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Factorial invariance across gender of a perceived ICT literacy scale

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ABSTRACT

This study used the framework of multiple-group confirmatory factor analysis (MGCFA) to test the factorial invariance (configural, measurement, and structural invariance) of a newly developed three-factor, 17-item perceived information and communication technology (ICT) literacy scale (3F-PICTLS) across gender, which includes the three subscales of information literacy (information), internet literacy (communication), and computer literacy (technology). Using a stratified random sample of 825 secondary school students (396 males) with ages ranging from 11 to 16 (mean = 13.16, SD = .773), the scale showed configural and partial measurement invariance but not structural invariance across gender. These findings highlight the importance of measurement invariance as a methodological challenge for researchers who attempt to make meaningful comparisons and interpretations across gender in a variety of contexts in the scholarship of ICT in education, which is largely ignored in existing literature. From a practical standpoint, we discuss the implications for teachers to assess and promote ICT literacy for students of different genders. Taken together, this study provides new methodological and pragmatic insights into a greater understanding of the issue of gender differences in ICT literacy for researchers and practitioners.

1. Introduction

The use of information and communication technology (ICT) in education can enhance learning and teaching, and increase connections and exchange between school and home (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000; Ezziane, 2007; Kelly-Salinas, 2000). However, since using ICT in education requires certain degree of ICT literacy and devices to access, such as computers and internet access lines, the differences in ICT literacy between demographic groups have been the focus of research in recent years (Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008; Kim, Kil, & Shin, 2014; Luu & Freeman, 2011).

Gender among others remains a salient theme in ICT literacy research. Research on gender differences in ICT literacy has extra significance over the years since females consistently participate less than males in the science, technology, engineering, and mathematics (STEM) fields in school and workplace settings. For example, in the U.S., it was reported that there were only 19% female AP Computer Science test-takers in 2013, 12% female Computer Science undergraduate degree recipients at major research universities in 2012, and 26% female computing professionals in workforce in 2013 (NCWIT, 2014). This gender digital divide is prevalent in schools and corporations where women are underrepresented in these localities (Cooper, 2006). Even after more than several decades of efforts to narrow the digital divide, the gender gap still continues to persist. The WGBH Educational Foundation and the Association for Computing Machinery (2009) reported that college-bound females, regardless of race and ethnicity, show significantly less interest than males in computing. Females tend to associate computing with “typing”, “math”, and “boredom” while for males, they are more inclined to associate computing with “video games”, “design”, “electronics”, “solving problems”, and “interesting”.

In fact, new manifestations of the divide were found in the use rather than access of technology between the genders (Lim & Meier, 2011). While the gender issue is complex and multi-faceted, relevant research can shed light on our understanding of the role that gender plays in ICT literacy, particularly within the background of measurement invariance, and provides possible avenues for us to approach the gender digital divide problem from a quantitative methodological perspective that aims to uncover some causes behind gender differences (Boeve-de Pauw, Jacobs, & Van Petegem, 2012).

ICT literacy has been defined and conceptualized using various terminology and frameworks in the literature (see Section 2 for more details). In terms of measurement, self-report remains a common and valid method for assessing ICT literacy (Zelman, Shmis, Avdeeva, Vasiliev, & Froumin, 2011), and youth in school still constitute the major subjects in many studies as they consistently and heavily engage in ICT use. Against this background, this study aimed to test whether a self-reported perceived ICT literacy scale is invariant across gender in a group of adolescents at three levels of invariance: configural invariance, measurement invariance, and structural invariance, which are collectively known as factorial invariance (Dimitrov, 2010). While a

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review of literature shows that there are a variety of definitions of ICT literacy, this study defined it as follows: "ICT literacy is using digital technology, communication tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (ICT Literacy Panel, 2007, p. 2). Testing factorial invariance has become an increasingly important procedure for psychometric evaluation of measurement scale since it ensures that individuals from different groups ascribe the same meaning to the scale items and any group differences are the result of genuine differences across groups (Wu, Li, & Zumbo, 2007).

2. Gender differences in ICT literacy

There has been ongoing research on the gender issue in ICT literacy examining the traditional view that males tend to be more ICT literate than females. Numerous studies have investigated the issue based on different conceptualizations and measures of ICT literacy, where literacy has been understood to include abilities, knowledge, skills, and competencies (Bawden, 2001). Voogt (1987) administered a Dutch version called "Computer Alfabetisme Schalen Twente" (CAST) of the Minnesota Computer Literacy Awareness Assessment to a group of secondary school students aged 12 to 16. In the study, computer literacy referred to the knowledge students displayed in a cognitive test comprising items from domains of programming and algorithms, software and data processing, and computer mystique and applications. Boys outperformed girls on the cognitive test of the CAST ($p < .001$). Tsai and Tsai (2010) developed an Internet Self-Efficacy Scale (ISES) to examine junior high school students' internet self-efficacy including the online exploration (explorative ISE) and online communication (communicative ISE) dimensions. The former subscale measured students' perceived ability to navigate or search information on the internet whereas the latter subscale assessed students' perceived ability to communicate through the internet. While the study found no statistically significant difference between the genders in the online exploration subscale, female students scored significantly higher ($t = 2.055$, $p < .05$) than male students in the online communication subscale.

Zhao, Lu, Huang, and Wang (2010) adapted items from a General Internet Self-Efficacy (GISE) scale created by Hsu and Chiu (2004) to assess internet self-efficacy of high school students. Internet self-efficacy was conceptualized as students' self-assessed ability to accomplish some tasks using the internet. They showed that male students had higher internet self-efficacy than did female students ($t = 10.649$, $p < 0.000$), providing some evidence of inequality in internet skills. Hatlevik and Christophersen (2013) found no gender differences in digital competence and argued that the general assumption that boys are more digitally competent than girls should be reconsidered. Digital competence in their study was defined as students' ability to access, process, evaluate, produce, and communicate information with the aid of technology. Using the self-assessment scale about ICT use in the Program for International Student Assessment (PISA) surveys in 2003 and 2006, Zhong (2011) found that boys reported higher digital skills than did girls in the two years and digital skills here referred to students' perceived ability to finish some designated tasks on computers and the internet.

Whereas the gender differences reported in the aforementioned studies may be due to the different measures that were used by the researchers, these studies appear not to sufficiently address the fundamental issue concerning measurement invariance when it comes to mean comparisons across groups. This could possibly be one of the reasons as to why mixed results are reported.

The joint committee of the American Educational Research Association (AERA), American Psychological Association (APA), and National Council on Measurement in Education (NCME) published a book entitled 'Standards for Educational and Psychological Testing' in 1999, which provides a sensible set of psychological test guidelines that were endorsed by major professional associations. The AERA et al. (1999) suggested that validity is the evidence for inferences made about a test score, and there are three types of evidence, namely construct-related, criterion-related, and content-related. They also recommended 20 standards for reliability (AERA et al., 1999, pp. 31–36). Measurement instruments have been developed with reference to these guidelines. However, as Vandenberg and Lance (2000) noted, the prevailing focus on the measurement properties of observed variables based on their reliability and validity has not adequately dealt with the issue such as whether respondents from different demographic background and cultures interpret a given measure in a conceptually similar manner (p. 5). It has been advocated that the invariant properties of a measurement instrument have to be verified before it is administered to individuals, so that any differences of the latent means of constructs across groups stem from genuine differences but not methodological artifacts (Boeve-de Pauw et al., 2012).

Dimitrov (2010) discussed the generalizability aspect of validity, which is related to whether properties and interpretations of scores can be generalized across population groups, settings, and tasks, and pointed out that factorial invariance is required to achieve this aspect of validity. Nimon and Reio (2011) also argued that ignoring measurement invariance could have significant implications for quantitative theory building and practices. It is equally inappropriate to recommend practices based on theory that is not tested for measurement invariance. These studies highlighted the importance of measurement invariance as a methodological challenge for researchers who attempt to make meaningful comparisons and interpretations across groups in a variety of contexts.

3. Method and results

3.1. Measure

This study tested the factorial invariance properties of a perceived ICT literacy scale. The new scale (3F-PICTLS) (see Appendix A), which consists of 17 items with three subscales including information literacy (information), internet literacy (communication), and computer literacy (technology), was developed and validated in a prior study (Lau & Yuen, 2014). Findings of the study showed that the scale was internally consistent with Cronbach's alpha values of the factors ranging from .856 to .906 in exploratory factor analysis (EFA) in a calibration sample ($n = 413$) and from .844 to .908 in confirmatory factor analysis (CFA) in a validation sample ($n = 386$) respectively. Whereas there is ongoing discussion regarding how EFA should be conducted (Costello & Osborne, 2005; Schmitt, 2011), we used the principal component extraction method followed by a promax rotation in our EFA since our aim was to extract as much total variance as possible from the set of the manifest variables with the minimum number of dimensions, and it was expected that the latent factors were correlated (Kaplan, 2009; Widaman, 2007).

The factor structure of the scale was supported through CFA ($\chi^2/df = 2.244$, CFI = .964, TLI = .958, and RMSEA = .057). Face, content, convergent, and discriminant validity were also affirmed. Face validity from the perspective of students and content validity as determined by the authors and teachers were considered good. Convergent validity of the scale was established based on the following conditions: (1) The factor loadings of most items were at least .7 on its respective construct (Carmines & Zeller, 1979); (2) Composite reliability values for the three constructs were all greater than .7 for 'modest' reliability in early stages of research by Nunnally (1978); and (3) The average variance extracted for the three constructs were .5 or above, which reached the minimum requirement of .5 suggested by Fornell and Larcker (1981). Discriminant validity was supported as chi-square difference tests showed statistically significant differences between the unconstrained model (the correlation between two constructs is free) and the constrained model (the correlation between the constructs is set to 1.0) for each pair of constructs one at a time (Bagozzi, Youjae, & Lynn, 1991). Taken