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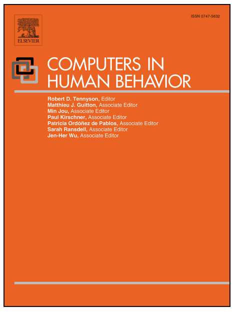

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The Development of Gender Differences in Information and Communication Technology (ICT) Literacy in Middle Adolescence

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The Development of Gender Differences in Information and Communication Technology (ICT) Literacy in Middle Adolescence

Abstract

Information and communication technology (ICT) literacy represents an essential skill for adolescents to efficiently participate in a modern society. Previous research reported conflicting findings regarding gender differences in ICT literacy. Therefore, the aim of the present study was the exploration of cross-sectional and longitudinal gender effects on ICT literacy across a period of three years among a sample of German 15-year-olds (*N* = 13,943). The results showed that ICT literacy increased across the study period. Although gender differences in ICT literacy were negligible at age 15, small differences in favor of boys emerged at age 18. In contrast, gender differences in ICT confidence favored boys at age 15 but did not change subsequently. Hypotheses with regard to moderating effects of gender role orientations were not supported. Overall, the study found only small differences in ICT literacy between boys and girls. The small size of the observed effect does not warrant alarming conclusions regarding increasing disadvantages in ICT literacy for girls.

Keywords: literacy, competence, computer, gender, longitudinal

The Development of Gender Differences in Information and Communication Technology (ICT) Literacy in Middle Adolescence

The rapid emergence of modern information and communication technologies (ICT) has substantially changed the type of skills that are needed to successfully participate, communicate, and work in a modern society. Therefore, in many countries national strategies have been developed to foster digital competences in school and the workplace. Despite this global aim, many studies found substantial interindividual differences in ICT literacy among adolescents (e.g., Christoph et al., 2015; Ihme & Senkbeil, 2017; Siddiq & Scherer, 2019). Particularly, gender differences disadvantaging girls have been repeatedly observed (Goldhammer et al., 2013; Kuhlemeier & Hemker, 2007). Although some research suggested that these differences might have reduced or even reversed in recent years (Eickelmann et al., 2019; Hatlevik & Christophersen, 2013; van Deursen & van Diepen, 2013), it is still unclear how gender differences in ICT literacy develop. Therefore, the present study examined changes in ICT literacy among a period of three years among a representative sample of German 15-year-olds. Moreover, it was hypothesized that individual gender role orientations of the respondents might moderate the emergence of gender differences in ICT, leading to larger gender differences for students emphasizing more traditional gender roles.

Information and Communication Technology Literacy

Advances in computer technologies and the diffusion of smartphones and internet applications in school, work, and homes have fundamentally changed how people find, process, and evaluate information. The massive amount of knowledge that is electronically accessible today also created new affordances of information use that allow people to successfully live in and cope with the demands of a technological world. These new skills (e.g., the ability to critically appraise the quality of information or to digitally process available data) have been referred to with different terms such as digital competence (Calvani et al., 2012), 21st century skills (Binkley et al., 2012), or ICT literacy (ETS, 2002). Many of these concepts overlap and are not clearly distinguishable on the basis of well-defined theories (for a review see van Laar et al., 2017), giving rise to so-called jingle-jangle fallacies[1] (Block, 1995; Kelley, 1927). Initial concepts of digital competence primarily emphasized specific technologies (e.g., collaborative writing systems, distant communication technologies) that might foster competence development (Bruce & Peyton, 1999). In contrast, conceptualizations that are more recent integrate diverse cognitive, socio-emotional, and behavioral aspects of technology use (e.g., Eshet-Alkalai, 2004; Hobbs, 2017; Ng, 2012). For example, Hobbs (2017) stresses the ability to access and evaluate digital information to actively solve problems as integral aspects of competent technology use. Similar, Eshet-Alkalai (2004) defines digital literacy as a combination of various distinct skills such as the ability to understand symbols necessary to communicate in digital environments (e.g., emoticons), the ability to identify and integrate digital information to create new information from available data, and skills enabling distant communication and collaboration. Although the precise definitions of digital competences (and related concepts) differ between authors, most of these ideas stress the importance of declarative and procedural components about diverse technological systems (e.g., how to use certain computer programs) but also competences that allow users of digital media to effectively process and manipulate electronic information.

[1] Psychological measurements infer latent variables from a set of observed indicators. However, assigning a particular label to these measurements does not establish its convergent or discriminant validity with regard to another construct. The *jingle* fallacy refers to the assumption that measures with similar names reflect the same construct, whereas the *jangle* fallacy pertains to the belief that scales with different names also reflect different constructs.

ICT literacy is typically defined from a functional perspective as the ability of individuals to use “digital technology, communication tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society” (ETS, 2002, p. 2). Thus, ICT literacy is seen as an integral competence to participate effectively and flourish in a modern society, in terms of economic and psychological well-being. ICT literate individuals possess knowledge about diverse technological systems but also have the appropriate procedural skills that allow them to use digitally available information in order to develop new understanding and communicate with others (Senkbeil et al., 2013). More precisely, ICT literacy encompasses five critical components (see ETS, 2002) including knowledge about and the ability to find digital information (*access*), sort and categorize information (*manage*), summarize digital data (*integrate*), make quality judgments about digital information (*evaluate*), and generate new information (*create*). Although these skills afford various cognitive abilities such as reasoning or problem solving, they are distinct from domain-general cognitive functioning (van Deursen & van Diepen, 2013). Importantly, ICT literacy is generally conceived as a unidimensional construct, despite subsuming various technological and information skills.

Gender Differences in ICT Literacy

Previous research offered various explanations for the observed differences in computer abilities among adolescents and adults (Sáinz & Eccles, 2012). Particularly, the respondents’ gender has been identified as an important factor. Prevalent theory and research suggests that firmly held believes and cultural stereotypes might contribute to gender differences in technology usage and computer skills (Cheryan et al., 2013; Master et al., 2016). As a consequence, these might also be responsible for gender differences in measured ICT skills as well as in self-reported confidence in one’s ICT skills. The following sections summarize the basic theoretical reasoning regarding the role of stereotype effects in ICT domains and respective empirical evidence.

The Role of Gender Stereotypes

Stereotypes are generalized expectations about the characteristics and behaviors of members of a social group (Ellemers, 2018). Most people hold specific gender stereotypes regarding different domains (e.g., Chaffee et al., 2019; Plante et al., 2019). For example, mathematics is generally viewed as a male domain, whereas languages have a female connotation. Exposure to gender stereotypes influences how men and women are treated, the type of behavior expected from each gender, and, in the long run, their access to specific experiences (Eccles & Wigfield, 2002). If individuals are faced with certain self-relevant stereotypes that are shared by an important social group, these might unfold expectancy effects (Muntoni & Retelsdorf, 2018) and act as self-fulfilling prophecies leading individuals to adopt these beliefs and behave in line with these expectations (e.g., Madon et al., 2018; Snyder et al., 1977). Consequently, stereotype beliefs also predict domain-specific achievements in school. For example, in secondary school girls showed lower mathematical competence when harboring stronger implicit stereotypes that mathematic represented a male domain; reverse effects were found for boys (Steffens & Jelenec, 2011). Similar, domain-specific gender stereotypes predicted grades in mathematics and languages among sixth and eight graders (Plante et al., 2013). Importantly, computers and technology in general are a domain with a stereotypically male connotation in which (according to prevalent norms) women are expected to perform poorly (Cheryan et al., 2013; Master et al., 2016). Thus, stereotype threat theory (Steele & Aronson, 1995) would suggest that women perform less well on ICT-related achievement tests because of their exposure to negative stereotypes. Experimental research provides some support for this assumption (Cooper, 2006; Koch et al., 2008). For example, female students primed with their gender performed worse on a computer task than a control group (Cooper, 2006). Similar, Koch and colleagues (2008) showed that women tend to attribute failures on computer tasks to their lack of competence whereas men are more likely to blame external sources (e.g., software glitches). Taken together, this reasoning might suggest that girls would underperform on tasks related to ICT literacy.

Evidence for Gender Differences in ICT Literacy

A substantial body of research in the 1990ies and early 2000th showed a disadvantage for girls in ICT literacy (e.g., Hakkarainen et al., 2000; Janssen Reinen & Plomp, 1993; Kuhlemeier & Hemker, 2007; Volman et al., 2005). In contrast, more recent studies revealed a less consistent pattern (see Punter et al., 2017, for a review). For example, in two international comparison studies including 21 countries (Eickelmann et al., 2019; Fraillon et al., 2014), most samples found that 14-year old girls outperformed boys in ICT literacy. Similar results were observed among Flemish sixth-graders (Aesaert & van Braak, 2015), Korean students in grades 4 to 6 (Kim et al., 2014), and also eighth graders from the United States (Hohlfeld et al., 2013). However, despite some evidence that gender differences in ICT literacy may have reversed in recent years, the available findings are rather inconsistent. For example, no differences in computer skills were found among secondary school students in Norway (Hatlevik & Christophersen, 2013), the Netherlands (van Deursen & van Diepen, 2013), and Germany (Ihme & Senkbeil, 2017). Summarizing the available body of research, a recent meta-analysis including 46 effect sizes estimated a small gender difference in ICT literacy of Hedges' $g = 0.13$ in favor of girls (Siddiq & Scherer, 2019). However, the respective analyses also uncovered pronounced heterogeneity in the observed effects resulting in a rather large credibility interval of 95% *CrI* [-0.08, 0.35]. Together, these findings raise doubts whether universal gender differences in ICT literary still exist that induce women (or men) to systematically underperform on ICT-related tasks. Furthermore, the focus on cross-sectional designs (e.g., Fraillon et al., 2014; Hatlevik & Christophersen, 2013; Ihme & Senkbeil, 2017), does not inform about the development of gender differences across the life course. Rarely, digital competences were examined from a longitudinal perspective (e.g., Hosein et al., 2010; Park & Burford, 2013) and, when repeated measurement designs were employed, these primarily referred to short-term change processes. For example, Hosein and colleagues (2010) examined changes in competences for 10 ICT activities across one school year. Thus, little is known how gender differences in ICT literacy emerge and change throughout adolescence.

Empirical Evidence for Gender Differences in ICT Confidence

Self-confidence is a task-specific metacognition reflecting an individual's perceived degree of success in a particular task (Stankov et al., 2012). It represents a blend of cognitive abilities and personality (Kröner & Biermann, 2007), with the latter related to an individual's self-concept (i.e., her or his self-beliefs about the competence). Subjective self-beliefs about one's competence are important determinants of actual achievements (cf. expectancy value theory, Eccles, 1994), and, thus, can also shape individuals' ICT competences (Rohatgi et al., 2016). Again, gender stereotypes have been shown to affect how people evaluate their own competence (e.g., Hackett & Betz, 1989; Shin et al., 2019). Because prevalent stereotypes attribute lower ICT competence to women (Cheryan et al., 2013; Master et al., 2016), women frequently report less confidence about their own competence, whereas men hold more positive beliefs about their abilities and even overestimate their own ICT performance (Meelissen, 2008). Consequently, previous research found pronounced gender differences in self-efficacy for ICT (Ihme & Senkbeil, 2017; Scherer & Siddiq, 2015). Similar gender differences have also been observed for constructs related to ICT self-efficacy such as negative affect (Schottenbauer et al., 2004). Again, the available findings are not unambiguous because some studies also found opposite effects. For example, a study among eighth graders in the United Stated demonstrated that girls rated their ICT skills higher than boys (Hohlfeld et al., 2013). Two recent studies addressed this issue from a meta-analytic perspective (Borokhovski et al., 2018; Cai et al., 2017). Both meta-analyses identified significantly lower computer-related self-efficacy for women of g = -0.18 (Cai et al., 2017) and g = -0.23 (Borokhovski et al., 2018). Interestingly, gender differences in negative affect towards computers were negligible ($g \leq .10$). Importantly, Borokhovski and colleagues (2018) also observed decreasing gender differences in ICT self-efficacy over time: For studies conducted between 2014 and 2018 respective differences between men and women were less than half the size as compared to older studies. Taken together, these studies demonstrate that gender differences in self-beliefs in ICT literacy still exist, although they might have reduced in recent years.

Gender Role Orientations and ICT literacy

Gender role orientations represent normative expectations about what constitute typical characteristics and behaviors of men and women (Eagly et al., 2000). Individuals can differ in the degree they accept these gender norms. A classical view (Bem, 1974) distinguishes two independent dimensions of masculinity and femininity pertaining to the beliefs about typical traits for men (e.g., assertiveness, dominance) or for women (e.g., compassion, sensitivity). Because these dimensions do not have biological roots, both men and women can associate themselves with either dimension, neither dimension (i.e., undifferentiated), or both dimensions (i.e., androgynous). A more recent perspective focuses on the degree individuals adopt either more traditional or more egalitarian gender role orientations. The latter indicate more gender-diverse beliefs rejecting typical gender stereotypes, whereas the former emphasize the classical stereotypical differences between men and women (Athenstaedt, 2000). Thus, gender role orientations also incorporate domain-specific gender stereotypes but are more broad encompassing different domains. So far, little is known about potential negative effects of gender role orientations on domain-specific achievements. Only recently, Ehrtmann and Wolter (2018) identified a gender-specific effect for this association: Boys and girls exhibited stronger competence development in domains stereotypically associated with the opposite gender when they held more egalitarian gender role orientations. Consequently, gender role orientations might also affect gender differences in ICT literacy. More specifically, students emphasizing more traditional gender roles are likely to typecast computers and new technologies in a more male-dominated way, in line with prevalent gender stereotypes (see Cheryan et al., 2013; Master et al., 2016), whereas respondents with more egalitarian views might show smaller or no differences between genders. Thus, gender role orientations might be an important moderating influence on the size of gender differences in ICT literacy.

The Present Study

Most research on gender differences in ICT literacy is limited to a cross-sectional perspective (e.g., Fraillon et al., 2014; Hatlevik & Christophersen, 2013; Ihme & Senkbeil, 2017; van Deursen & van Diepen, 2013). So far, little is known about the development of potential gender differences across the life course. Therefore, the present study examines changes in ICT literacy among a representative sample of German 15-year-olds across a period of three years. Instead of concurrent effects, the focus of the study is on changes in ICT literacy and how gender differences evolve across time. So far, the direction of gender differences in ICT literacy has not clearly established. Although prevalent theoretical explanations (e.g., stereotype threat theory) would assume gender difference in ICT literacy disadvantaging girls, recent empirical findings cast doubts on the direction of effects (Siddiq & Scherer, 2019). Also, gender differences in access to and experience with computers seem to have decreased over time (Colley & Comber, 2003); at the same time, gender norms changed towards more gender diverse role beliefs (Eagly et al., 2019; Miller et al., 2018). As a result, it might have become more acceptable for women to engage with formerly stereotypically male-typed domains such as computer and information technologies. Therefore, the study explores the following research question (RQ 1):

Do gender differences in (a) ICT literacy and (b) confidence in ICT literacy change during middle adolescence?

A follow-up research question (RQ 2) pertained to students' gender role orientations as a potential moderating influence that might affect the emergence of gender differences in ICT literacy. Students emphasizing more traditional gender roles might exhibit gender differences in favor of boys—as found in initial studies on ICT literacy (e.g., Hakkarainen et al., 2000; Volman et al., 2005)—, whereas respondents with more egalitarian (androgynous or undifferentiated) views might show no gender differences, thus, corroborating the findings in recent studies (e.g., Aesaert & van Braak, 2015; Hohlfeld et al., 2013).

Do gender differences in (a) ICT literacy and (b) confidence in ICT literacy increase for students with more traditional gender role orientations as compared to students with egalitarian gender role orientations?

Materials and methods

Sample and procedure

Participants were part of the German National Educational Panel Study (NEPS) that follows representative samples of students across their life courses (see Blossfeld et al., 2011). They were sampled using a stratified two-stage approach that first drew random samples of schools and, subsequently, students within these schools (see Aßmann et al., 2019, for details). For this study, responses from N = 13,943 students (50% female) were analyzed who were initially assessed in 2010 attending ninth grades of 545 different secondary schools across the country (see Table 1). Their mean age was M = 15.62 (SD = 0.63) years. Students were tested in small groups at their respective schools by experienced interviewers. All students who agreed further participation were contacted three years later (in 2013) for a follow-up assessment. Students that still attended school (i.e., in twelfth grade) were retested in school, whereas students that had left school were individually tested at their private homes. In total, N = 5,407 students (54% female) were retested a second time.

Ethics statement

Written informed consent was given by the students and their parents in accordance with the Declaration of Helsinki. Moreover, informed consent was also given by the educational institutions to take part in the study. The consent procedure was approved by a special data protection and security officer of the NEPS. The Federal Ministries of Education in Germany approved the study. Further approval by an ethics committee was not required according to the local and national guidelines.

Instrument

Information and communication technology literacy was measured at both time points with paper-based achievement tests that were specifically constructed for administration in the NEPS. The theoretical frameworks for these tests adopted the ETS (2002) definition of ICT literacy (see above) and are described in Senkbeil, Ihme, and Wittwer (2013). Different tests with 36 or 31 items were administered in both waves that were targeted at the average competence level of the respective age group. Each item required a multiple-choice response that asked test-takers to identify a correct solution from up to six response options (see Figure 1 for an example item). All tests were scaled using models of item response theory (see Pohl & Carstensen, 2013) and linked across waves to allow for longitudinal mean-level comparisons (see Fischer et al., 2016). The marginal reliabilities (Adams, 2005) of the two tests were good with .83 and .74. Further details on the psychometric properties of the administered tests including analyses of longitudinal measurement invariance and gender-related differential item functioning are reported in Senkbeil and Ihme (2012, 2017). These analyses showed stable measurement models across time and between boys and girls.

Confidence in one's ICT literacy was measured with a single item that asked students after each achievement test to estimate their own test performance by indicating the number of items presumably answered correctly. The accuracy of these metacognitive judgments was calculated as difference between a respondent's estimated test performance and his or her actual performance on the respective test standardized at the number of administered items (in percent; see Schraw, (2009)). Hence, positive values indicated an overestimation of one's ICT literacy, a negative value reflected an underestimation, and a value close to zero suggested accurate judgments.

Gender role orientations were measured in ninth grade with six items adapted from Athenstaedt (2000) on four-point response scales from 1 "completely disagree" to 4 "completely agree". Responses were coded in such a way that larger scores represent more egalitarian and lower scores more traditional gender role orientations. An exploratory ordinal factor analysis suggested the extraction of a single factor, with the largest eigenvalues being 3.47, 0.70, and 0.57. The respective factor loadings are given in Table 2 showing that all items were substantially associated with the latent factor (all λs > .50). Similar, confirmatory item response modeling supported a unidimensional scale (see supplement material). The omega categorical reliability (Green & Yang, 2008) was .81.

Students' *socio-economic status* was captured by the highest International Socio-Economic Index of occupational status (ISEI; Ganzeboom, 2010) of their parents. The ISEI ranges between 10 and 98 with higher values reflecting a higher occupational prestige.

Cultural capital in the family was measured with a single item asking about the number of books at home on a six-point scale from 1 "0 to 10 books" and 6 "more than 500 books". Similar items are routinely administered in large-scale social and educational studies and provide a valid assessment of objectified cultural capital (e.g., Sieben & Lechner, 2019).

Student's *migration background* was derived from the origin of birth of their parents and grandparents. If at least one of his or her (grand)parents were born outside of Germany the student was classified as having a migration background (coded 1 = yes, 0 = no).

Data analyses

Gender differences in ICT literacy and ICT confidence were examined with latent change score analyses (McArdle, 2009). Thus, the literacy scores (or confidence scores) at the second measurement occasion (T2) was reparameterized in the form of two additive components (see Figure 2): the scores at the first measurement occasion (T1) and the difference between the two scores (T2-T1). To test for gender differences, the latent difference score was regressed on gender. Because the development of cognitive abilities can be influenced by economic, social, and, cultural aspects of the family environment (cf. Akukwe & Schroeders, 2016; Schroeders et al., 2016) four control variables (age, migration background, socio-economic status, cultural capital) were included in this analysis[2]. Because these models are just-identified, no model fit indices are available. Dependencies in the data resulting from the nesting of students within different schools[3] were acknowledged by estimating cluster-robust standard errors (Cameron & Miller, 2015). ICT literacy scores were *z*-standardized with respect to the scores at T1; as a result, the regression parameters for

[2] All analyses were also examined without inclusion of any covariate. However, these analyses did not lead to different conclusions. The respective results are available in the OSF data repository.

[3] Intraclass-correlations (ICC) indicated that dependencies in ICT literacy scores were primarily a result of students being nested within schools (ICC = .40) as compared to within classes (ICC = .02). Therefore, the school-level was acknowledged in the analyses.

gender (coded 0 for men and 1 for women) can be interpreted similar to standardized mean differences. These effect sizes were evaluated in line with conventional standards (Cohen, 1992) using 0.20 and 0.50 as thresholds for small and medium effects, respectively. The latent change score models were estimated in *R* version 3.6.1 (R Core Team, 2019) with the *lavaan* package version 0.6-4 (Rosseel, 2012) and *lavaan.survey* version 1.1.3.1 (Oberski, 2014).

ICT literacy at the two measurement occasions and gender role orientations were modeled with plausible values (see von Davier et al., 2009; Wu, 2010 for an introduction into the plausible value technique) that acknowledge the uncertainty in the measurements and allow for the analysis of latent relationships (similar to latent variable modeling in structural equation modeling). Thus, for each respondent 20 plausible values were drawn using *TAM* version 3.2-24 (Robitzsch et al., 2019). The latent change score analyses were repeated for each plausible value and, subsequently, combined using Rubin's (1987) rules (see also Mislevy, 1991). For non-responders missing values were imputed based on the background model during the plausible value estimation (cf. Braun & von Davier, 2017). Missing values on the background variables were handled using multiple imputation with predictive mean matching (Weirich et al., 2014).

Open practices

Means, standard deviations, and correlations between the study variables are given in Table 3. The respondent data (including the study material) is available to the research community at https://doi.org/10.5157/NEPS:SC4:9.1.1. Moreover, the *R* code to reproduce the presented findings and the results of the statistical analyses can be accessed in the *Open Science Framework* (Soderberg, 2018) at https://osf.io/xvqfa/?view_only=04f100887aad47d08066b7838db79398.

Results

Selectivity analyses

The study observed a substantial dropout of 61% over the course of the two measurement occasions. This pattern falls in line with a general trend of increasing non-response rates in many social surveys (Kreuter, 2013; Williams & Brick, 2018). For example, recent rounds of the European Social Surveys in Germany achieved response rates as low as 35%, despite extensive fieldwork efforts (see Beullens et al., 2018). To examine the dropout process in more detail, a dichotomous non-response indicator (coded 1 for non-response and 0 for participation at the second wave) was regressed on the ICT literacy and ICT confidence scores from the first wave, gender role orientations, and the available control variables (see Table 4). These analyses showed that proportionally more dropout was observed for students with lower ICT literacy (d = -0.32, p < .001) and boys (d = -0.13, p < .001). In contrast, confidence scores (d = 0.02, p = .105) and gender role orientation (d = -0.01, p = .643) did not predict participation propensity. Consequently, participation at the second measurement occasion was at least partially driven by a missing at random process (see Zinn & Gnambs, 2018) which was acknowledged by including these variables in the background model for the estimation of the plausible values.

Latent Change Score Models for ICT Literacy

ICT literacy exhibited a high rank-order stability over the three years (r = .76, p < .001). However, the latent change score model (Model 1 in Table 5) identified a small mean-level increase within this period of about Cohen's d = 0.40 (p < .001). Thus, on average, students improved their ICT skills. Nevertheless, the significant variance of the latent change score (Var = 0.42, p < .001) indicated substantial interindividual differences in change that might be explained by moderating influences. Therefore, the unconditional change score model was extended by including gender as predictor of literacy skills in ninth grade and the respective change score (see Model 2). These analyses revealed a negligible gender difference in ICT literacy in ninth grade (d = -0.03, p = .107). More importantly, increases in ICT literacy across time were significantly larger for boys as compared to girls (d = -0.13, p < .001). Thus, within three years small gender differences emerged: for girls, ICT literacy increased by d = 0.34 (p < .001), whereas boys improved by d = 0.47 (p < .001). It was also hypothesized that gender differences would be contingent on the gender role orientations of the respondents. Thus, gender differences should be larger for students embracing more traditional gender roles. To test this assumption, gender role orientations and the interaction with gender were added as additional predictors to the latent change score model (see Model 3 in Table 5). However, gender role orientations assessed in ninth grade did neither moderate gender differences in ninth grade (B = -0.02, p = .433), nor gender differences in changes of ICT literacy across time (B = -0.02, p = .216). Thus, there was no support for different gender effects depending on the students' gender role orientations.

Latent Change Score Models for ICT Confidence Scores

The confidence scores for ICT literacy performance showed that students, on average, tended to overestimate their ICT literacy at both time points, M = 0.64 (SD = 0.18) and M = 0.64 (SD = 0.17). Moreover, confidence in ones' abilities was less stable than ICT literacy, with a longitudinal correlation of r = .41 (p < .001). More importantly, there were no mean-level changes between the two measurement occasions, d = -0.01, p = .516 (see Model 1 in Table 6). Thus, on average, the degree of overestimation of one's skills remained comparable. Again, the significant variance of the latent change score (Var = 1.08, p < .001) suggested potential moderating influences. Including gender as predictor of the confidence scores in ninth grade and the respective change score (see Model 2) revealed small gender differences in ninth grade favoring boys (d = -0.31, p < .001), but no gender differences regarding changes across time (d = -0.03, p = .306). Again, there was no evidence for moderating effects of gender role orientations (Model 3 in Table 6).

Discussion

The ability to efficiently access, evaluate, and mange digital information has been termed one of *the* essential 21st century skills (Binkley et al., 2012). Therefore, the present study examined the development of ICT literacy in a representative sample of German adolescents across three years. These analyses showed that, on average, students' ICT literacy increased, whereas their confidence in ICT performance remained unchanged. Although most students tended to overestimate their test performance, the degree of overestimation was similar at ages 15 and 18. This trend to overestimate ones' performance is a general tendency that has been observed in different domains but tends to decrease with age (cf. Fredricks & Eccles, 2002; Robins & Beer, 2001; Schneider & Lockl, 2008). Thus, it is unlikely that ratings of ones' ICT performance will become more realistic in older age groups.

Previous research suggested that gender differences in ICT literacy might have vanished in recent years (Hatlevik & Christophersen, 2013; van Deursen & van Diepen, 2013) or even reversed to favor girls (Aesaert & van Braak, 2015; Eickelmann et al., 2019; Fraillon et al., 2014). In line with these findings the present investigation found only negligible differences between boys and girls in ninth grade. However, during the course of the study small gender differences emerged; at age 18 girls had a slightly lower ICT literacy as compared to boys. Interestingly, the identified effect with a disadvantage for girls (Cohen's d = -0.15) was at odds with recent meta-analytic findings that reported gender differences in favor of girls, Hedge's g = 0.13 (Siddiq & Scherer, 2019). The reason for this discrepant finding remains open for speculation. It might be the case that more conservative gender stereotypes prevail in Germany as compared to the countries examined in Siddiq and Scherer (2019) which spanned Europe (from Norway to Slovenia), America (from Canada to

Argentina), and Asia (e.g., China, Korea). However, empirical evidence does not support this conjecture: despite the existence of cross-cultural variations in stereotypical beliefs about gender roles (cf. Best & Williams, 1994; van de Vijver, 2007), respective studies typically show more egalitarian views in Germany as compared to, for example, the United States (Scott, 2008). It could also be speculated that the German educational system provides inferior opportunities for students to engage with modern technologies and systematically acquire computer skills (cf. Gerick et al., 2016). As a result, German adolescents might more strongly depend on non-formal learning opportunities (e.g., the home environment) and activities outside of school that are more strongly determined by gender-specific interests (as compared to mandatory school courses). Another explanation might be cultural and socioeconomic differences between Germany and the countries included in Siddiq and Scherer (2019). Stoet and Geary (2018) suggested that in less gender-equal countries women are more likely to engage with science, technology, engineering, and mathematics (STEM) fields to escape difficult living conditions. Germany is a rather gender-equal country with a well-established social welfare system. Thus, girls might not feel the pressure to learn new technologies and acquire ICT competences. Rather, they can follow their (gendered) interests when choosing leisure activities which, in turn, might affect their development of ICT competences. It must be emphasized that, so far, these *post-hoc* explanations remain speculative. However, it should be stressed that the observed gender difference in ICT literacy that emerged during middle adolescent was rather small. Thus, future research needs to examine whether the effect replicates in independent samples and age cohorts. In addition, it is unknown whether the effect accumulates over time, thus, leading to more pronounced gender differences during the transition to adulthood and beyond.

Regarding ICT confidence a different pattern emerged. In line with previous research (Ihme & Senkbeil, 2017), boys overestimated their performance stronger than girls. The respective effect (Cohen's *d* = -0.31) also fell in line with meta-analytic estimates on gender differences in computer self-efficacy, Hedge's *g* = -0.23 (Borokhovski et al., 2018). However, this gender difference remained unchanged across measurement occasions and was similar at both ages. Thus, the observed differences between boys and girls seem to represent a general tendency that is rather stable in the observed age range. Similar findings have also been observed for other competence domains (e.g., Fredricks & Eccles, 2002; Herbert & Stipek, 2005; Watt, 2004). For example, mathematic competence beliefs showed only modest (and rather stable) gender differences in grades 9 to 12, whereas they were more pronounced (and more variable) in primary school (Fredricks & Eccles, 2002). Changes in gender differences were neither found for competence beliefs in English between grades 7 to 11 (Watt, 2004). Thus, in middle adolescent gender differences in competence beliefs seem to be rather stable. Interestingly, the relative strength of men and women's overestimation seems to depend on the gender connotation of the competence domain. Domains stereotypically considered male (e.g., mathematics, sport) typically observe a stronger tendency for boys to slightly overestimate their ability, whereas domains with a female connotation (e.g., languages such as English) tend to result in a stronger overestimation for girls (see Fredricks & Eccles, 2002; Watt, 2004). Thus, the tendency to overestimate one's abilities seems to be a (more or less) stable individual difference in middle adolescent and is not limited to the realm of ICT literacy.

Finally, hypotheses regarding gender role orientations were not supported. Gender differences in ICT literacy were comparable for respondents emphasizing different stereotypes about men and women. These results do not corroborate related research that highlighted pronounced associations between student's endorsements of gender stereotypes in different domains and respective grades (Plante et al., 2013) or between gender role orientations and changes in domain-specific competences of boys and girls (Ehrtmann &

Wolter, 2018). At this point, the reasons for the discrepant findings are unclear. It might be speculated that the male stereotype associated with computers and new technologies does not hold anymore in Germany and, thus, ICT literacy lacks a gender-specific connotation. However, recent research highlighted that the mental models of German teenagers regarding computer scientists is still predominantly male, particularly among boys (Brauner et al., 2018). Also, German adults still attribute lower computer skills to women when their sex is emphasized (Fleischmann et al., 2016), suggesting that the traditional stereotypes regarding computers still exist. It might also be the case that, rather than gender stereotypes, differences in interests play a more important role for the development of gender differences in ICT literacy. For example, women tend to show more interest in working with other people, whereas males prefer more abstract tasks and, thus, also show greater interest in STEM (Su et al., 2009). These interests gradually develop in early adolescence and are well-established before finishing school (see Wang & Degol, 2017 for a review). Domain interests are reinforced through an ongoing process of decisions to (not) engage in specific tasks and respective experiential outcomes. Thus, gender differences in ICT competence might be a consequence of different experiences of boys and girls needed for the acquisition of these competences that are determined by gendered interests. Therefore, initiatives to increase girls' interest in programming and other computer applications (Schroeder et al., 2018) might help reducing differences in ICT literacy.

Limitations and Directions for Future Research

A notable strength of the study is the large, representative sample embedded in a longitudinal design. However, some aspects might have weakened the generalizability of the results. First, economic constraints allowed only the administration of a short test to measure ICT literacy. Therefore, the test did not allow for the examination of different facets of ICT. Although the presented analyses fall in line with the prevalent conception of ICT literacy as unidimensional construct (ACARA, 2018), Punter and colleagues (2017) suggested that gender differences in ICT literacy might be dependent on specific facets: whereas computer and technology literacy tends to favor boys, information literacy due to its close association with reading literacy might exhibit a gender difference in favor of girls. Future research should study specific facets of ICT literacy over time which might uncover different patterns of change. Second, ICT literacy and confidence in one's abilities might exert interactive effects and influence each other over time. Overconfidence has been shown to prevent the development of self-regulatory strategies: six-years-old children who underestimate their actual abilities showed higher monitoring and control skills as compared to overestimators (Destan & Roebers, 2015). In turn, these differences might contribute to increases in their competences (Rinne & Mazzocco, 2014). Thus, future research should emphasize the role of self-regulatory skills in the development of ICT literacy. Third, although it was hypothesized that computers and ICT in general might be viewed as male-typed domain, this assumption was not explicitly tested in the present study. Instead, a rather global measure of gender role orientation was used that captures general stereotypical views regarding men and women. It is conceivable that different aspects of ICT such as the technological and the informational aspect are associated with different stereotypes (e.g., technology literacy might be perceived as a male domain and informational literacy as a female domain). This might explain the failure to uncover moderating effects in the present study. Fourth, the study did not address the cause of the observed changes in ICT literacy and respective gender differences. It might be the case that girls lack appropriate role models to develop interest in ICT which steers them away from considering professions in computer sciences (Murphy et al., 2007). Similar, in school, teachers and textbooks might involuntarily perpetuate implicit gender stereotypes (see Kollmayer et al., 2018, for a review) that might result in increasing gender differences over time. Thus, future research is encouraged to explore factors in and out of school that could explain the observed changes in ICT literacy. Finally, the study covered a rather short period of time. Longer observational periods would allow the analyses of non-linear changes and could scrutinize whether the observed gender differences accumulate over time or remain constant. Moreover, given the rapid diffusion of digital technologies into many areas of adolescents' private and academic lives the presented findings need to be replicated in different cohorts to explore whether gender differences in ICT literacy might evolve differently in changing technological contexts.

Conclusion

Information and communication literacy represents an important ability for the successful participation in the modern world. The present study showed that, in Germany, ICT literacy increased during middle adolescents more strongly for boys as compared to girls. Moreover, boys also overestimated their own ICT performance more strongly than girls, although this difference was similar at ages 15 and 18. Overall, the observed gender differences in ICT literacy were rather small; thus, on average, boys and girls were more similar rather than different in their ability to deal with digital information and the challenges of a technological society.

References

ACARA. (2018). *NAP Sample Assessment ICT Literacy: Years 6 and 10*. Australian Curriculum, Assessment and Reporting Authority.

Adams, R. J. (2005). Reliability as a measurement design effect. *Studies in Educational Evaluation*, *31*(2–3), 162–172. https://doi.org/10.1016/j.stueduc.2005.05.008

Aesaert, K., & van Braak, J. (2015). Gender and socioeconomic related differences in performance based ICT competences. *Computers & Education*, *84*, 8–25. https://doi.org/10.1016/j.compedu.2014.12.017

Akukwe, B., & Schroeders, U. (2016). Socio-economic, cultural, social, and cognitive aspects of family background and the biology competency of ninth-graders in Germany. *Learning and Individual Differences*, *45*, 185–192. https://doi.org/10.1016/j.lindif.2015.12.009

Aßmann, C., Steinhauer, H. W., Würbach, A., Hammon, A., Kiesl, H., Rohwer, G., Rässler, S., & Blossfeld, H.-P. (2019). Sampling design of the National Educational Panel Study: Setup and panel development. In H.-P. Blossfeld & H.-G. Roßbach (Eds.), *Education as a lifelong process*. Springer.

Athenstaedt, U. (2000). Normative Geschlechtsrollenorientierung: Entwicklung und Validierung eines Fragebogens. *Zeitschrift Für Differentielle Und Diagnostische Psychologie*, *21*(1), 91–104. https://doi.org/10.1024//0170-1789.21.1.91

Bem, S. L. (1974). The measurement of psychological androgyny. *Journal of Consulting and Clinical Psychology*, *42*(2), 155–162. https://doi.org/10.1037/h0036215

Best, D. L., & Williams, J. E. (1994). Masculinity/femininity in the self and ideal self descriptions of university students in fourteen countries. In A. M. Bouvy, F. J. R. van de Vijver, P. Boski, & P. Schmitz (Eds.), *Journeys into Cross-Cultural Psychology* (pp. 297–306). Swets & Zeitlinger.

Beullens, K., Vandenplas, C., Loosveldt, G., & Stoop, I. (2018). Response rates in the European Social Survey: Increasing, decreasing, or a matter of fieldwork efforts? *Survey Methods: Insights from the Field*. https://doi.org/10.13094/SMIF-2018-00003

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining 21st century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills* (pp. 17–66). Springer.

Block, J. (1995). A contrarian view of the five-factor approach to personality description. *Psychological Bulletin*, *117*(2), 187–215. https://doi.org/10.1037/0033-2909.117.2.187

Blossfeld, H.-P., Roßbach, H.-G., & von Maurice, J. (2011). Education as a lifelong process—The German National Educational Panel Study (NEPS). *Zeitschrift Für Erziehungswissenschaft*, *14*(S2), 19–34. https://doi.org/10.1007/s11618-011-0179-2

Borokhovski, E., Pickup, D., El Saadi, L., Rabah, J., & Tamim, R. M. (2018). *Gender and ICT: Meta-Analysis and Systematic Review*. Commonwealth of Learning.

Braun, H., & von Davier, M. (2017). The use of test scores from large-scale assessment surveys: Psychometric and statistical considerations. *Large-Scale Assessments in Education*, *5*(1), 17. https://doi.org/10.1186/s40536-017-0050-x

Brauner, P., Ziefle, M., Schroeder, U., Leonhardt, T., Bergner, N., & Ziegler, B. (2018). Gender influences on school students’ mental models of computer science: A quantitative rich picture analysis with sixth graders. In N. Marsden & V. Wulf (Eds.), *Proceedings of the 4th Conference on Gender & IT - GenderIT ’18* (pp. 113–122). ACM Press. https://doi.org/10.1145/3196839.3196857

Bruce, B., & Peyton, J. K. (1999). Literacy development in network-based classrooms: Innovation and realizations. *International Journal of Educational Technology*, *1*, 1–26.

Cai, Z., Fan, X., & Du, J. (2017). Gender and attitudes toward technology use: A meta-analysis. *Computers & Education*, *105*, 1–13. https://doi.org/10.1016/j.compedu.2016.11.003

Calvani, A., Fini, A., Ranieri, M., & Picci, P. (2012). Are young generations in secondary school digitally competent? A study on Italian teenagers. *Computers & Education*, *58*(2), 797–807. https://doi.org/10.1016/j.compedu.2011.10.004

Cameron, A. C., & Miller, D. L. (2015). A practitioner's guide to cluster-robust inference. *Journal of Human Resources*, *50*(2), 317–372. https://doi.org/10.3368/jhr.50.2.317

Chaffee, K. E., Lou, N. M., Noels, K. A., & Katz, J. W. (2019). Why don't "real men" learn languages? Masculinity threat and gender ideology suppress men's language learning motivation. *Group Processes & Intergroup Relations*. https://doi.org/10.1177/1368430219835025

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, *69*(1–2), 58–71. https://doi.org/10.1007/s11199-013-0296-x

Christoph, G., Goldhammer, F., Zylka, J., & Hartig, J. (2015). Adolescents' computer performance: The role of self-concept and motivational aspects. *Computers & Education*, *81*, 1–12. https://doi.org/10.1016/j.compedu.2014.09.004

Colley, A., & Comber, C. (2003). Age and gender differences in computer use and attitudes among secondary school students: What has changed? *Educational Research*, *45*(2), 155–165. https://doi.org/10.1080/0013188032000103235

Cooper, J. (2006). The digital divide: The special case of gender: The digital divide. *Journal of Computer Assisted Learning*, *22*(5), 320–334. https://doi.org/10.1111/j.1365-2729.2006.00185.x

Destan, N., & Roebers, C. M. (2015). What are the metacognitive costs of young children's overconfidence? *Metacognition and Learning*, *10*(3), 347–374. https://doi.org/10.1007/s11409-014-9133-z

Eagly, A. H., Nater, C., Miller, D. I., Kaufmann, M., & Sczesny, S. (2019). Gender stereotypes have changed: A cross-temporal meta-analysis of U.S. public opinion polls from 1946 to 2018. *American Psychologist*. https://doi.org/10.1037/amp0000494

Eagly, A. H., Wood, W., & Diekman, A. H. (2000). Social role theory of sex differences and similarities: A current appraisal. In T. Eckes & H. M. Trautner (Eds.), *The Developmental Social Psychology of Gender* (pp. 123–174). Erlbaum.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*(4), 585–609. https://doi.org/10.1111/j.1471-6402.1994.tb01049.x

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Ehrtmann, L., & Wolter, I. (2018). The impact of students' gender-role orientation on competence development in mathematics and reading in secondary school. *Learning and Individual Differences*, *61*, 256–264. https://doi.org/10.1016/j.lindif.2018.01.004

Eickelmann, B., Bos, W., Gerick, J., & Labusch, A. (2019). Computer- und informationsbezogene Kompetenzen von Schülerinnen und Schülern der 8. Jahrgangsstufe in Deutschland im zweiten internationalen Vergleich. In B. Eickelmann, W. Bos, J. Gerick, F. Goldhammer, H. Schaumburg, K. Schwippert, M. Senkbeil, & J. Vahrenhold (Eds.), *ICILS 2018 Deutschland. Computer- und informationsbezogene Kompetenzen von Schülerinnen und Schülern im zweiten internationalen Vergleich und Kompetenzen im Bereich Computational Thinking* (pp. 113–136). Waxmann.

Ellemers, N. (2018). Gender stereotypes. *Annual Review of Psychology*, *69*(1), 275–298. https://doi.org/10.1146/annurev-psych-122216-011719

Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia*, *13*, 93–106.

ETS. (2002). *Digital transformation. A framework for ICT literacy*. Educational Testing Service.

Fischer, L., Rohm, T., Gnambs, T., & Carstensen, C. H. (2016). *Linking the data of the competence tests* (No. 1; NEPS Survey Paper). Leibniz Institute for Educational Trajectories.

Fleischmann, A., Sieverding, M., Hespenheide, U., Weiß, M., & Koch, S. C. (2016). See feminine – Think incompetent? The effects of a feminine outfit on the evaluation of women's computer competence. *Computers & Education*, *95*, 63–74. https://doi.org/10.1016/j.compedu.2015.12.007

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). *Preparing for life in a digital age: The IEA international computer and information literacy study international report*. International Association for the Evaluation of Educational Achievement.

Fredricks, J. A., & Eccles, J. S. (2002). Children's competence and value beliefs from childhood through adolescence: Growth trajectories in two male-sex-typed domains. *Developmental Psychology*, *38*(4), 519–533. https://doi.org/10.1037/0012-1649.38.4.519

Ganzeboom, H. B. G. (2010, May). *A new international socio-economic index [ISEI] of occupational status for the International Standard Classification of Occupation 2008 [ISCO-08] constructed with data from the ISSP 2002-2007*. Annual Conference of International Social Survey Programme, Lisbon, Portugal.

Gerick, J., Eickelmann, B., Droessel, K., & Lorenz, R. (2016). Perspektiven von Schulleitungen auf neue Technologien in Schulen. In B. Eickelmann, J. Gerick, K. Drossel, & W. Bos (Eds.), *ICILS 2013 – Vertiefende Analysen zu computer- und informationsbezogenen Kompetenzen von Jugendlichen* (pp. 60–92). Waxmann.

Goldhammer, F., Naumann, J., & Keßel, Y. (2013). Assessing Individual Differences in Basic Computer Skills: Psychometric Characteristics of an Interactive Performance Measure. *European Journal of Psychological Assessment*, *29*(4), 263–275. https://doi.org/10.1027/1015-5759/a000153

Green, S. B., & Yang, Y. (2008). Reliability of Summed Item Scores Using Structural Equation Modeling: An Alternative to Coefficient Alpha. *Psychometrika*, *74*(1), 155–167. https://doi.org/10.1007/s11336-008-9099-3

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education*, *20*(3), 261. https://doi.org/10.2307/749515

Hakkarainen, K., Ilomäki, L., Lipponen, L., Muukkonen, H., Rahikainen, M., Tuominen, T., Lakkala, M., & Lehtinen, E. (2000). Students' skills and practices of using ICT: Results of a national assessment in Finland. *Computers & Education*, *34*(2), 103–117. https://doi.org/10.1016/S0360-1315(00)00007-5

Hatlevik, O. E., & Christophersen, K.-A. (2013). Digital competence at the beginning of upper secondary school: Identifying factors explaining digital inclusion. *Computers & Education*, *63*, 240–247. https://doi.org/10.1016/j.compedu.2012.11.015

Herbert, J., & Stipek, D. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Journal of Applied Developmental Psychology*, *26*(3), 276–295. https://doi.org/10.1016/j.appdev.2005.02.007

Hobbs, R. (2017). *Create to Learn: An Introduction to Digital Literacy*. Wiley.

Hohlfeld, T. N., Ritzhaupt, A. D., & Barron, A. E. (2013). Are gender differences in perceived and demonstrated technology literacy significant? It depends on the model. *Educational Technology Research and Development*, *61*(4), 639–663. https://doi.org/10.1007/s11423-013-9304-7

Hosein, A., Ramanau, R., & Jones, C. (2010). Learning and living technologies: A longitudinal study of first□year students' frequency and competence in the use of ICT. *Learning, Media and Technology*, *35*(4), 403–418. https://doi.org/10.1080/17439884.2010.529913

Ihme, J. M., & Senkbeil, M. (2017). Warum können Jugendliche ihre eigenen computerbezogenen Kompetenzen nicht realistisch einschätzen? *Zeitschrift Für Entwicklungspsychologie Und Pädagogische Psychologie*, *49*(1), 24–37. https://doi.org/10.1026/0049-8637/a000164

Janssen Reinen, I., & Plomp, T. (1993). Gender and computers: Another area of inequity in education? In W. J. Pelgrum, I. Janssen Reinen, & T. Plomp (Eds.), *Schools, Teachers, Students and Computers: A Cross-national Perspective* (pp. 91–116). University of Twente.

Kelley, T. L. (1927). *Interpretation of Educational Measurements*. World Book.

Kim, H.-S., Kil, H.-J., & Shin, A. (2014). An analysis of variables affecting the ICT literacy level of Korean elementary school students. *Computers & Education, 77*, 29–38. https://doi.org/10.1016/j.compedu.2014.04.009

Koch, S. C., Müller, S. M., & Sieverding, M. (2008). Women and computers. Effects of stereotype threat on attribution of failure. *Computers & Education*, *51*(4), 1795–1803. https://doi.org/10.1016/j.compedu.2008.05.007

Kollmayer, M., Schober, B., & Spiel, C. (2018). Gender stereotypes in education: Development, consequences, and interventions. *European Journal of Developmental Psychology*, *15*(4), 361–377. https://doi.org/10.1080/17405629.2016.1193483

Kreuter, F. (2013). Facing the nonresponse challenge. *The ANNALS of the American Academy of Political and Social Science*, *645*(1), 23–35. https://doi.org/10.1177/0002716212456815

Kröner, S., & Biermann, A. (2007). The relationship between confidence and self-concept—Towards a model of response confidence. *Intelligence*, *35*(6), 580–590. https://doi.org/10.1016/j.intell.2006.09.009

Kuhlemeier, H., & Hemker, B. (2007). The impact of computer use at home on students' Internet skills. *Computers & Education*, *49*(2), 460–480. https://doi.org/10.1016/j.compedu.2005.10.004

Madon, S., Jussim, L., Guyll, M., Nofziger, H., Salib, E. R., Willard, J., & Scherr, K. C. (2018). The accumulation of stereotype-based self-fulfilling prophecies. *Journal of Personality and Social Psychology*, *115*(5), 825–844. https://doi.org/10.1037/pspi0000142

Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, *108*(3), 424–437. https://doi.org/10.1037/edu0000061

McArdle, J. J. (2009). Latent Variable Modeling of Differences and Changes with Longitudinal Data. *Annual Review of Psychology*, *60*(1), 577–605. https://doi.org/10.1146/annurev.psych.60.110707.163612

Meelissen, M. (2008). Computer attitudes and competencies among primary and secondary school students. In J. Voogt & K. Knezek (Eds.), *International Handbook of*

Information Technology in Primary and Secondary Education (pp. 381–395). Springer.

Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of U.S. draw-a-scientist studies. *Child Development*, *89*(6), 1943–1955. https://doi.org/10.1111/cdev.13039

Mislevy, R. J. (1991). Randomization-based inference about latent variables from complex samples. *Psychometrika*, *56*(2), 177–196. https://doi.org/10.1007/BF02294457

Muntoni, F., & Retelsdorf, J. (2018). Gender-specific teacher expectations in reading—The role of teachers' gender stereotypes. *Contemporary Educational Psychology*, *54*, 212–220. https://doi.org/10.1016/j.cedpsych.2018.06.012

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science*, *18*(10), 879–885. https://doi.org/10.1111/j.1467-9280.2007.01995.x

Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, *59*(3), 1065–1078. https://doi.org/10.1016/j.compedu.2012.04.016

Oberski, D. (2014). lavaan.survey: An R Package for Complex Survey Analysis of Structural Equation Models. *Journal of Statistical Software*, *57*(1). https://doi.org/10.18637/jss.v057.i01

Park, S., & Burford, S. (2013). A longitudinal study on the uses of mobile tablet devices and changes in digital media literacy of young adults. *Educational Media International*, *50*(4), 266–280. https://doi.org/10.1080/09523987.2013.862365

Plante, I., de la Sablonnière, R., Aronson, J. M., & Théorêt, M. (2013). Gender stereotype endorsement and achievement-related outcomes: The role of competence beliefs and task values. *Contemporary Educational Psychology*, *38*(3), 225–235. https://doi.org/10.1016/j.cedpsych.2013.03.004

Plante, I., O'Keefe, P. A., Aronson, J., Fréchette-Simard, C., & Goulet, M. (2019). The interest gap: How gender stereotype endorsement about abilities predicts differences in academic interests. *Social Psychology of Education*, *22*(1), 227–245. https://doi.org/10.1007/s11218-018-9472-8

Pohl, S., & Carstensen, C. H. (2013). Scaling the competence tests in the National Educational Panel Study. *Journal for Educational Research Online*, *5*, 189–216.

Punter, R. A., Meelissen, M. R., & Glas, C. A. (2017). Gender differences in computer and information literacy: An exploration of the performances of girls and boys in ICILS 2013. *European Educational Research Journal*, *16*(6), 762–780. https://doi.org/10.1177/1474904116672468

R Core Team. (2019). *R: A language and environment for statistical computing* [R]. R Foundation for Statistical Computing. https://www.R-project.org

Rinne, L. F., & Mazzocco, M. M. M. (2014). Knowing Right From Wrong In Mental Arithmetic Judgments: Calibration Of Confidence Predicts The Development Of Accuracy. *PLoS ONE*, *9*(7), e98663. https://doi.org/10.1371/journal.pone.0098663

Robins, R. W., & Beer, J. S. (2001). Positive illusions about the self: Short-term benefits and long-term costs. *Journal of Personality and Social Psychology*, *80*(2), 340–352. https://doi.org/10.1037/0022-3514.80.2.340

Robitzsch, A., Kiefer, T., & Wu, M. (2019). *TAM: Test Analysis Modules* (3.2-24) [R]. https://CRAN.R-project.org/package=TAM

Rohatgi, A., Scherer, R., & Hatlevik, O. E. (2016). The role of ICT self-efficacy for students' ICT use and their achievement in a computer and information literacy test. *Computers & Education*, *102*, 103–116. https://doi.org/10.1016/j.compedu.2016.08.001

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2). https://doi.org/10.18637/jss.v048.i02

Rubin, D. B. (1987). *Multiple Imputation for Nonresponse in Surveys*. Wiley.

Sáinz, M., & Eccles, J. (2012). Self-concept of computer and math ability: Gender implications across time and within ICT studies. *Journal of Vocational Behavior*, *80*(2), 486–499. https://doi.org/10.1016/j.jvb.2011.08.005

Scherer, R., & Siddiq, F. (2015). Revisiting teachers' computer self-efficacy: A differentiated view on gender differences. *Computers in Human Behavior*, *53*, 48–57. https://doi.org/10.1016/j.chb.2015.06.038

Schneider, W., & Lockl, K. (2008). Procedural metacognition in children: Evidence for developmental trends. In J. Dunlosky & R. A. Bjork (Eds.), *Handbook of Metamemory and Memory* (pp. 391–409). Psychology Press.

Schottenbauer, M. A., Rodriguez, B. F., Glass, C. R., & Arnkoff, D. B. (2004). Computers, anxiety, and gender: An analysis of reactions to the Y2K computer problem. *Computers in Human Behavior*, *20*(1), 67–83. https://doi.org/10.1016/S0747-5632(03)00044-X

Schroeder, U., Bergner, N., & Leonhardt, T. (2018). Paving the Way for Computer Science in German Schools. In E. Bayro-Corrochano & E. Hancock (Eds.), *Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications* (Vol. 8827, pp. 590–609). Springer International Publishing. https://doi.org/10.1007/978-3-319-98355-4_34

Schroeders, U., Schipolowski, S., Zettler, I., Golle, J., & Wilhelm, O. (2016). Do the smart get smarter? Development of fluid and crystallized intelligence in 3rd grade. *Intelligence*, *59*, 84–95. https://doi.org/10.1016/j.intell.2016.08.003

Scott, J. (2008). Changing gender role attitudes. In J. Scott, S. Dex, & H. Joshi (Eds.), *Women and Employment: Changing Lives and New Challenges* (pp. 156–176). Edward Elgar Publishing.

Senkbeil, M., & Ihme, J. M. (2012). *NEPS Technical Report for Computer Literacy – Scaling Results of Starting Cohort 4 in Ninth Grade* (No. 17; NEPS Survey Paper). Otto-Friedrich-University Bamberg.

Senkbeil, M., & Ihme, J. M. (2017). *NEPS Technical Report for Computer Literacy: Scaling Results of Starting Cohort 4 for Grade 12* (No. 27; NEPS Survey Paper). Leibniz Institute for Educational Trajectories.

Senkbeil, M., Ihme, J. M., & Wittwer, J. (2013). The test of technological and information literacy (TILT) in the National Educational Panel Study: Development, empirical testing, and evidence for validity. *Journal for Educational Research Online, 5*, 139–161.

Shaw, G. (2009). Measuring metacognitive judgments. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 415–429). Routledge.

Shin, Y.-J., Lee, E. S., & Seo, Y. (2019). Does traditional stereotyping of career as male affect college women's, but not college men's, career decision self-efficacy and ultimately their career adaptability? *Sex Roles*, *81*(1–2), 74–86. https://doi.org/10.1007/s11199-018-0976-7

Siddiq, F., & Scherer, R. (2019). Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy. *Educational Research Review*, *27*, 205–217. https://doi.org/10.1016/j.edurev.2019.03.007

Sieben, S., & Lechner, C. M. (2019). Measuring cultural capital through the number of books in the household. *Measurement Instruments for the Social Sciences, 1*(1), 1. https://doi.org/10.1186/s42409-018-0006-0

Snyder, M., Tanke, E. D., & Berscheid, E. (1977). Social perception and interpersonal behavior: On the self-fulfilling nature of social stereotypes. *Journal of Personality and Social Psychology*, *35*(9), 656–666. https://doi.org/10.1037/0022-3514.35.9.656

Soderberg, C. K. (2018). Using OSF to Share Data: A Step-by-Step Guide. *Advances in Methods and Practices in Psychological Science*, *1*(1), 115–120. https://doi.org/10.1177/2515245918757689

Stankov, L., Lee, J., Luo, W., & Hogan, D. J. (2012). Confidence: A better predictor of academic achievement than self-efficacy, self-concept and anxiety? *Learning and Individual Differences*, *22*(6), 747–758. https://doi.org/10.1016/j.lindif.2012.05.013

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*(5), 797–811. https://doi.org/10.1037/0022-3514.69.5.797

Steffens, M. C., & Jelenec, P. (2011). Separating implicit gender stereotypes regarding math and language: Implicit ability stereotypes are self-serving for boys and men, but not for girls and women. *Sex Roles*, *64*(5–6), 324–335. https://doi.org/10.1007/s11199-010-9924-x

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science*, *29*(4), 581–593. https://doi.org/10.1177/0956797617741719

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin*, *135*(6), 859–884. https://doi.org/10.1037/a0017364

van de Vijver, F. J. R. (2007). Cultural and gender differences in gender-role beliefs, sharing household task and child-care responsibilities, and well-being among immigrants and majority members in The Netherlands. *Sex Roles*, *57*(11–12), 813–824. https://doi.org/10.1007/s11199-007-9316-z

van Deursen, A. J. A. M., & van Diepen, S. (2013). Information and strategic Internet skills of secondary students: A performance test. *Computers & Education*, *63*, 218–226. https://doi.org/10.1016/j.compedu.2012.12.007

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, *72*, 577–588. https://doi.org/10.1016/j.chb.2017.03.010

Volman, M., Vaneck, E., Heemskerk, I., & Kuiper, E. (2005). New technologies, new differences. Gender and ethnic differences in pupils' use of ICT in primary and secondary education. *Computers & Education*, *45*(1), 35–55. https://doi.org/10.1016/S0360-1315(04)00072-7

von Davier, M., Gonzalez, E., & Mislevy, R. J. (2009). What are plausible values and why are they useful? In M. von Davier & D. Hastedt (Eds.), *IERI monograph series: Issues and Methodologies in Large-Scale Assessments* (Vol. 2, pp. 9–36). IER Institute.

Wang, M.-T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th- through 11th-grade Australian students. *Child Development*, *75*(5), 1556–1574. https://doi.org/10.1111/j.1467-8624.2004.00757.x

Weirich, S., Haag, N., Hecht, M., Böhme, K., Siegle, T., & Lüdtke, O. (2014). Nested multiple imputation in large-scale assessments. *Large-Scale Assessments in Education*, *2*(1). https://doi.org/10.1186/s40536-014-0009-0

Williams, D., & Brick, J. M. (2018). Trends in U.S. face-to-face household survey nonresponse and level of effort. *Journal of Survey Statistics and Methodology*, *6*(2), 186–211. https://doi.org/10.1093/jssam/smx019

Wu, M. (2010). Measurement, Sampling, and Equating Errors in Large-Scale Assessments: Winter 2010. *Educational Measurement: Issues and Practice*, *29*(4), 15–27. https://doi.org/10.1111/j.1745-3992.2010.00190.x

Zinn, S., & Gnambs, T. (2018). Modeling competence development in the presence of selection bias. *Behavior Research Methods*, *50*(6), 2426–2441. https://doi.org/10.3758/s13428-018-1021-z

Table 1.

Characteristics of Participants

	Overall sample	Boys	Girls
Sample size (*N*)	13,943	7,016	6,927
Age (*M* / *SD*)	15.62 / 0.63	15.68 / 0.64	15.57 / 0.61
Migration background (%)	25%	25%	26%
HISEI [a] (*M* / *SD*)	51.03 / 20.53	51.13 / 20.58	50.93 / 20.47
Cultural capital (*M* / *SD*)	3.80 / 1.48	3.73 / 1.50	3.88 / 1.50
School type: [c]			
- General secondary school	21%	24%	18%
- Intermediate secondary school	22%	22%	22%
- Grammar school	35%	31%	38%
- other	23%	23%	22%

Note. [a] HISEI = Highest parental International Socio-Economic Index of occupational status (Ganzeboom, 2010). [b] School type: General secondary school = “Hauptschule”, Intermediate secondary school = “Realschule”, Grammar school = “Gymnasium”.

Table 2.

Results of Exploratory Ordinal Factor Analysis of Gender Role Orientation Scale

	Item	λ	h^2
1.	Women and men should have the same household obligations.	.74	.55
2.	Girls can use technical devices as well as boys.	.75	.57
3.	Girls should be able to train for the same professions as boys.	.75	.57
4.	Men are better suited for certain jobs than women. #	.59	.35
5.	It's the man's job to earn money and the woman's job to take care of the household and family. #	.68	.46
6.	The number of women in politics should be the same as the number of men.	.69	.48
	Eigenvalue	2.98	
	Proportion of explained variance	0.50	

Note. λ = Factor loading; h^2 = Communality. # reverse coded

Table 3.

Means, Standard Deviations, and Correlations between Study Variables

		M	*SD*	MV	1.	2.	3.	4.	5.
1.	ICT literacy at T1	0.12	0.79	0.00					
2.	ICT literacy at T2	0.45	0.61	0.61	.76*				
3.	ICT confidence at T1	0.64	0.18	0.00	.22*	.21*			
4.	ICT confidence at T2	0.64	0.17	0.61	.13*	.18*	.41*		
5.	Gender (0 = men, 1 = women)	0.50	0.50	0.00	.02	-.07*	-.15*	-.17*	
6.	Gender role orientation	-0.04	0.98	0.25	.15*	.09*	-.06*	-.08*	.59*

Note. N = 13,943. MV = Fraction of missing values. Results are based upon 20 plausible values and multiple imputed datasets; thus, the statistics are corrected for measurement error.
* $p < .05$

Table 4.

Probit Regression for Non-Response at the Second Measurement Occasion

		Responders		Non-Responders		Regression	
		M	*SD*	*M*	*SD*	*B*	(*SE*)
1.	Gender (0 = men, 1 = women)	0.54	0.50	0.47	0.50	-0.13*	(0.03)
2.	Age (in years)	15.47	0.55	15.72	0.66	0.21*	(0.02)
3.	Migration (0 = no, 1 = yes)	0.22	0.42	0.28	0.45	-0.14*	(0.03)
4.	Socio-economic status [a]	0.30	0.99	-0.19	0.96	-0.14*	(0.01)
5.	Cultural capital [a]	0.31	0.94	-0.20	0.99	-0.13*	(0.01)
6.	Gender role orientation [a]	0.13	0.98	-0.08	1.00	-0.01	(0.02)
7.	ICT literacy at T1 [a]	0.40	0.96	-0.26	0.94	-0.32*	(0.02)
8.	ICT confidence at T1 [a]	0.06	0.97	-0.04	1.02	0.02	(0.01)

Note. *N* = 13,943. Dependent variable is non-response (coded 1 = non-response and 0 = participation), *B* = Regression weight, *SE* = Standard error of *B*. Results are based upon 20 plausible values and multiply imputed datasets. [a] *z*-standardized.
* $p < .05$

Table 5.

Estimates of Latent Change Score Model for ICT Literacy

	Model 1		Model 2		Model 3	
	B	(*SE*)	*B*	(*SE*)	*B*	(*SE*)
ICT literacy at T1						
Intercept	0.05*	(0.02)	0.06*	(0.02)	0.13*	(0.02)
Gender			-0.03	(0.02)	-0.15*	(0.02)
Gender role orientation					0.11*	(0.01)
Gender x gender role					-0.02	(0.02)
Variance	0.75*	(0.01)	0.75*	(0.01)	0.75*	(0.01)
R^2	.25		.25		.26	
ICT literacy difference T2-T1						
Intercept	0.40*	(0.01)	0.47*	(0.01)	0.45*	(0.01)
Gender			-0.13*	(0.01)	-0.08*	(0.01)
Gender role orientation					-0.03*	(0.01)
Gender x gender role					-0.02	(0.01)
Variance	0.42*	(0.01)	0.41*	(0.01)	0.41*	(0.01)
R^2	.02		.03		.03	
Covariance	-0.37*	(0.01)	-0.37*	(0.01)	-0.37*	(0.01)

Note. *B* = Estimated parameter, *SE* = Standard error of *B*. Covariance = Covariance between ICT literacy at T1 and ICT literacy difference T2-T1. Gender was coded 0 for men and 1 for women. Gender role orientation and ICT scores were *z*-standardized (*M* = 0, *SD* =1). Results for *z*-standardized control variables (age, migration background, socio-economic status, cultural capital) are not presented (see supplement material).

Table 6.

Estimates of Latent Change Score Model for ICT Confidence

	Model 1		Model 2		Model 3	
	B	(*SE*)	*B*	(*SE*)	*B*	(*SE*)
ICT confidence at T1						
Intercept	0.00	(0.01)	0.15*	(0.01)	0.18*	(0.02)
Gender			-0.31*	(0.02)	-0.34*	(0.02)
Gender role orientation					0.04*	(0.02)
Gender x gender role					-0.04	(0.03)
Variance	0.90*	(0.01)	0.97*	(0.01)	0.97*	(0.01)
R^2	.01		.03		.03	
ICT confidence difference T2-T1						
Intercept	-0.01	(0.02)	0.01	(0.02)	0.00	(0.03)
Gender			-0.03	(0.03)	-0.02	(0.04)
Gender role orientation					-0.01	(0.03)
Gender x gender role					0.02	(0.04)
Variance	1.08*	(0.02)	1.09*	(0.02)	1.09*	(0.02)
R^2	.00		.00		.00	
Covariance	-0.61*	(0.02)	-0.62*	(0.02)	-0.62*	(0.02)

Note. *B* = Estimated parameter, *SE* = Standard error of *B*. Covariance = Covariance between ICT confidence at T1 and ICT confidence difference T2-T1. Gender was coded 0 for men and 1 for women. Gender role orientation and ICT scores were *z*-standardized (M = 0, SD =1). Results for *z*-standardized control variables (age, migration background, socio-economic status, cultural capital) are not presented (see supplement material).

This table shows the number of tickets that have been sold for a school play. Which formula is needed in the table to calculate the total number of tickets issued on Thursday?

D7

	A	B	C	D	E	F
1			Drama Club Play			
2			Tickets			
3		Tickets sold	Tickets issued free of charge	Total no. of tickets	Total attendance	
4	Monday	28	0	28	26	
5	Tuesday	29	24	53	53	
6	Wednesday	65	16	81	80	
7	Thursday	58	8		64	
8	*Total*	180	48	228		
9						
10						

© Microsoft

Please check the right answer! Please check one box only!

a	=B7+C7
a	=D5:D7
a	=E8-B8
a	=B8-C8

Figure 1. Example item of the ICT literacy test. Copyright Leibniz Institute for Educational Trajectories (LIfBi). Reproduced with permission.

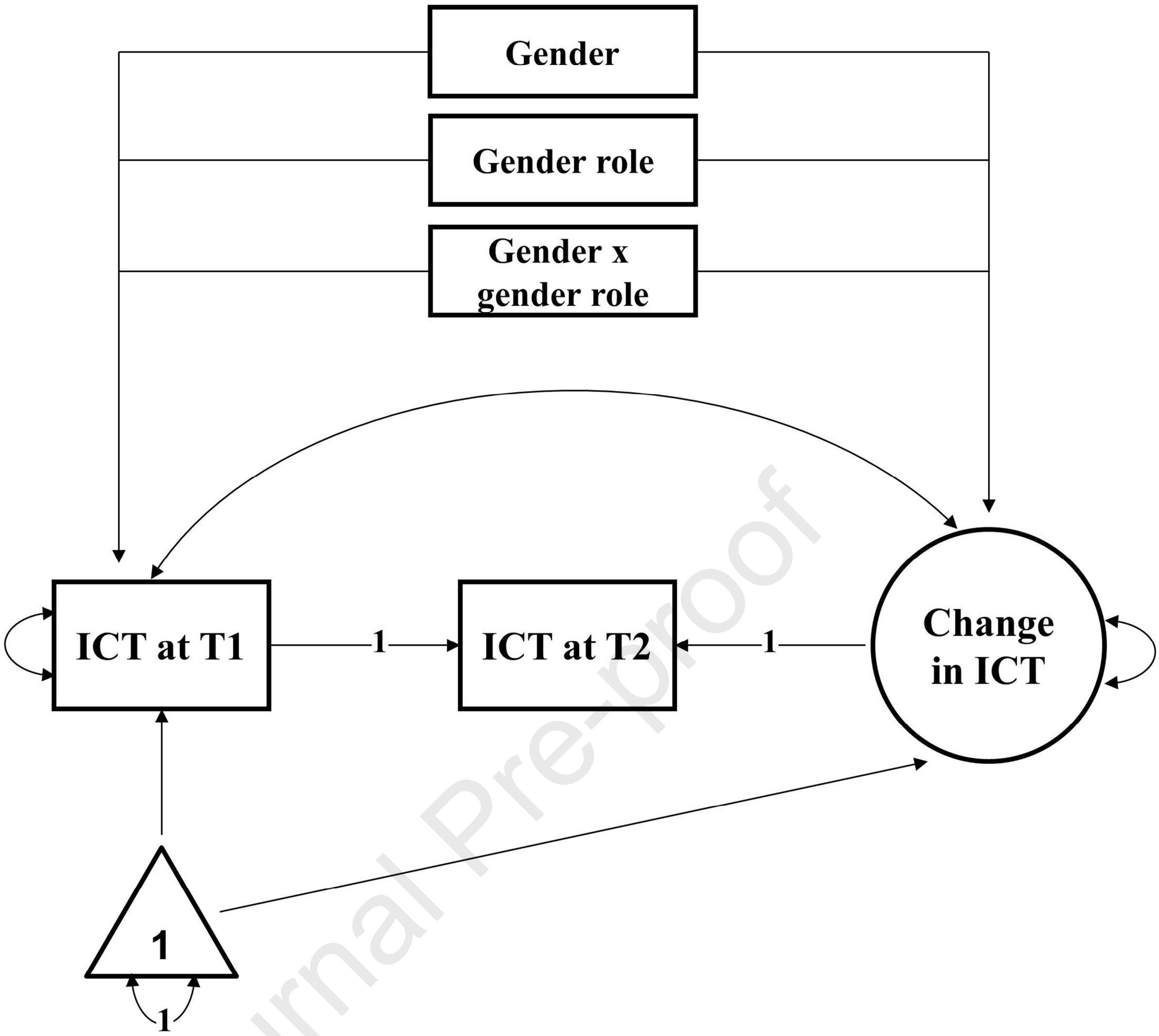

Figure 2. Latent change score model for ICT literacy and ICT confidence.

Highlights

- A longitudinal studies with adolescents at ages 15 and 18 is presented.
- Across three years, ICT literacy increased by Cohen's $d = 0.36$.
- Gender differences in favor of boys increased to $d = 0.13$.
- Gender differences in ICT confidence remained unchanged.
- Gender role orientations did not moderate the observed effects.