjustment would bring the observed $g^+ = 0.228$ down to a point estimate of 0.141 (still statistically significant, with a corresponding confidence interval of 0.099–0.195).

The Classic Failsafe procedure was used to determine how many potentially "missing" null effects would bring the probability of the average effect size to a non-significant ($p > .05$) level. We found the following numbers. For the General Attitude outcome category, the Classic Failsafe N = 3,347. The actual number of effects ($k = 153$) means that the observed effect size of $g^+ = 0.066$ (random-effects model) would be rendered statistically non-significant if each of the included effects were "compensated" for by at least 21 hypothetical "null" effects. "Nullification" means bringing the effect size to statistically non-significant value (i.e., not differing from the hypothesized "zero"). Nullification of the calculated effect size of $g^+ = 0.228$ in the ICT Confidence outcome category would require 21,471 potentially "missing" null effects (or more than 131 per each observed one). For the ICT Motivation outcome category, the Classic Failsafe is N = 2,519 (roughly 21 per each of the 121 observed effects) to render the calculated $g^+ = 0.079$ statistically non-significant. Finally, as would be expected for an effect size of such low magnitude, $g^+ = 0.048$ in the ICT Actual Use outcome category was the least stable, being already at the level of marginal statistical non-significance ($p = 0.054$, $k = 117$). Together, the results of these analyses indicate that our findings, even when small in magnitude, were very robust and should be considered reliable representations of the corresponding effects in the population.

Orwin's fail-safe analytical procedure is similar to the Classic Failsafe, in that it indicates the number of potentially "missing" null effects that, if discovered and accounted for, would bring the observed effects to some trivial number (e.g., unworthy to pursue when it comes to assessing the cost of experimental intervention). Using the corresponding lowest observed effect sizes in Whitley (1997) and Rabah et al. (2017) as the reference points, we preset the level of "triviality" at 0.05 for General Attitudes and Motivation, at 0.025 for Actual Use and at 0.10 for ICT Confidence. Orwin's fail-safe analysis, applied to each outcome-type collection of effect sizes, then produced the following numbers: N = 147 (for General Attitudes); N = 139 (for Confidence); N = 136 (for Motivation); and N = 79 (for Actual Use).

SENSITIVITY ANALYSIS

It is always important to make sure that the findings of a meta-analysis (just like the results of any quantitative primary research) are not distorted by the presence of outliers. The one-study-removed CMA routine allows each effect size to be checked for potential disproportionate influence on the entire distribution of effect sizes. This procedure was run for all four types of outcome and found only one outlier: a study by Klahr et al. (2007) produced an effect size of overly large magnitude ($g = 4.109$), which was removed from the data set. As a result, the data presented in the above section with respect to the ICT Confidence outcome category do not include this out-of-range effect size.

MODERATOR VARIABLE ANALYSIS

After aggregating the effect sizes within each of the outcome categories, we ran a series of moderator variable (coded study characteristics) analyses to explain systematic variations (if any) in individual effect sizes.

Checking Methodological Moderators. No statistically significant differences in effect sizes emerged as a result of methodological variable analyses across outcome type categories. Different levels of the "measure source" and "extraction procedure" moderator variables did not result in sufficiently substantial changes in magnitude of the respective effect sizes to question the inclusion of any in the overall analyses. In one instance, the effect size of g = 0.487 reported by the authors (Friedrich et al., 2010) significantly differed from the rest of the collection in the Computer Motivation outcome category. Its removal restored the homogeneity of the distribution ($Q_{between}$ = 7.76, p > .05), but since prior sensitivity analysis had not identified this effect as an outlier, it was kept in the collection. In all other cases across outcome type categories, the homogeneity of the respective distributions was never in question, up to the point of the lowest $Q_{between}$ = 0.21 (p = .976) for the precision of the effect size extraction procedure variable in the Actual ICT Use outcome category.

Substantive and Demographic Moderator Variables. For the subsequent analyses of substantive and demographic variables, only statistically significant findings and trends approaching, but not reaching, the level of statistical significance (that is, differences between/among levels of the moderator variable in question) within each outcome type category are reported in table format. In a few cases, when the sum of the number of effects across the levels of the moderator does not match the total for that outcome type category, this means that the effects missing relevant information were excluded from the analyses.

General ICT Attitudes. This outcome type was very consistent across levels for most of the moderator variables. The only exception was a statistically significant difference in effect sizes in studies conducted in different regions (Table 3). On average, general ICT attitudes were almost identical for Commonwealth and non-Commonwealth countries (positive g^{+} = 0.092 and g^{+} = 0.093, respectively) but significantly different from effect sizes derived from studies conducted in either the USA or Scandinavian countries (though the latter were represented by only two cases, and their results should be treated with caution). Effect sizes for non-Commonwealth countries were much lower (up to the point of direction reversal), indicating smaller differences between male and female students in their perceptions of and satisfaction with ICT experiences.

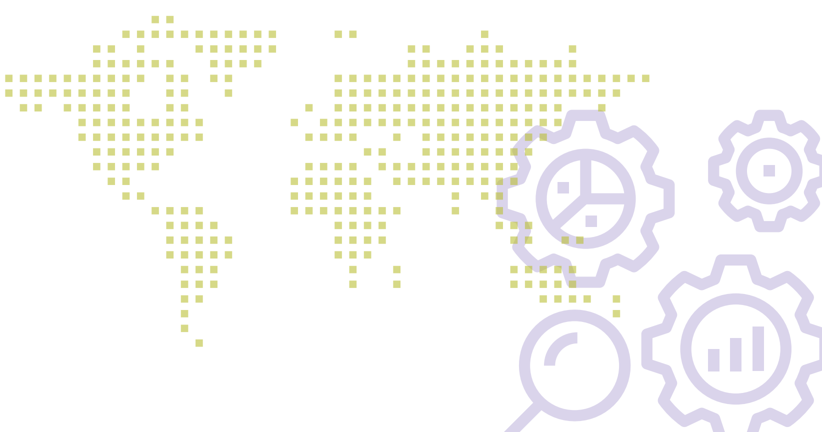


Table 3

Results of the Moderator Variable Analyses for the General Attitudes Outcome Category

Levels of Moderator Variables	Number of Effects (k)	Category Average ES (g^{+})	Lower 95th CI	Upper 95th CI	$Q_{Between}$
Region of the Study: Four Options					
Commonwealth Countries	33	0.092	–0.04	0.22	
Non-Commonwealth Countries	65	0.093	0.03	0.16	
USA	52	0.021	–0.05	0.09	
Scandinavian Countries	2	–0.433	–0.84	–0.03	
Between Groups: $df = 3$					8.22, $p = .042$

No statistically significant difference was detected between Commonwealth and non-Commonwealth countries before the latter were split into the three categories described earlier: $g^{+} = 0.092$ ($k = 33$) and $g^{+} = 0.059$ ($k = 119$), $Q_{between} = 0.22$, $p = .64$. Other moderators also produced non-significant results. For example, potentially the most interesting comparison of specific fields of study showed no difference between STEM ($g^{+} = 0.083$, $k = 22$) and non-STEM ($g^{+} = 0.085$, $k = 20$) disciplines, with the lowest effect size for the field of education ($g^{+} = 0.011$, $k = 8$). The entire distribution was homogeneous across subjects ($Q_{between} = 0.82$, $p = .846$). Meta-regression analysis run on publication dates resulted in a nearly flat line with a slope of 0.0015 ($p = .744$).

ICT Confidence/Self-Efficacy.

The major results of moderator variable analyses for this outcome category are summarised in Table 4. Effect sizes differed significantly across grade across grade levels ($Q_{between} = 17.95$, $p = .003$), with the largest effect size of $g^{+} = 0.320$ ($k = 34$) for secondary and high school students and the lowest for graduate students; the latter was actually negative (i.e., in favour of female students): $g^{+} = -0.002$ ($k = 6$). Technological context was another variable that produced nearly significant differences in effect sizes between its levels ($Q_{between} = 3.07$, $p = .080$). The degree of confidence expressed by males compared with females was higher when they worked with specific tools and applications ($g^{+} = 0.336$, $k = 31$) than with respect to ICT in general ($g^{+} = 0.205$, $k = 131$). Another trend approaching the level of statistical significance was the tendency of effect sizes to decrease with time. The regression line had a small negative slope of –0.009 ($p = .069$). When analysed as a categorical variable (split into five-year periods), publication date produced the lowest effect size of $g^{+} = 0.103$, $k = 21$ for the studies conducted between 2014 and 2018. It was more than twice as low (though not significantly) than other effect sizes in the collection (which ranged from 0.210 to 0.285): $Q_{between} = 7.38$ ($p = .061$). That the magnitude of the effect size reflecting differences between men and women in ICT confidence dropped substantially in the last four-year period may not be decisive for our prognosis regarding further developments but is of undeniable interest and importance.

Table 4

Results of the Moderator Variable Analyses for the Confidence/Self-Efficacy Outcome Category

Levels of Moderator Variables	Number of Effects (k)	Category Average ES (g+)	Lower 95th CI	Upper 95th CI	$Q_{Between}$
		Grade Level			
K & Elementary School Students	12	0.228	0.06	0.39	
Secondary & High School Students	34	0.320	0.20	0.44	
College & Undergraduate Students	102	0.232	0.18	0.28	
Graduate Students	6	–0.002	–0.13	0.13	
Adult Population	4	0.173	–0.35	0.70	
Mixed Age Samples	4	0.034	–0.15	0.22	
Between Groups: $df = 5$					17.95, $p = .003$
		Technology Context			
Generic ICT Context	131	0.205	0.16	0.25	
Specific Tools & Applications	31	0.336	0.20	0.48	
Between Groups: $df = 1$					3.07, $p = .080$

The results of other moderator variable analyses were not statistically significant. Specifically, educational context produced homogeneous distributions of effect sizes: $Q_{between} = 5.18$ ($p = .269$), though it is worth mentioning that, similar to the General Attitudes category of outcome, the lowest effect size was detected for education: $g^+ = -0.014$ ($k = 6$). Given that this outcome type produced the highest overall weighted average effect size of $g^+ = 0.228$, this negative (though non-significant) effect size for ICT confidence in education is indeed telling.

ICT Motivation and Interest.

Moderator variable analyses in this outcome category resulted in some noteworthy findings, presented in Table 5.

Very much in line with findings for the General Attitudes outcome category, the average effect size for studies conducted in the USA ($g^+ = -0.122$, $k = 30$) was not only significantly different from effect sizes derived from either Commonwealth or non-Commonwealth countries ($Q_{between} = 23.93$, $p < .001$) but also negative (in favour of women) and statistically significant ($p = .008$). Another statistically significant difference was detected among levels of the variable "data collection time" ($Q_{between} = 6.95$, $p = .003$). Both levels associated with a specific time and context (that is, pre-intervention and post-intervention assessments) resulted in negative average effects of $g^+ = -0.031$ ($k = 7$) and $g^+ = -0.035$ ($k = 26$), respectively, different from the average effect sizes for data collected at unspecified times. In other words, knowing what to expect or actually working through a specific learning experience makes female students' interest in ICT rise to the point of surpassing their male peers' interest.

Although the results of moderator variable analysis for the educational context were not statistically significant ($Q_{between} = 2.27$, $p = .132$), they depicted a tendency for lower effect sizes in specific educational contexts: $g^+ = 0.001$ – virtually zero ($k = 24$), versus unspecified contexts (i.e., across subject matters), where $g^+ = 0.095$ ($k = 97$). These findings resemble those described earlier for the other two outcome categories' pattern of lower average effects specifically for the field of education and as such are reflected in the table. It seems that in the context of specific educational programmes and individual courses, female and male students are equally interested in and motivated to use ICT for learning to succeed in the respective fields of study.

Table 5

Results of the Moderator Variable Analyses for the Motivation/Interest Outcome Category

Levels of Moderator Variables	Number of Effects (k)	Category Average *ES* (g^+)	Lower 95th *CI*	Upper 95th *CI*	$Q_{Between}$
Region of the Study: Four Options[a]					
Commonwealth Countries	23	0.130	–0.01	0.27	
Non-Commonwealth Countries	66	0.148	0.09	0.21	
USA	30	–0.122	–0.21	–0.03	
Between Groups: $df = 2$					23.93, $p < .001$
Educational Context					
Generic (Across Subject Fields)	97	0.095	0.04	0.25	
Specific (In the Context of a Specific Course)	24	0.001	–0.11	0.11	
Between Groups: $df = 1$					2.27, $p = .132$
Time of Data Collection					
Pre-Intervention	7	–0.031	–0.22	0.16	
Post-Intervention	26	–0.035	–0.14	0.07	
Unspecified (No Context)	88	0.116	0.06	0.17	
Between Groups: $df = 2$					6.95, $p = .003$

[a] One study from Scandinavian countries and one study with an unreported location were removed from the analyses.

None of the other moderator variable analyses we conducted (including on publication date) produced statistically significant results.

Actual ICT Use. This outcome type category produced the lowest overall weighted average effect size of $g^{+} = 0.048$ but was not the least heterogeneous ($Q_{Total} = 1075.82$, $p < .001$). Subsequently, we could expect some statistically significant results to come out of the moderator variable analyses. These are summarised in Table 6.

Table 6

Results of the Moderator Variable Analyses for the Actual ICT Use Outcome Category

Levels of Moderator Variables	Number of Effects (k)	Category Average *ES* (g^{+})	Lower 95th *CI*	Upper 95th *CI*	$Q_{Between}$
Grade Level					
K & Elementary School Students	9	0.112	–0.04	0.27	
Secondary & High School Students	33	0.099	0.00	0.19	
College & Undergraduate Students	66	0.028	–0.04	0.10	
Graduate Students	4	–0.219	–0.36	–0.08	
Adult Population	5	0.037	–0.10	0.17	
Between Groups: $df = 4$					15.26, $p = .004$
Educational Context (Four Options)					
Unspecified (Across Fields of Study)	96	0.050	–0.00	0.10	
Education	4	–0.014	–0.33	0.30	
Non-STEM	8	–0.060	–0.13	0.01	
STEM	9	0.217	0.00	0.43	
Between Groups: $df = 3$					9.32, $p = .025$

Once again (as for General Attitudes before), the difference between male and female respondents in reported actual use of ICT tools and applications was smallest for graduate students ($k = 4$, though) as well as being negative (i.e., in favour of women) and statistically significant: $g^{+} = -0.219$, $z = -3.07$, $p = .002$. Also in line with some of the previously presented findings, education subject areas produced a low and negative average effect size of $g^{+} = -0.014$ ($k = 4$), this time joined by $g^{+} = -0.060$ ($k = 8$) for non-STEM disciplines, both different from the average effect sizes for the other two levels of this moderator variable: $Q_{between} = 9.32$ ($p = .025$).

Summary by Moderator Variable across Outcome Categories.

In this section, we try to summarise tendencies (though not necessarily statistically significant ones) more or less consistently observed across several outcome types. For example, as already mentioned, gender differences in graduate students not only were small but also went in the other direction in three out of four outcome types (in one case, to a significantly different extent than effect sizes for other education levels), suggesting that at higher education levels, gender bias may also be in favour of women.

Another persistent tendency towards lower-magnitude effect sizes was observed across outcome types for studies conducted in the USA and Scandinavian countries. The latter were represented by too few cases to build any solid conclusions, whereas effects for the USA consisted of: $g^+ = -0.122$ (in the ICT Motivation category, $k = 30$); $g^+ = 0.021$ (in the General Attitudes category, $k = 52$); $g^+ = 0.030$ (in the Actual Use category, $k = 36$); and $g^+ = 0.228$ (in the ICT Confidence category, $k = 52$) — virtually identical to the overall weighted average for this outcome category.

Studies conducted in the field of education (as the subject matter being studied) also produced consistently smaller effect sizes across outcome types. They were not very frequent but ranged in magnitude from $g^+ = -0.014$ (for both ICT Confidence and Actual Use) to $g^+ = 0.117$ (for ICT Motivation, though this average was based on only two cases and should not be seen as a reliable representation of the corresponding population).

Finally, analyses of the moderator variable "time of data collection" resulted in effect sizes consistently smaller (with just a few minor exceptions) for contextually more definitive pre-intervention and post-intervention survey administration in comparison to unspecified times of data gathering. Consider, for example, effects as low as $g^+ = -0.074$ ($k = 5$) for pre-intervention data on General Attitudes, $g^+ = -0.052$ ($k = 22$) for post-intervention data on Motivation and Interest, or $g^+ = -0.015$ ($k = 25$) for post-intervention data on Actual Use.

Even when not reaching the level of statistical significance, all these patterns may nevertheless be indicative of more nuanced dynamics within the issue of gender-based differences in ICT perception and use.

DISCUSSION

We build the discussion of the major findings of our meta-analysis around a set of questions that are of undeniable conceptual and applied interest to large audiences of educational researchers and practitioners, policy makers and the general public alike. These questions guided our review, and though we did not find exhaustively nuanced, definitive answers through the review, they serve as organisational points for summarising what we have learned by addressing them.

Does a gender gap in ICT perception and use exist?

The overallweighted average effect sizes in all but one outcome category were positive and statistically significant, indicating that male students have a more positive perception of ICT tools and applications (satisfaction with ICT practices), as well as higher levels of confidence in and motivation to engage with ICT activities in educational contexts. The only exception was statistically non-significant, $g^+ = 0.048$ ($p = .054$), in the category of actual ICT use. In other words, it appears that the so-called "primary" digital divide (that is, a gender gap in access to and experience with ICT) is no longer a serious issue.

Women and men on average are very much compatible in their educational use of computer-based and online technologies, whereas a gender-based "secondary" digital divide still persists, reflected in differences in ICT-related attitude, confidence and motivation measures.

How big is the magnitude of that gap?

We have already mentioned that the outcome category of Actual ICT Use produced the overall weighted average that statistically cannot be discriminated from zero (i.e., no difference between genders). Average point estimates (calculated according to the random-effects model) in the other three outcome categories were: $g^{+} = 0.066$ (for General Attitudes), $g^{+} = 0.228$ (for ICT Confidence and Self-Efficacy), and $g^{+} = 0.079$ (for ICT Motivation and Interest). By Cohen's standards for the social sciences (Cohen, 1988, 1992), all — even the highest one, reflecting gender-differentiated scores for ICT Confidence — belong to the category of small effect sizes.

Interpreted in terms of difference in percentile point, the latter, for instance, would mean that roughly 9.02% of male students would manifest more ICT confidence than their female peers (59.02% of the "experimental" group exceeding the mean score, i.e., 50% of the "control" group). For the other two outcome types, that difference would constitute 2.63% and 3.15%. Considering the entire population of learners in need of various degrees of ICT exposure and mastery, these percentages are by no means small, but neither do they represent an insurmountable obstacle to achieving a balance in outcomes if equality of opportunity is assured.

Is the gap closing (narrowing down) or even reversing its poles?

Given the statistical impossibility of directly comparing data reported in previous meta-analyses that explored gender differences in ICT perception and use to our own findings (that is, without access to all primary data and accounting for any single overlap in the data sets), we can approach this task (which is also complicated by serious fluctuations in defining outcome types across past meta-analyses) only descriptively. It seems that the numbers reported in meta-analyses of the 1990s are on average just fractionally higher than the corresponding numbers of the 2000s. For example, compare the overall effect size of 0.192 reported by Liao (1999) or 0.410 (computer self-efficacy) reported by Whitley (1997) with $g^{+} = 0.159$ (for computer cognitive beliefs) in Cai et al. (2106), or Rabah et al.'s (2017) figures of $g^{+} = 0.185$ (for perceived ease of use), $g^{+} = 0.225$ (for computer self-efficacy), $g^{+} = 0.143$ (for motivation to use ICT) and $g^{+} = 0.077$ (for perceived ICT usefulness). Our meta-analysis reports an even lower set of average weighted effect sizes (e.g., with respect to actual ICT use, non-significant $g^{+} = 0.048$ versus very close in magnitude but still statistically significant $g^{+} = 0.075$, observed in Rabah et al., 2017).

In addition, we can rely on analyses of publication dates in our review. They showed either flat (e.g., for general satisfaction data collection) or slightly negative regression lines, even approaching the level of statistical significance, as in the case of computer confidence (with a slope of –0.009, p = 0.069). Comparison of effect sizes for different publication dates, split by either decades or five-year periods, largely confirmed this observation.

All in all, the tendency for the gap to tighten (if not close) seems quite evident — a finding largely in line with some earlier observations (e.g., explicitly reported by Kay in 2008 or Cai et al. in 2016). Another, though indirect, indication of this may reside in the gender composition of the participants in the reviewed studies. The proportion of female respondents is typically higher across outcome types and levels of moderator variables. Moreover, whenever we could identify specific fields of study and compare them to each other, specifically STEM and non-STEM subjects, the number of female students was higher than the number of their male peers for both. For example, in the outcome category of ICT confidence, 19 effect sizes for STEM and 12 effect sizes for non-STEM disciplines were based on data collected from 2,918 male versus 5,286 female students for the former, and from 2,043 male versus 3,021 female students for the latter (i.e., women's representation in the STEM fields was even higher than in the non-STEM fields). Similar proportions of participation were observed in most of the past meta-analyses. There is, of course, always the possibility that women were more accurate in responding to surveys or/and more interested in the survey topics; however, the results also may speak to women's enrolment in STEM programmes and courses being higher than men's.

How much do we know about what moderates (increases or decreases) the gap?

Moderator variable analyses did not discover obvious (statistically significant) regularities in patterns of results that would provide a definitive answer to the question of what study characteristic consistently influenced the corresponding effect sizes (i.e., sign and magnitude of gender gaps) in any particular direction. Nevertheless, some of them were of great interest, especially when compared with the findings of previous meta-analyses.

For example, contrary to Whitley's (1997) finding of higher computer use by males of all age groups, we not only established a non-significant effect size with respect to this particular outcome type but also observed a tendency for lower (or even reversed in favour of women) effect sizes in older students (especially university graduates) in other categories of outcomes. Our findings also do not confirm Whitley's claim (echoed by Huang, 2013) that the gender gap in computer self-efficacy increases with age. A similar statement is found in Sanders (2006) regarding overall ICT-related gender differences. On the contrary, and somewhat similar to findings by Liao (1999), the graduate student, adults and participants in mixed-age groups in our review demonstrated more ICT confidence than younger samples. Perhaps new generations of students have simply outgrown this issue through the incredible availability and prevalence of various technological tools (especially mobile devices) in recent years.

In addition, we did find that specific contexts — whether particular technological tools and applications, concrete courses and programmes, or even times of data collection being directly linked to real educational experiences — produced lower effect sizes, possibly indicating that in familiar (expected) environments with some applied motivation, gender differences with respect to ICT tend to disappear. Scandinavian countries and the USA, on average, produced smaller effect sizes than broader (and likely less cohesive) groups of either Commonwealth or non-Commonwealth countries. Hopefully, upcoming research efforts will further advance our understanding of the factors that influence gender differences in ICT perception and use.

Does education matter? Can it exert sufficient influence to facilitate closing the gap and/or overcoming its undesirable consequences?

These questions were not part of the set originally conceived to guide this meta-analysis. However, some of the results patterns that emerged (especially in conjunction with some specific findings in previous research) gave us reasons to believe that addressing them is very important conceptually and may have great applied value.

First, consider what other research has established in connection with educational practice. Cam et al. (2016) reported ICT attitude effect sizes for in-service and pre-service teachers as low, $g^{+} = 0.040$ and $g^{+} = 0.023$, respectively. Tondeur et al. (2016) explicitly stated that according to their data collected from over 1100 university students, while women had less positive ICT attitudes in general, this difference virtually disappeared when technology was used for educational purposes. Baker and Aspray (2006), as reiterated in Kay

(2008), speculated that the existence of a digital gender gap might be partly explained by the fact that elementary school teachers — who are predominantly females with limited ICT exposure and experience —might be "poor role models for young girls" (p. 14) and thus propagate the stereotype.

In our meta-analysis, the field of education (as a specific subject) emerged as a strong moderator towards tightening the gap between male and female students in several outcome categories. As well, we found some confirmation of the observation by Tondeur and colleagues that the educational context in general (that is, across subjects but for the purposes of studying) also led to a reduction in the magnitude of the respective effect sizes. We also noticed that a large portion of the studies we reviewed at both the abstract and the full-text levels addressed populations of teachers. Though these studies were beyond the scope of the current meta-analysis, what role education may play in approaching the issue of a gender "digital divide" is of evident interest.

All of the above suggest that education is ahead of the curve in addressing gender differences with respect to ICT perception and use. The extent of teachers' impact on their students' attitudes and skills should be understood and comprehensively described by researchers to better inform the general public and help policy makers devise viable solutions (e.g., teacher training and professional development, awareness-raising interventions, practice-oriented activities embedded in curricula, and like measures) for successfully overcoming the undesirable consequences of an ICT-related gender gap.

? *What are the points of special interest on which future research into the issue of gender-related differences in ICT perception and use should focus?*

With respect to the questions in the previous subsection, we have already mentioned the high potential of studies conducted on samples of educators. Those not included in the current meta-analysis could form a solid foundation for another independent systematic review specifically dedicated to teacher populations.

Special attention needs to be paid to the issue of the role played by gender stereotypes not only in lay perceptions but also in research practices. There are indicators of such a need in many previously conducted meta-analyses. In fact, whenever researchers accounted for a very specific outcome type of "gender beliefs," the effect sizes reflecting differences between men and women were among the highest. We have already mentioned that Liao (1999) found the only significant effect size in that study to be $g^{+} = 0.193$ (which largely determined the overall average of that meta-analysis), for measures subsumed under the category of "sex-related stereotypes." Whitley (1997) reported even higher effects (between 0.44 and 0.67) for what was described as "sex biases" about computer-based technology. Similarly, Cai et al. (2016) named "sex-role stereotypes" as contributors to the overall tendency for women to hold less positive ICT beliefs and expectations than men. Not only the media, as Sanders (2006) duly noted, but also academic research continues to insist that the gender gap in ICT exists and is detrimental for society.

Is it possible then that we are in part dealing with some form of "self-fulfilling prophecy"? Could respondents to numerous similarly constructed surveys perhaps involuntarily reflect in their self-reports not only what is, but also what is expected? Further research (including in-depth qualitative studies) may shed some light on this issue, but researchers themselves are also responsible for designing better assessment tools (see a much earlier expression of this concern by Kay, 1992) to systematically analyse the most representative data and carefully and transparently report their research findings.

4.0 SYSTEMATIC REVIEW OF POLICY DOCUMENTS

This section of the report presents a systematic descriptive review of governmental policy documents with respect to action plans and regulations that are envisioned or in place across regions of the Commonwealth, as well as in the United States and Scandinavian countries. This review aimed to explore the following research questions:

1. What policies regarding gender and ICT in education are in effect (and/or being planned) in Commonwealth countries, the USA, or one of the Scandinavian countries (as reference points)?
2. Do action plans exist, and are specific policies implemented to bridge the gender gap, so as to empower women through ICT educational practices?
3. What differences and/or similarities in educational policies with respect to the issue of gender and ICT exist among Commonwealth countries in various regions (e.g., Europe, Asia, etc.)?

4.1 Introduction to the Policy Documents Review

Whether or not empirical data confirm the existence of the "digital gender gap" (Losh, 2004) and irrespective of the magnitude of that gap (see this report's section on the outcomes of the meta-analysis), the goal of ensuring that female and male students benefit equally from the advantages of ICT in general, and educational technology in particular, in their academic and professional experiences is commendable and is expected to guide the policies and practices of governments and institutions around the world.

UNESCO has taken a lead in promoting ICT education for women and girls (UNESCO, 2015) and recently released a document entitled *Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM)*, in which they describe the current status of young women's participation and progress in STEM education (UNESCO, 2017a). The report is positioned in support of UNESCO's 17 Sustainable Development Goals to Transform our World (UNESCO, 2017b), specifically with respect to Quality Education (Goal 4) and Gender Equality (Goal 5). The 17 development goals are in turn a continuation and further development of the United Nations' original Millennium Development Goals (United Nations General Assembly, 2000), which first resolved that women's economic development must be at the heart of any poverty eradication initiative.

As such, many actions suggested in these UN documents deal directly with empowering women for higher and more productive involvement with ICT-related fields of study and career. For these policies to succeed, it is important to pay attention to the factors that may interfere with achieving the goal of equality and subsequently not only consider women as recipients of help but actively involve them (their knowledge and expertise) in policy design and implementation, and place them in decision-making positions. Motivation to actively use ICT may come for women from realising its importance for their own projects and activities that are already at the core of their interests. If technology may help in achieving goals of personal importance, then using it presents less of a challenge, with less anxiety and greater perceived satisfaction. This approach could be described as a typical "bottom-up" applied tactic. On the other hand, "top-down" strategies for fostering equality in ICT perception and use would incorporate employing ICT (e.g., the Internet) to explain the nuances of policies and intervention programmes for gender equality, as well as to disseminate information about their impact (including objective research and individual feedback) and recruit participants and supporters. Special attention should be paid to the financial and infrastructure-related components of the policies. UNESCO (2015) promotes budgeting and funding allocation for specific projects supporting women's engagement with ICT education and development. Also emphasised are the implications for educational systems, which include the need for considerable transformation with respect not only to the integration of constantly advancing technology but also related changes to curricular development and pedagogical theory and practice (e.g., to focus on critical thinking, creativity, interdisciplinary content and student-centred learning experiences).

In the following review of government policy documents, we try to recognise and pay specific attention to the qualities of governmental policies and practices outlined in Education 2030, but we also rely on several of our previous reviews of policy documents in related areas of education when interpreting and evaluating policy (Borokhovski et al., 2011; Tamim, Borokhovski, Pickup, & Bernard, 2015).

4.2 Methodology

Various methods for synthesising qualitative research exist (see Bethel & Bernard, 2010 for an overview). The main idea behind most of them is to systematically identify recurrent themes, categories of variables and findings to establish and explain meaningful relationships among them.

For the purposes of the current project, two reviewers independently checked documents specifically for:

1. policies/plans to encourage girls/women to study in ICT-related fields;
2. policies meant to ensure gender equity in ICT education; and
3. policies/plans meant to assess any gender gaps in the ICT domain.

These independent observations were compared and documented as either most frequently consistent categories or as unique but potentially most influential open-entry descriptions. As a result, in addition to enabling summaries of qualitative findings, this systematic coding informed our meta-analysis by pinpointing important moderator variables, as suggested, for example, by the EPPI-Centre.

SEARCH STRATEGY AND OUTCOMES

Several strategies were employed to locate government policy documents from within Commonwealth Member States that pertained to the encouragement and promotion of women in the ICT field. In addition to Commonwealth countries, to explore points of comparison, searches were also conducted to locate relevant policies from the United States and Scandinavian countries.

First, the websites of national governments were searched, along with any subsidiary department or ministry websites in related domains (e.g., Ministry of Information Technology, Department of Education, Office on the Status of Women). Due to a lack of advanced search features, these searches were kept simple — for example, any of the terms (ICT OR computers OR "information technology") paired with (women OR girls OR gender). Searches were conducted in English, and while most countries had at least portions of their websites available in English, in some cases it was not possible to delve very deeply, and policies not translated into English may have been missed.

Second, these same websites were browsed for links to "policy," "resources," "acts/laws" and/or "documents." Policy documents related to ICT more generally were downloaded and searched for the terms "women," "girls" and/or "gender," and if these words appeared, the policy documents were retained for more detailed review.

Third, the Google search engine was used to conduct additional searches for policy documents by country, with the first five pages of results (an arbitrary cut-off point, owing to both declining relevance of the results and time constraints) checked for relevant policy documents. Each country was searched for separately — for example:

> Kenya government policy (women OR girls) ("information technology" OR computers OR ICT)

We considered sources under review potentially relevant and informative if they:

1. contained direct links to government websites;
2. reported specific information on the topic of women in ICT (including, for instance, evaluation reports by some third party); or
3. presented a press release or news story touching on the topic of women and ICT.

In the latter two cases, results were checked for mentions of explicit government policies; when identified by name, these policies were searched for in Google directly in an attempt to locate them for inclusion in our review. Some press releases/blog posts were retained for further review if they were considered to include sufficient detail about action items generated by the policy. Assessment reports and general news stories were not retained for additional review, as the intention of this report was to review policy documents only.

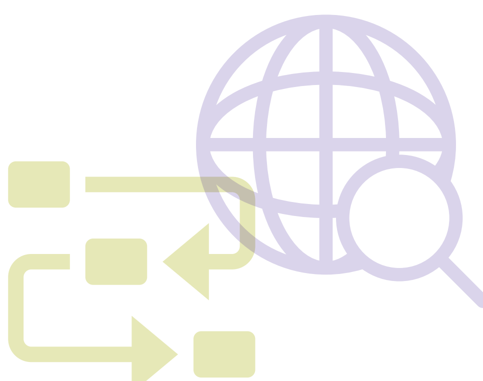


Table 7

Policy Documents Retrieved for Review, by Country

COUNTRY BY REGION	DOCUMENTS RETRIEVED
Africa	
Botswana	1
Cameroon	–
The Gambia	–
Ghana	–
Kenya	3
Lesotho	2
Malawi	3
Mauritius	2
Mozambique	–
Namibia	1
Nigeria	1
Rwanda	3
Seychelles	2
Sierra Leone	–
South Africa	2
Swaziland	2
Tanzania	1
Uganda	2
Zambia	2
Asia	
Bangladesh	1
Brunei Darussalam	–
India	3
Malaysia	1
Pakistan	2
Singapore	–
Sri Lanka	1
Caribbean and Americas	
Antigua and Barbuda	–
The Bahamas	–
Barbados	–

Belize	1
Canada	9
Dominica	–
Grenada	1
Guyana	2
Jamaica	2
St. Kitts and Nevis	1
Saint Lucia	2
St. Vincent and the Grenadines	1
Trinidad and Tobago	1
United States	8
Europe	
Cyprus	–
Denmark	1
Finland	1
Iceland	–
Malta	2
Norway	1
Sweden	2
United Kingdom	4
Pacific	
Australia	8
Fiji	1
Kiribati	–
Nauru	–
New Zealand	1
Papua New Guinea	1
Samoa	1
Solomon Islands	1
Tonga	–
Tuvalu	–
Vanuatu	–
TOTAL	**87**

INCLUSION CRITERIA

To qualify as a policy, the documents were either released on ministries' websites pertaining to women's issues and/or ICT, or they were a government press release/blog with details about the policy, or they were descriptions of a programme that started as a policy and evolved into a running programme. For example, Digital Canada 150 (2014), was not included as it largely reported on why fewer women than men study science and enter the IT sector, and although the report included recommendations, there was no indication of resulting policy supports. Similarly, and also from Canada, Lord and Martell (2004) focused on job training for low-income women in Nova Scotia and provided recommendations that included transitional programmes with mentoring support, but there was no indication that the report resulted in specific policy changes. Of the 87 documents retrieved for review, 65 were ultimately included in the study.[4]

CODING CATEGORIES FOR THE REVIEW OF POLICY DOCUMENTS

Each of the identified policy documents was reviewed and coded to reflect the following categories of characteristics.

Focus. The beginning point of our review was to identify and describe the reviewed documents' degree of relevance to the issue of gender and ICT as the main area of interest. We distinguished policies that:

1. focused on gender equality (especially in education) with some elements addressing ICT;
2. were devoted primarily to ICT practices and developments, with some gender issues addressed; or
3. balanced both issues in joint coordinated approaches.

Other types of documents (i.e., in which either of the main two topics was entirely absent) were excluded from further consideration.

Policy status. Policies were coded to reflect whether they were:

1. in effect;
2. planned (announced or under development); or
3. reflections on the current state of affairs (e.g., relevant statistical data describing effects of the policy implementation or other means of policy/practice evaluation).

Education level. The principal education level addressed by the policy was coded:

1. kindergarten and elementary school;
2. high school;
3. undergraduate;
4. graduate;
5. adult education; or
6. vocational education (training, professional improvement, remediation, workforce reintegration, etc., specifying which one in an open-entry format).

Outcome type. Where possible, we coded for intended outcomes — data available on expectations, targets, focus of attention of each particular policy/practice. Whenever possible, described outcomes were matched to the four major outcome types of the meta-analysis.

Monitoring (effectiveness evaluation, feedback). Policies were coded to indicate whether follow-up or monitoring procedures were in place (yes/no), with evaluation procedures described in an open-ended form.

Support for policy implementation. Whether or not, and to what degree, infrastructure, training, dedicated professionals, financial resources, etc. were provided in support of the policy.

Geographic specificity. Whether the policy is relatively unique (a specific initiative) for the country/region or is implemented in compliance with some broader international (e.g., UN) policy.

Time frame. When the policy was initiated, to what date preliminary and final actions/goals are set, and by what time the effect of implementation is expected to show.

[4] http://hdl.handle.net/11599/3089

4.3 Results of Policy Review and Coding

This section summarises the results of our review of identified policy documents according to their major qualities (characteristics) as outlined in the method section above.

POLICY FOCUS

Table 8 provides the frequencies of the policy documents' focus (ICT-focused, gender-focused, or "balanced") organised by region. Information and telecommunication policies that addressed gender equity or women's inclusion in the industry were by far the most frequent.

Table 8

Summary of Policy Focus by Region

Countries by Region	Balanced ICT Gender Policy	ICT Policy with Mention of Gender	Gender Policy with Mention of ICT
Africa	1	16	4
Asia	–	6	1
Caribbean & Americas	4	8	1
Europe	–	3	–
Pacific	5	3	4
Scandinavia	–	3	1
United States	3	2	–

Balanced ICT gender policy. Rwanda's *Vision 2020* (Republic of Rwanda Ministry of Education, 2000) is a broad government policy "to develop a new Vision for Rwanda and translate it into an achievable programme based on 6 pillars" (p. 6). Among them, one is gender and one is ICT. They are dealt with as separate topics rather than in unison, but both are addressed in some detail. Another example policy, from Papua New Guinea, provides scholarships to girls in Grade 12 planning to continue in ICT education (National Information and Communications Technology Authority, 2014). The Guyana Ministry of Public Telecommunications (2018) advanced a policy that "is taking a sustained approach to training more Guyanese girls and women in the area of Information and Communications Technology" (para. 1). The ministry further describes a special programme: "Guyanese Girls Code is a free 12-week course designed to teach Guyanese girls . . . beginners coding/programming. The goal of this initiative is to address the gender disparity in Guyana's ICT sector where women and girls remain underrepresented" (para. 3).

ICT policy with mention of gender. Business and/or industry agendas, mainly national telecommunications policies, that accounted for gender equity were coded as ICT policies with mention of gender. A good example is provided by Swaziland's *National Information and Infrastructure and Communication Policy* (Kingdom of Swaziland Ministry of Information, Communications & Technology, 2012), which though heavily focused on communications policy mentions women throughout the document — for example: "[i]n the design of ICT projects within the plan, gender balance will be ensured so as to raise the level of awareness on the role, use, application and potential of ICT in gender empowerment and meeting specific developmental needs of women" (p. 17). A more typical example is offered by Pakistan's *Digital Pakistan Policy 2017*, which details the nation's digital infrastructure and includes a section briefly addressing "Youth, Women and Girls empowerment using IT," in which they call for "specific ICT for Girls' programmes for imparting quality trainings in computer skills, including software coding, across the country to reduce inequalities, provide decent work and promote economic growth" (Government of Pakistan Ministry of Information Technology, 2017, p. 7). The Government of the Republic of Trinidad and Tobago (2017) offers a well-written policy with a clear plan and objectives. The main challenges and areas of progress are addressed. There is reference to reflections on past policies as well as global ICT trends. The policy covers strategies and programmes, and has an implementation road map as well as a plan for monitoring and assessing progress. However, gender is mentioned only once, under a strategy for increasing human capacity, in one of five bullets referring to implementing an annual Girls in ICT day.

Gender policy with mention of ICT. These were generally career-oriented policies, such as policies encouraging girls and women into STEM fields. For instance, Jamaica's *Vision 2030 National Development Plan: Gender Sector Plan* (Government of Jamaica, 2010) includes only a brief mention of ICT training as a desirable outcome. Similar examples are provided by the *Fiji National Gender Policy*, which includes one short section mentioning women's access to information technology (Fiji Government Ministry for Social Welfare, Women & Poverty Alleviation, 2014, p. 17), and South Africa's *National Policy Framework for Women's Empowerment and Gender Equality* (Office of the Status of Women, 1992), which frames the issue more in terms of access to communications technology rather than ICT use.

POLICY STATUS

Retrieved policy documents were coded as to whether the policy was currently in effect, planned but not yet implemented, or partially implemented (combination); see Table 9. Nearly twice as many were planned as were currently in effect.

Table 9

Summary of Policy Status by Region

Countries by Region	In Effect	Planned	Combination
Africa	2	19	–
Asia	2	5	–
Caribbean & Americas	5	7	1
Europe	2	1	–
Pacific	9	2	1
Scandinavia	2	2	–
United States	1	4	–

EDUCATION LEVEL

Studies were coded with regard to the education level(s) addressed in the policy. As can be seen in Table 10, the policies were heavily skewed towards older populations, with few addressing younger populations.

Table 10

Summary of Education Levels Addressed in Policy, by Region

Countries by Region	K–6	7–12	Undergrad	Graduate	Adult	Across	Vocational
Africa	–	–	–	–	3	3	15
Asia	–	–	–	–	5	–	2
Caribbean & Americas	–	1	–	–	8	2	2
Europe	–	–	–	–	–	1	2
Pacific	–	–	1	–	5	2	4
United States	–	–	–	–	2	3	–
Scandinavia	–	–	–	–	–	–	4

OUTCOME TYPES

As evidenced by Table 11, the intended outcomes of the policies collected were almost exclusively focused on increasing actual use of ICT. Two policies from Africa addressed computer anxiety (confidence to use) in addition to actual use of ICT as outcomes (Republic of Rwanda Ministry of Education, 2008; Seychelles Ministry of Education, 2014). One study included an outcome we had not intended to code for: awareness (Samoa Ministry of Communications and Information Technology, 2012). Namely, they would "[w]ork in collaboration with existing community groups, such as churches, women's groups, seniors, schools and libraries to provide outreach to their constituents in raising the awareness of ICT benefits, and provide opportunities for hands-on training" (p. 12).

Table 11

Summary of Policy Outcome Types by Region

Countries by Region	Attitudes	Confidence	Intent to Use	Actual ICT Use
Africa	–	2	–	21
Asia	–	–	–	7
Caribbean & Americas	–	–	–	13
Europe	–	–	–	3
Pacific	–	–	–	11
Scandinavia	–	–	–	4
United States	–	–	–	5

MONITORING

While some policies had no mention of any monitoring procedures, most provided information about the evaluation and monitoring of the policy. This information was either general or specific as to measures and steps to be taken (see Table 12).

Table 12

Summary of Policy Monitoring Procedures by Region

Countries by Region	Unknown	Yes	Specific Measures	Non-specific Measures
Africa	1	20	13	7
Asia	–	7	2	5
Caribbean & Americas	5	8	5	3
Europe	–	3	3	–
Pacific	7	5	4	1
Scandinavia	1	3	3	–
United States	4	1	1	–

POLICY SUPPORT

As expected, various government policies did stipulate an array of supports, both financial and tangible, to back up policy goals, with the most emphasis being given to budgeting and training. Most policies provided more than one type of support. Finance includes funding, incentives and scholarships. Training includes mentoring, coaching and counseling. Infrastructure includes facilities, materials and resources. Frequencies with respect to these policy components are reflected in Table 13.

Table 13

Summary of Policy Support(s) by Region

Countries by Region	Finance	Training	Infrastructure	Administrative	Unknown
Africa	16	19	10	8	1
Asia	5	6	1	–	–
Caribbean & Americas	7	12	4	1	–
Europe	3	3	2	–	–
Pacific	7	8	4	1	–
Scandinavia	4	3	1	1	–
United States	3	2	3	–	2

A good example of administrative support comes from the *Lesotho Science & Technology Policy 2006–2011* (Kingdom of Lesotho, 2007), which stipulates that the government will propose regulations in consultation with stakeholders, and that the "operation of the civil service, government, through relevant ministries, will identify from time to time scarce S&T skills and introduce provisions for premium packages to encourage such disciplines" (p. 49). With regards to training to support implementation, a number of policies addressed this through career counselling (Republic of Zambia, 1996), coaching (Australian Government Digital Transformation Agency, 2018) or mentoring (Government of New Zealand, 2017).

The government of Malta's *Digital Malta* strategy meanwhile emphasises the need for supportive infrastructure throughout the strategy, and with regards to eLearning in particular notes that a "complete ICT infrastructure will be provided for educators, students and parents, encouraging a digital mindset and widening learning opportunities" (Government of Malta, 2014, p. 45).

GEOGRAPHIC SPECIFICITY

Despite our best efforts to find in the reviewed documents information pertaining to what policies or practices outside of individual countries had inspired or encouraged the development of the local policies (e.g., in compliance with some broader international or regional policy), this was not available. Even more interesting would have been information about collaboration or coordination between different countries or regions, but this was also missing.

POLICY TIME FRAME

Most policies had a clear time frame with beginning and end dates; of those, some were dated, whereas others had a final moving-target action plan or were still running. Most of the policies with a moving target were in line with a bigger government vision policy. The category of unknown time frame includes those policies that either had no mention of a timeline or were missing information regarding either the start or end date. Please, refer to Table 14 for the respective frequency counts.

Table 14

Summary of Policy Time Frame by Region

Countries by Region	Dated	Moving Target	Running	Unknown
Africa	6	8	1	6
Asia	4	1	–	2
Caribbean & Americas	4	5	2	2
Europe	–	2	1	–
Pacific	3	3	6	–
Scandinavia	–	2	–	2
United States	–	1	–	4

4.4 Standout Policies and Regional Comparisons

Of the 65 policy documents reviewed, a number stood out as particularly noteworthy due to the level of detail provided, the tangible supports offered for implementation or the innovative approaches taken to address gender equity and the participation of girls/women.

COMMONWEALTH NATIONS

A number of documents stood out as being particularly good overall examples of detailed policies and initiatives. The Government of Trinidad and Tobago's (2017) *fastforward II, a Draft National ICT Plan 2017–2021* is a well-written policy with a clear plan and objectives. Main areas of progress and challenges are addressed. There is reference to reflections on past policies as well as global ICT trends. The policy covers strategies and programmes, and it has an implementation road map as well as plans to monitor and assess progress. The policy even mentions green ICT and societal benefits. However, gender (girls) is mentioned only once, with respect to a strategy to increase human capacity, in one line referring to implementing an annual Girls in ICT day.

The Government of Malta's (2014) *Digital Malta: National Digital Strategy 2014–2020* offers a well-presented ICT policy that starts off with addressing challenges and opportunities. It targets citizens, business and government. It also focuses on infrastructure and human capital. The policy clearly lists its goals, principles and actions for each item. It also has a section on attaining the vision and measuring its success. As for gender, it addresses access to all, minimising gender imbalance in general. The 80-page document also has one bullet (1/7) under strengthening the workforce, mentioning increasing female participation.

The Government of the United Kingdom's (2017) *UK Digital Strategy 2017* provides a different calibre of digital policy that is quite forward thinking in its goals. The policy not only addresses the usual issues of infrastructure, skills, government and inclusion but also focuses on a higher level of digital business, as well as cloud computing and virtual reality. It notes that women lack representation in "digital roles" and offers a number of specific programmes to address this issue.

The Australian government's (2017) *Towards 2025: A Strategy to Boost Australian Women's Workforce Participation* is a well-outlined policy that not only deals with women in the workforce, with special attention to STEM, but also identifies six groups of women who experience different or greater barriers to participating in the labour force: Aboriginal and Torres Strait Islander women, culturally and linguistically diverse women, mature-age women, rural and regional women, women with disabilities, and young women. The policy presents the current status and then gives action plans as well as describing programmes that address various needs — for example, an expansion of the Science in Australia Gender Equity (SAGE) pilot project.

SCANDINAVIA

In addition to reviewing policies developed by Commonwealth Member States, an essential component of the mandate for this review was to compare how the Commonwealth performed in comparison with another groups of nations, the Scandinavian countries, which are popularly held to be on the cutting edge of gender equity. We did not in fact come across very many documents, though limiting the searches to English may have been a factor here. Nevertheless, the Government Offices of Sweden's (2011) *ICT for Everyone — A Digital Agenda for Sweden* offered a different calibre of ICT policy. When gender is addressed, it is to be involved not only in the workforce but in decision making and key contributions: "[t]here is a need for more women to be involved in making decisions and to take part in the development of digitization and its capabilities" (p. 53). It addresses the role of ICT in societal development and in democracy.

In contrast, the Norwegian Ministry of Government Administration, Reform and Church Affair's (2012) *Digital Agenda for Norway: ICT for Growth and Value Creation* did not specifically address gender issues, though it did provide a detailed plan for improving the nation's digital infrastructure, listing inclusion as a key priority:

> [o]ne of the key priorities in the ICT policy is increased digital competence and inclusion. From primary education up through all life phases, digital competence shall be improved to ensure inclusion to and confidence in digital solutions. The universal design of ICT is based on the idea that digital services should be accessible to everyone, regardless of age, functional ability or level of education, and is a key element of the Government's ICT policy (p. 25)

For Finland, we found only a policy from the Ministry of Foreign Affairs of Finland (2005) that focused its policies on "support[ing] developing countries' access to new information and communication technology (ICT), promot[ing] efforts toward bridging the digital divide, and in cooperation with the private sector and the developing countries themselves, seek[ing] ICT solutions that suit the poorest countries" (p. 5).

The European Parliament Directorate-General for Internal Policies (2015) focused on gender equality in Denmark for both women and men, noting both are underrepresented in many domains. Three programmes launched in 2011 are highlighted: *The Future is Yours*, which promoted non-traditional educational choices overall, *Practice as a Problem Solver*, which encouraged girls to pursue natural sciences and technology education, and *Change Your Job, Not Your Gender*, intended to stimulate interest among unemployed men from traditionally masculine professions in the private sector to seek public-sector jobs with a more traditional female representation.

UNITED STATES

As part of the mandate of this review, we further sought to find out how Commonwealth nations compared to the United States in terms of policies offered. We found no specific gender policies in US documents, though we did find mention of running programmes that focused on STEM (National Science and Technology Council Committee on STEM Education, 2013) and/or entrepreneurship (115th Congress of the United States, 2018; National Science Foundation, 2013). One reviewed document that addressed gender with a focus on marginalised girls/women in particular (Jarrett, 2015) was a posting on the White House blog that did not reference any specific policy document. It did, however, indicate that the US Department of Education would be offering policy guidance to ensure equal access to career technical education (CTE) programmes; that the Departments of Energy and Education would be expanding a mentoring programme that links STEM professionals with marginalised students; and that the National Science Foundation would partner with several other groups to create a new web portal aiming to expand girls' access to CTE programmes (as well as STEM programmes).

4.5 Overall Observations

In general, policies seemed to fall into several types of documents. First, there are what we would describe as start-up policies — that is, policies where the government is setting up the country to catch up to the digital age. There is a need to build the whole digital infrastructure and to provide digital training and resources for the workforce (e.g., Government of Grenada, 2006; Government of Malawi, 2006; Kingdom of Lesotho, 2005). Second, there are follow-up policies that update a previous existing policy and look into the progress and challenges faced (e.g., Government of Malta, 2014; Government of the Republic of Trinidad and Tobago, 2017). Third, there are specifically described programmes that are a result of policies that have been implemented and are now actual, running programmes. Finally, there are higher level documents, policies for an already digital nation where a higher standard of infrastructure and values is expected and desirable (e.g., Australian Government, 2017; Government of New Zealand, 2017; Government of Sweden, 2011; Norwegian Ministry of Government Administration, Reform and Church Affairs, 2012).

With regard to how gender is addressed, there were several recurring ways in which this element was presented in the reviewed documents:

- In a separate gender policy to deal with a variety of inequalities in society, from health care, to workplace equity, to domestic violence.
- Acknowledged in ICT policies and specifically addressed. There is awareness of the disparity, and measures are taken to deal with it.
- The concept of access for all when society is viewed as a unit. Access for all is inclusive of young and old, male and female, immigrant and non-immigrant, able or disabled. In this case, female gender does not stand out on its own (e.g., European Parliament Directorate-General for Internal Policies, 2015).
- Marginalised groups within a gender: where sub-groups of women are addressed (e.g., Australian Government, 2017; Jarrett, 2015).

It seems that the difference in the category of a policy and the way gender is addressed is related to the level of economic and cultural standards in a society. Nations with stronger economic standings are naturally ahead in the digital race, and this is reflected in their policies. Also, societies that have culturally moved on to embrace women's contribution to decision making in the workforce, in the public domain and at a domestic level have a different way of addressing gender inequality than those that have not. Table 15 concludes the review with a more detailed breakdown of the reviewed documents in terms of policy focus, within individual Commonwealth nations, the USA, and Scandinavian countries.

Table 15

Summary of Policies by Region and Focus

Countries by Region	Total Number of Policies	Policy Focus		
		Balanced	ICT	Gender
Africa	**21**	**1**	**16**	**4**
Lesotho	2	–	2	–
Malawi	3	–	3	–
Mauritius	1	–	1	–
Nigeria	1	–	1	–
Rwanda	3	1	1	1
Seychelles	3	–	3	–
South Africa	2	–	–	2
Swaziland	2	–	1	1
Tanzania	1	–	1	–
Uganda	2	–	2	–
Zambia	1	–	1	–
Asia	**7**	**–**	**6**	**1**
Bangladesh	1	–	1	–
India	3	–	2	1
Pakistan	2	–	2	–
Sri Lanka	1	–	1	–
Caribbean & Americas	**13**	**4**	**8**	**1**
Canada	3	1	2	–
Grenada	1	–	1	–
Guyana	2	1	1	–
Jamaica	2	–	1	1
St. Kitts and Nevis	1	–	1	–
Saint Lucia	2	1	1	–
Saint Vincent and the Grenadines	1	1	–	–
Trinidad and Tobago	1	–	1	–

Europe	**3**	**–**	**3**	**–**
Malta	1	–	1	–
United Kingdom	2	–	2	–
Pacific	**12**	**5**	**3**	**4**
Australia	7	4	–	3
Fiji	1	–	–	1
New Zealand	1	–	1	–
Papua New Guinea	1	1	–	–
Samoa	1	–	1	–
Solomon Islands	1	–	1	–
Scandinavian Countries	**4**	**–**	**3**	**1**
Denmark	1	–	–	1
Finland	1	–	1	–
Norway	1	–	1	–
Sweden	1	–	1	–
United States	**5**	**3**	**2**	**–**

DISCUSSION

Drawing firm conclusions from a collection of documents so diverse in scope and focus as those in our systematic review of policy documents presents a serious challenge. Nevertheless, some worthwhile observations were made. We summarise them as follows.

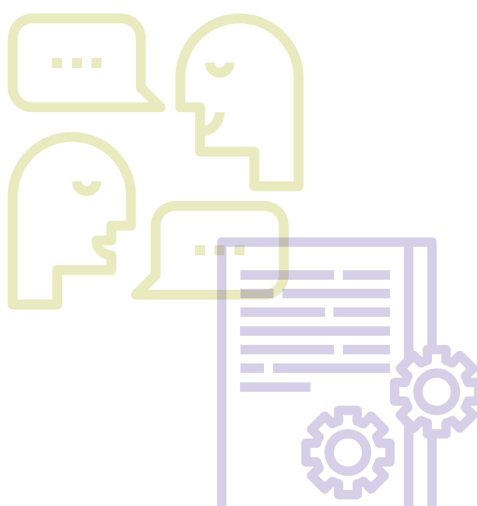
We discovered few policies that specifically and fully addressed the main topic of research by accounting more or less equally for issues of gender and ICT in conjunction (what we called balanced policies). Most of the reviewed documents presented some general (tele) communication policies of various governments that included a section where gender equity and/or women as a specific target population were mentioned, or they were gender equality policies with brief references to promoting ICT as a field of study/employment for women.

Where gender equity was addressed, it was often aspirational in language or pro forma as a desirable goal, but with no specified outcomes with which to measure progress. Likewise, policies generally lacked detailed specifics in terms of how policy goals might be achieved — for instance, in terms of funds budgeted, committees/agencies created to support or maintain goals, etc. Most documents described plans for future programmes/policies, with a much smaller number reporting on policies in effect and describing evaluations of their effectiveness. Policies also tended to be highly skewed towards older populations, primarily addressing employment needs (i.e., college-to-work transitions, job training and retraining), and did not address the issue at earlier stages of education (i.e., K–12 formal educational settings).

A number of outstanding (i.e., balanced and comprehensive) policies emerged, one notable example being the United Kingdom's *UK Digital Strategy 2017*, which not only addressed the issues of infrastructure and skills training but also focused on achieving a higher level of digital business, cloud computing and virtual reality. It noted that women lack representation in "digital roles" and subsequently presented a number of specific programmes to address this issue. Another interesting example of a more balanced policy approach came from Denmark: *The Future is Yours 2011* programme promoted non-traditional educational choices overall, while *Practice as a Problem Solver* encouraged girls to pursue natural sciences and technology education, and *Change Your Job, Not Your Gender* was intended to stimulate interest among unemployed men from traditionally masculine professions to seek jobs with traditionally higher female representation.

It is also the intention of this report to compare how Member States of the Commonwealth compared with the Scandinavian countries and the United States in terms of policies developed. Unfortunately, the small number of policies prevented us from formulating definitive conclusions. However, the Scandinavian policies, though few in number, did seem to originate from a more progressive baseline — for example, assuming gender equity in a push for more general inclusion, or addressing the digital divide and promoting equity values as a foreign policy in other countries. With regards to the United States, actual policy documents were difficult to locate, though public relations statements and blog posts on the official White House website did reveal support for the goal of seeing more women working in ICT fields.

All countries, it seems, could do a better job formulating concrete policies, with specific deliverables, support mechanisms and assessment criteria provided, to address the issue of gender equality in ICT perception and use, and possibly moving beyond it to include rising interest in the issue from the perspective of the LGBT community.



5.0 CONCLUSIONS

Two systematic reviews, undertaken to address the major questions of the current research project, were based on a simple premise that due to the undeniable importance of ICT in modern society, ensuring its acceptance and effective use by all learners indiscriminately is not only fair but also extremely beneficial. Indeed, the importance of information and communications technology for the learning outcomes of students across academic levels and fields of study has been vastly documented in primary empirical research and meta-analyses alike (e.g., Bernard, Borokhovski, Schmid, & Tamim, 2018; Tamim et al., 2011).

Constantly advancing in functionality and interactivity, technological tools and applications increase access to education through distance, blended, and mobile learning (e.g., Bernard et al., 2004, 2014; Bernard, Borokhovski, & Tamim, 2014; Means, Toyoma, Murphy, & Baki, 2013; Sung, Yang, & Lee, 2017; Tamim et al., 2015), support students' cognition (Belland, Walker, Kim, & Lefler, 2017; Cobb, 1997; Schmid et al., 2014), facilitate interactions of all kinds (Anderson, 2003; Bernard et al., 2009), promote more meaningful science education by employing computer simulations (e.g., D'Angelo, Rutstein, & Harris, 2014) and serious games (e.g., Clark, Tanner-Smith, & Killingsworth, 2016), engage learners in critical discourse or enable more student control over the learning process (e.g., Karich, Burns, & Maki, 2014; Kulik & Fletcher, 2016) and more, thus laying a foundation for further successes in life, both professionally and socially.

Under these conditions, it is even more critical with respect to advances in educational technology to make sure that they are equally beneficial for all students, regardless of grade level, race, ethnicity, cultural background, socio-economic status and especially gender. Men's and women's different attitudes toward using ICT tools and applications play a key role during learning and when making career choices (e.g., Buche et al., 2007; Huang et al., 2015). Uncovering the dynamics between gender and students' ICT usage and perceptions is vital because there is an impression of the persistent pattern of fewer women enrolling in educational programmes and seeking professional careers in ICT-related fields (OECD, 2017). The research summarised in this report is intended to contribute to our understanding of the origins of this issue and hopefully will assist in overcoming the undesirable consequences of that gender gap. To that end, we conducted:

1. a meta-analysis of primary research that compares perception and actual ICT use by female and male students; and
2. a systematic review of policy documents in Commonwealth Member States, the USA and Scandinavian countries with respect to the issue of gender equality in ICT.

The results of both are presented in detail in the corresponding sections of this report.

In conclusion, we would like to highlight the most interesting findings, especially when they agree in describing the current status and envisioning trends in research and practice with respect to gender and ICT. Quantitative outcomes of the meta-analysis resulted from measurements (though of variable psychometric quality) collected in real educational settings from female and male students, whereas discoveries from the systematic review of policy documents are consistent observations made by the reviewers. But when the findings from these two efforts converge, their suggestive power rises considerably.

Both reviews seem to concur with each other’s findings that the gender gap in perceptions of ICT and especially in the use of ICT in education is closing. The meta-analysis found the effect size for actual ICT use to be statistically non-significant, though the difference between male and female students’ attitudes toward ICT persists, with the highest effect being in computer confidence and self-efficacy. However, these effects are distributed unevenly among grade levels, subjects and geographic regions. The latter is quite evident not only from the findings of the moderator variable analyses in our quantitative synthesis, but also from the review of policy documents derived from different countries, where policies and practices in the Scandinavian region in particular seem to reflect more gender-balanced realities — even to the point that, for instance, the Danish government has introduced policies to encourage men (as much as women) to consider less stereotypical jobs, including those in the ICT sector.

In both reviews, a somewhat similar issue of quality of evaluations emerged. The meta-analysis noted the persistent problem of unevenly reliable assessment tools, and the systematic review expressed serious concern about the lack of details regarding assessing the effectiveness of policies. Apparently, both researchers and policy makers need to do a better job of defining outcomes and monitoring trends in their respective fields. Though the following observation may be perceived as a somewhat speculative stretch, we could not ignore that more advanced students (university graduates) demonstrated much smaller gender-based differences in ICT perceptions and use, pretty much as more developed countries exhibited more balanced policies with respect to gender and ICT. It should also be noted that while most policies addressed older populations (adults, university students), the meta-analysis found these age groups the least likely to experience a gender gap. Policy makers may wish to direct future endeavours toward younger audiences.

Finally, though in both reviews we found some clear indications of the critical role education may and should play in overcoming the undesirable consequences of the gender digital divide, they were neither frequent nor specific enough to devise exact recommendations for practice. However, what could be a powerful take-away message from both reviews is the need for higher objectivity and transparency so as not to overstate the problem but rather to continue the search for balanced, evidence-based solutions.

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APPENDIX A: Meta-Analysis: Methodology Overview

A meta-analysis is a specific class of systematic review that relies on quantitative data from a multitude of primary studies addressing a common core research question. Meta-analysis summarises systematically collected effect sizes from individual studies to estimate either the magnitude of a difference between groups of interest (*d*-family effect size) or the degree of association between variables of interest (*r*-family effect size) in the entire population in question, and then tries to explain the variability that surrounds the overall effect size by systematically coding and analysing methodological, substantive and demographic moderator variables. The main research question (or a group of related research questions) should be stated and substantiated a priori to inform search strategies, to set up and describe inclusion criteria, and to meaningfully guide the review process through all its steps (for example, as outlined by Cooper, 2017) — from study selection, through effect-size extraction, aggregation and analyses, toward interpretation and presentation of the findings. Our meta-analysis takes exactly that approach, specific details of which are provided in the upcoming sections.

Meta-Analysis as Quantitative Synthesis

The basic metric and the unit of analysis in meta-analytical research is an effect size. Most frequently used in comparative studies in the social sciences in general, and especially in education, is the *d*-type effect size, which is the standardised difference between the means of two groups that are compared to each other on a consistent set of relevant outcomes. Below we provide basic equations used in typical comparative meta-analyses.

The *d*-type effect size (also known as Cohen's *d*) is the standardised mean difference between two groups (usually the treatment and the control, but non-interventional studies compare categories of participants, e.g., gender or geographical location), represented by $\overline{X}_E$ and $\overline{X}_C$, respectively in Equation 1:

$$d = \frac{\overline{X}_E - \overline{X}_C}{SD_{Pooled}}$$

Equation 1

The denominator is the pooled standard deviation (the weighted average of the standard deviations of the respective groups), or the standardisation term, calculated according to Equation 2:

$$SD_{Pooled} = \sqrt{\frac{(n_E - 1)SD_E^2 + (n_C - 1)SD_C^2}{(n_E - 1) + (n_C - 1)}}$$

Equation 2

An effect size of *d*-type can also be calculated or estimated from various inferential statistics, such as *t*-tests, *F*-ratios and/or associated *p*-values (exact or in relation to the preset alpha-levels), using an array of formulas (see, for example, Glass, McGaw, & Smith, 1981; Hedges, Shymansky, & Woodworth, 1989; Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014). Regardless of what specific formula is used, the sample size of both groups (or at least a total number of participants to be arbitrarily split in the most likely proportions) must be available, and for non-signed statistics, the direction of the effect must be indicated in the report to enable reasonably reliable effect-size extraction.

There is also a correction to Cohen's *d* for potential bias associated with small samples, known as Hedges' *g*. *Equation 3* is used to calculate it:

$$g \cong d\left(1 - \frac{3}{4N - 9}\right)$$

Equation 3

To enable weighting of individual effect sizes, taking into account the associated sample sizes (depicted as n_e and n_c, respectively), the standard error of *g* is calculated using *Equation 4*:

$$SE_g = \sqrt{\frac{1}{n_e} + \frac{1}{n_c} + \frac{g^2}{2(n_e + n_c)}}\left(1 - \frac{3}{4(n_e + n_c) - 9}\right)$$

Equation 4

Subsequently the 95% confidence intervals are constructed by applying *Equation 5*:

$$C.I. = g \pm (1.96 \cdot SE_g)$$

Equation 5

They are used to detect the statistical significance of individual *g*-values — if the *C.I.* contains zero, the effect size is not significant. Another way of assessing statistical significance is to calculate the corresponding value of the *z*-test and check it for significance using the normal distribution.

EFFECT-SIZE AGGREGATION

At the synthesis phase of a meta-analysis, to produce a truly representative overall average, effect sizes are weighted according to one of the two analytical models: (1) the fixed-effect model or (2) the random-effects model. Comprehensive descriptions of the conceptual underpinnings and procedural details of these two models can be found in the literature on meta-analysis (e.g., Borenstein, Hedges, Higgins, & Rothstein, 2009, 2010; Hedges & Olkin, 1985; Pigott, 2012).

Here we simply remind the reader that these two analytical models are based on different assumptions. The fixed-effect model assumes that treatments are uniform across studies and that the collection is exhaustive. The random-effects model, on the other hand, assumes a random selection of studies from similar but sufficiently diverse collections of treatments, settings and samples. Subsequently, the analytical procedures differ: in the fixed-effect model, the weight of each individual effect size is the inverse of the within study variance, whereas under the random-effects model, between study variance is added to within study variance, then the inverse is calculated and used to weigh individual effect size for proper aggregation.

For the purposes of the current review, we use the random-effects model, as it is more suitable for the great variety of samples, settings and contexts in the reviewed research. This overall analysis is followed by analyses of moderator variables according to the logic and rules of the mixed-effects model. The results then are reflected in the following metrics:

- g^+ represents the weighted average effect size for the entire collection (e.g., of all confidence outcomes) or a sub-collection of effects from the same level of a given moderator variable (e.g., for graduate university students);
- *k* depicts the number of cases (effect sizes) per category;
- $Q_{Between}$ is used to test differences in weighted average effect sizes representing different levels of moderator variables; in our report, it is always accompanied by the corresponding *p*-value (significance level).

For more detailed information about the procedures and statistics of a typical meta-analytical review, please see Bernard et al. (2014), Borenstein et al. (2009), Cooper, Hedges and Valentine (2009) and Lipsey and Wilson (2001), among many others.

LEARNING FOR SUSTAINABLE DEVELOPMENT

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