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Moving beyond cognitive elements of ICT Literacy:
First evidence on the structure of ICT Engagement

Abstract

The use of Information and Communication Technology (ICT) is of immense importance in today's digital knowledge society. As a basis for private and vocational participation in society, ICT literacy has been widely discussed in recent decades. Although motivational and metacognitive facets play an important role in developing ICT literacy and competence, studies assessing media, computer or ICT literacy often fail to present a comprehensive concept on these motivational and metacognitive facets. This article addresses this issue by integrating them into the concept of ICT engagement. Its theoretically deduced dimensions of ICT-related interest, self-concept related to the use of ICT, and social exposure to ICT were analyzed in an explorative study assessing *N* = 445 students aged between 14 and 17 years in the German federal state of Baden-Wuerttemberg. The obtained dimensional structure included the assumed factors, and suggested to distinguish a positive and a negative self-concept on using ICT as well as to separate interest in computers and interest in mobile devices factor. The ICT engagement dimensions were related to individual differences in behavioral, cognitive and emotional ICT constructs as expected.

1. Introduction

As computer technology has increasingly pervaded most areas of people's life in recent decades, individual competencies related to the use of information and communication technology (ICT) have become a necessary precondition for professional success as well as a crucial factor for private life (Blossfeld, 2010; Kozma, 2009; Partnership of 21st Century Skills, 2007). Over the past two decades, diverse approaches on ICT competencies have been proposed, amongst others in the field of empirical educational research (ETS, 2002; Gonzalez, Ramirez &

Viadel, 2012; Richter, Naumann & Horz, 2010). The variety of approaches corresponds to a diversity of applied terms, for instance, media literacy, media competence, computer literacy, information literacy, or digital literacy (cf. Lee & So, 2013; Zylka, Mueller & Martins, 2011). In empirical educational research, approaches have lately focused on the construct of ICT literacy (ETS, 2002; Goldhammer, Kroehne, Keßel, Senkbeil & Ihme, 2014).

According to ETS (2002, p. 2), ICT literacy is to be understood as a meta-competence not only relating to technical knowledge but also to enabling 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". These abilities are highly important for getting along in a changing global society as well as for life-long learning (Johnson, Adams Becker, Estrada & Freeman, 2014, p. 19). ICT literacy can be perceived as a continuum comprising the above-mentioned five abilities (i.e., access, management, integration, evaluation and creation of information), thus comprehending a specific set of skills that changes over the lifespan (ETS, 2002, p. 2; Senkbeil, Ihme & Wittwer, 2013). Although it is well known that literacy is subject to change over time and that diverse factors such as gender, personal experiences or social involvement influence learning and the development of literacy, a comprehensive concept integrating these conditions and factors has not been presented so far.

As regards ICT literacy, previous research has actually emphasized the relevance of motivational factors for ICT usage, performance and knowledge (e.g. Igbaria, Iivari & Maragahh, 1995; Richter et al., 2010; Sáinz & Eccles, 2012; Senkbeil et al., 2013; Shu, Tu & Wang, 2011; Wit, Heerwegh & Verhoeven, 2012) and the connection between using ICT and general learning motivation in specific didactic scenarios (e.g., Leng, Ali, Baki & Mahmud, 2010). At the same time, no comprehensive approach has been presented integrating motivational and metacognitive facets as conditioning factors for developing and adapting ICT skills in a self-regulated. Thus, a theoretically justifiable conceptualization and measure is necessary, enabling researchers to investigate those metacognitive and motivational factors that are assumed to facilitate intrinsically motivated use of ICT and the development of related skills through life span.

2. Connecting ICT and Media Literacy to ICT Engagement

The terminology that is applied to knowledge of and skills to use digital technologies differs strongly and depends on countries and scientific discourse (Badke, 2009; Zylka et al., 2011). (Digital) media-related abilities are often discussed in the context of media education, to a lesser degree also in computer science, and also from the measurement perspective also in empirical educational research. Besides ICT literacy, the following terms can be found: media education (e.g. Parola & Ranieri, 2011), media competence (e.g. Fedorov, 2011), media literacy (e.g. Hobbs, 2011; Inan & Temur, 2012; Moore, 2013), media literacy education (e.g., Schmidt, 2013), computer competence (e.g., Killian, 1984), computer literacy (Richter et al., 2010), computer education (Özdener & Bryik, 2007), ICT competencies (Hus, 2011), technology literacy (Davies, 2011), digital literacy (Perlmutter et al., 2010) and digital competency (Cartelli, 2009). Whichever term is being used, literacy related to ICT is mostly seen as an essential key competence of individuals living in today's knowledge-based society (e.g., ETS, 2002; European Commission, 2014; OECD, 2005).

Connecting ICT Literacy and Media Literacy

Media literacy is one of the most frequently applied terms to refer to (digital) media abilities and skills. Its use is widespread, especially in the Anglo-Saxon countries such as the United Kingdom, Australia, the United States and New Zealand. These countries generally have a long history of media-related discourse that can be traced to the development of mass media in the 1950s and 1960s (cf. Zylka et al., 2011). The original considerations of that time which are related to non-digital media are partially still implemented today, enhanced by the more recent ICT-related developments (Hobbs & Jensen, 2009). Over time, discussions have shifted towards media literacy education, initiated by the US National Association of Media Literacy Education (NAMLE).

Other terms, such as digital literacy or ICT literacy, evidently focus upon digital technologies that have been developed over the past two decades, and regularly emphasize that specific aspects of digital media – such as collaborative working, socializing or gaming – are to be regarded when discussing media-related abilities. „The increasing role of technology in our lives requires us to expand our notion of literacy. It is obvious that […] individuals must be literate in terms of traditional domains such as reading [...]. But today it is becoming increasingly clear that ICT literacy joins the ranks of essential and fundamental requirements." (ETS, 2002, p. 16). Another reason for the rising importance of ICT literacy can be found in the concept of literacy itself. It is often understood as "the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts" (UNESCO, 2004, p. 13). Furthermore, it also involves an understanding of ongoing learning enabling individuals to achieve their goals, to develop their potential, and to participate in their society (UNESCO, 2004). Thus, literacy, competencies and skills of individuals are expected to change over time, and this change is supposed to be most strongly influenced by individual motivational factors.

Quite many studies on ICT and media literacy have assessed individual differences in skills and abilities; however, approaches that extensively address motivational dimensions of ICT and media literacy are scarce. Nevertheless, constructs reflecting processes of the continuous and self-regulated development of these competencies are of major interest for empirical research and intervention studies.

Connecting ICT Literacy and ICT Engagement

Referring to constructive theories of learning, it is assumed that motivational facets play an important role for the development of individual abilities and knowledge (Craven & Marsh, 2008). For instance, being interested in and having a positive self-concept related to a specific activity – in other words: being engaged in a task – can be understood as a highly effective form of learning (cf. Mondi, Woods & Rafi, 2008, p.242). Therefore, metacognitive, motivational and cognitive facets can be assumed to be strongly interrelated.

Engagement. The concept of engagement is already well known, amongst others from the theoretical framework of reading engagement in PISA studies (OECD, 2007/2009) where it was introduced by Guthrie (1996; see also Guthrie et al., 1996; Guthrie et al., 2004). Guthrie argues that literacy is often understood as most important aspect for the regulation of a cognitive system (cf. Anderson & Pearson, 1984). He accentuates the relevance of motivational facets and states that persons who are engaged in reading choose to read for enjoyment, for gaining knowledge and/or for interaction in social relations (Guthrie et al., 1996, p.309). He therefore connects individual motivational needs to the individual's social milieu as well as to traditional understandings of cognitive competence (Guthrie, 1996, pp.435). By developing this comprehensive understanding of literacy-fostering dimensions, Guthrie moves beyond established notions of literacy and developed a concept of engagement, which seems highly valuable to be transferred and adapted to the context of ICT-related literacy.

Computer Engagement. The concept of engagement was not only used in terms of reading engagement by Guthrie, but also by other researchers who connected it amongst others to digital media. Previous research work investigated the assessment of computer apathy and computer anxiety (Charlton & Birkett, 1995). Further developments in this context aimed at distinguishing the addiction of students to computers and computer engagement (Charlton, 2002), for instance in the context of online games (Charlton & Danforth, 2007) which is linked to the work by Brown (e.g., 1991, 1993). Bygone years showed uprising research interest in this area, again. Some researchers discussed the concepts of computer or ICT engagement, but usually with a focus on the enhancement of student's general learning engagement through their use of ICT (cf. Coates & Friedmann, 2009; Varol, 2013). These approaches therefore understood ICT as supportive tool for enhancing learning engagement, but did not discuss the engagement in ICT or its connection to the area of ICT literacy. In contrast to these approaches, the concept of ICT engagement presented in this study does not concern computer-related engagement in the sense of addiction or general learning engagement, but it focusses to integrate metacognitive and motivational facets of ICT usage fostering the continuous development of ICT literacy.

3. Introducing ICT Engagement

In today's digital knowledge societies, ICT literacy is required in nearly all areas of work and ICT-related competencies are an essential component of employability (e.g., Drigas, Ionnidou, Kokkalia & Lytras, 2014, p.1500; Gallardo-Echenique, de Oliveira, Marqués-Molias & Esteve-Mon, 2015). They are a precondition for successful teaching and learning, efficient private and vocational communication as well as participating in society in general (e.g., de Pablos, Tennyson & Lytras, 2014). Actual technological developments include but are not limited to mobile devices, open educational ressources (OER), bring your own device (BYOD), cloud-based computing and the Internet of things (cf. Johnson, Becker, Estrada & Freeman, 2015). Further new developments, which cannot easily be foreseen, will appear every few years.

Because of the rapidly changing digital media and technology, continuous life-long learning is key factor for successfully keeping pace with recent developments in the area of ICT.

Therefore, staying engaged in ICT is essential for ICT and media literate life-long learners in the digital age. In our view, individuals engaged in ICT are supposed to become familiar with state-of-the-art ICT as well as new technological developments in an intrinsically motivated and self-determined way.

Grounding of ICT Engagement

ICT engagement is theoretically defined by concepts of motivation and metacognition. Although there is a great variety of motivational approaches, the fundamental distinction of intrinsic and extrinsic motivation is generally agreed upon in psychological research (cf. Wigfield, Eccles, Roeser & Schiefele, 2008, p.409). Extrinsic motivation means that the individual is doing an activity to achieve some outcome, whereas intrinsic motivation refers to doing an activity that is enjoyable, rewardable or inherently satisfying; accordingly, related activities are initiated and regulated in a self-determined way (cf. Ryan & Deci, 2000; Wigfield et al., 2008). Intrinsic motivation results in high-quality learning and creativity and is understood as a construct reflecting the human propensity to learn (cf. Ryan & Deci, 2000, p.60). Against this background, intrinsic motivation is understood to be strongly linked to the concept of ICT engagement. More specifically, ICT engagement is assumed to integrate those factors enabling intrinsically motivated ICT activities and the further development of ICT abilities.

Facets of ICT Engagement

ICT-related Interest. Common approaches of intrinsic motivation mainly focus on the dimension of interest (cf. Ryan & Deci, 2000, p.58; Wigfield et al., 2008, p. 410). Since interest is a content- or domain-specific concept (Schiefele, 1991, p. 301), it seems appropriate to assume the interest in ICT as a facet of ICT engagement.

The concept of interest itself can be traced back to Herbart (1806/1965), who understood interest as one of the important goals of education (Schiefele, 1991, p. 300). Interest has a directive role in intrinsically motivated behavior (Deci & Ryan, 1985, p. 34), it is understood as a long lasting preference for certain topics, subjects, or activities (Schiefele, 1991, p. 302) and is furthermore related to positive emotions, learning and performance outcomes (Eccles, 2005; Hidi & Renninger, 2006). It can be expected that the more subject-initiated and thus intrinsically motivated an activity is, the higher is the level of engagement and the higher is the quality of the respective learning process (cf. Ryan & Deci, 2000, p. 63).

ICT-related interest is conceived as a disposition with feeling-related and value-related components (cf. Schiefele, 1991, p. 303). Feeling-related valences refer to feelings such as enjoyment and involvement, whereas value-related valences actually advert to the subject's personal development, competence or understanding of problems. Engaged ICT users are therefore assumed to have well-developed long-term interests in the area of ICT as well as favourite ICT topics or types of ICT activities. Interest in ICT is not seen in a purely technology-driven way, it is instead understood as enjoying the use of specific ICT-based products, such as mobile devices, games, or social networks, and acknowledging related benefit.

Individual characteristics such as interests may be subject to change over time (Janneck, Vincent-Hoeper & Erhardt, 2013, p. 3), however, ICT engagement is assumed to reflect long-term interest as a key component. Thus, not only the existence of interest itself but also the sustainment of interest in ICT in the long-term is important. For the reinforcement of interest in ICT, the most important factors are feelings of competence, autonomy and social relatedness

(Ryan & Deci, 2000, p. 57; Deci & Ryan, 1985). Thus, intrinsic motivation in the field of ICT is supposed to be linked also to the self-concept on ICT (Ryan & Deci, 2000, p. 58).

Self-Concept related to the use of ICT. Researchers have conceptualized ICT- and computer-related self-concept as self-perceived ability, describing individuals' notions about their own computer-related abilities, such as handling every-day computer situations (cf. Janneck et al., 2013). The individual self-concept has a direct influence on intrinsic motivation, and, in particular, on interest (Eccles, 1994; Eccles & Wigfield, 1995). Furthermore, it is important for gaining domain-specific knowledge and skills (cf. Janneck et al., 2013). The self-concept related to the use of ICT thus points towards personal notions about ICT-related abilities facilitating intrinsically motivated behavior. It refers to individual ICT experiences, attitudes and beliefs and as such is a crucial determinant of ICT-related behavior (cf. Janneck et al., 2013, p. 2) and achievement (Helmke & van Aken, 1995). The positive influence of a positive self-concept related to the use of ICT on ICT-related performance outcomes is assumed to be mediated by ICT-related interest (Christoph, Goldhammer, Zylka & Hartig, 2015).

Besides the Self-concept related to the use of ICT, also ICT-related interest is linked to the social context of individuals, where they possibly could experience feelings of competence, and share the enjoyment of and the preference for ICT (Ryan & Deci, 2000, p. 58). This facet of ICT engagement will be referred to as Social exposure to ICT. Although this dimension has been discussed lately (e.g., Delen & Bulut, 2011; Palmer, Cicarelli, Falkmer & Parsons, 2013), it has not been connected to motivational facets yet.

Social Exposure to ICT. Social interaction has been shown to have a major effect on the regulation of motivation and interest (Thoman, Sansone & Pasupathi, 2007). For instance, the feeling of competence and the individual self-concept, respectively, depend to some extent on feedback and interaction with other individuals, peers, teachers and further more (cf. Ryan & Deci, 2000, p. 58; Wigfield et al., 2008, p. 414). Erstwhile, Guthrie (1996, p. 433) highlights the relevance of learner's social milieu for reading engagement, as children's reading experiences are often social. They share and exchange facts from the books they read as well as discuss characters. In a similar way, individuals' use of ICT and the development of their ICT knowledge and skills is socially embedded. For instance, adolescents photographing and exchanging photos via internet-based platforms such as Instagram, do not just upload pictures for themselves but they socialize using ICT, get feedback and discuss facts of shared pictures.

This facet of ICT engagement therefore indicates the extent to which students make ICT a subject of interpersonal communication and interaction, for instance, to talk about of the latest smartphone features or about problems with their computers at home. Frequent social exchange with peers, teachers, parents, or the class room community may increase the amount of time and breadth of using ICT and will foster long-term involvement (cf. Arnone, Small, Chauncey & McKenna, 2011, p. 187). ICT engaged individuals are supposed to rely on a web-based, partially web-based or non-digital social network to extend their competencies and share their knowledge and experiences with digital media and devices.

4. Research Goals and Hypotheses

Our literature review suggests that the newly developed construct of ICT engagement comprises at least three related dimensions: ICT-related interest, Self-Concept related to the use of ICT, and Social exposure to ICT. Based on our conceptualization, we developed a new questionnaire for measuring the various dimensions of ICT engagement. The measure was designed to tap in particular the ICT engagement of adolescents. Unlike children they can be expected to show relative stable interests (cf. Gottfried, Fleming & Gottfried, 2001; Patrick, 1993). Thus, their ICT engagement is supposed to be quite stable and should affect ICT-related behavior also in the long-term.

The first major goal was to provide empirical evidence on the dimensional structure of the newly developed measure in an exploratory way.

Hypothesis 1 (H1): The exploratory analysis of the ICT engagement measure yields a factor model comprising the proposed ICT engagement facets, that is, ICT-related interest, Self-concept related to the use of ICT, Social exposure to ICT.

In a second step and complementary to the first one, the explored dimensional structure of ICT engagement was cross-validated by means of a confirmatory analysis approach. In this step we also investigated whether a general higher-order factor of ICT engagement can be established.

Hypothesis 2 (H2): The explored dimensional structure of ICT engagement can be confirmed in an independent analysis.

The construct validity of the ICT engagement scale was analyzed by correlating the proposed ICT engagement dimensions with ICT-related cognitive, behavioral and emotional measures, namely theoretical computer knowledge, practical computer knowledge, and computer anxiety. We expected that ICT engagement is positively correlated to theoretical as well as practical computer knowledge as engaged individuals are supposed to self-intensify their computer-related knowledge. Furthermore, since computer anxiety is associated with a negative relationship to ICT and low computer literacy (cf. Milic & Škoric, 2010), and since it is expected to weaken intrinsic motivation to cope with ICT-specific situations and/or problems, we predicted negative correlations of ICT engagement dimensions with computer anxiety.

Hypothesis 3 (H3): ICT engagement is positively linked to theoretical and practical computer knowledge and negatively linked to computer anxiety.

To our knowledge, no systematic quantitative analysis has been conducted addressing the measurement of ICT engagement yet. Therefore, we aimed to develop an adequate measure starting with the development of new items. Their development was based on an extensive review of literature and published scales from the research fields described above. Given the scarcity of literature related to more recent developments in ICT (e.g., mobile devices), we explicitly addressed this area assuming that it is essential to assess adolescents' ICT engagement. Thus, the instrument finally targeted the whole range of digital devices, such as desktop computers or laptops, as well as to mobile devices, such as tablet computers and smartphones.

5. Materials and Method

Sample

Mainly two assumptions guided the selection of schools and students for the study. First, the ICT engagement measure was developed to assess adolescents. Second, participants need to be familiar with computers and state-of-the-art ICT and use them regularly. One possible group fulfilling these requirements are students aged around 15 years, who generally have their own computers, laptops, smartphones and internet access in Germany (Behrens & Rathgeb, 2012; MPFS, 2013).

The convenience sample finally consisted of N = 445 German students (53.1 % female) aged between 14 and 17 years (M = 15.09, SD = 0.48) from four schools (20 classes) in the federal state of Baden-Wuerttemberg, Germany. At secondary education level, the German school system is characterized by different school tracks, namely – depending on the respective federal state – a high-ability track (*Gymnasium*), an intermediate track (*Realschule*) and a low-ability track (*Hauptschule*). In our sample, 82.7 % of the assessed students attended the intermediate school track and 17.3 % attended the highest school track.

To investigate the three hypotheses the sample was split randomly with $N_{Sample1}$ = 222 and $N_{Sample2}$ = 223. The first sample was used for Hypothesis 1, and the second one for Hypotheses 2 and 3.

Measures

ICT Engagement. Based on the above described conceptualization of ICT engagement, we developed 48 new items, comprising items on ICT-related interest, Self-concept related to the use of ICT, and Social exposure to ICT. Given the sample of German students, all items were developed and delivered in German using a standardized paper-and-pencil questionnaire. Students were required to respond to an ICT engagement item on a 4-point rating scale, asking how strongly the adolescent would agree with different statements from his or her perspective (1 = Strongly disagree, 2 = Disagree, 1 = Agree, 4 = Strongly agree). For items with a negative phrasing, the coding of ratings was reversed.

Interest in using ICT devices was assessed through 20 items (e.g., *Working with computers brings me a lot of fun*) considering various digital devices such as desktop computers and mobile devices. The items reflect the use of ICT for enjoyment and utility across a broad range of situations in the life of adolescents.

Self-concept related to ICT, as the perceived competence and perceptions about oneself in ICT-related situations, was operationalized by 17 items (e.g., *I am able to install new programs on my computer without any help*). The items present diverse conceptions about oneself when using ICT. They range from the feeling of competence and control in the face of ICT problems to the feeling of struggling with ICT and insufficient understanding of ICT.

To measure Social exposure to ICT, 11 items were developed presenting situations in which adolescents make ICT a subject of interpersonal communication, interaction, and activities. For instance, this facet is reflected by the need for communication about ICT with others (e.g., *I like to talk to my friends about progress on computers*) or the wish to join ICT events (e.g., *I go to computer fairs with friends, e.g. CEBIT or Games Convention*).

Theoretical Computer Knowledge (TECOWI). The measurement of computer knowledge was based on a multiple-choice test assessing theoretical (TECOWI) as well as practical (PRACOWI) computer knowledge (Richter et al., 2010). Both scales mostly focus on desktop computers and respective knowledge and skills. They are commonly used to measure computer knowledge, for instance, to investigate its role in basic computer skills (e.g., Goldhammer, Naumann & Kessel, 2013).

The TECOWI measures terminological knowledge about basic ICT conceptions by means of 20 items, each representing common terms used in the field of computer, internet and network technology. Adolescents were asked to choose the best fitting answer out of the given five options. The following example translated by the authors asks for the meaning of the term 'JAVA' (from Richter et al., 2010, p. 25), for example:

Please choose the correct explanation for the term 'JAVA':
a) A program that automatically retrieves and analyses webpages
b) A web browser for WINDOWS
c) A programming language that allows for transferring programs to web browsers
d) A protocol used to transfer different types of files on the Internet
e) I don't know.

Practical Computer Knowledge (PRACOWI). As an indicator for the competent use of computer technology, practical computer knowledge represents adolescents' knowledge of how to handle common computer problems effectively (Richter et al., 2010), and is therefore highly related to every-day ICT practice. This knowledge test also included 20 items and asked adolescents to choose the best fitting answer out of five options, for example (from Richter et al., 2010, p. 24):

> *Your computer has crashed and you want to restart it carefully. What do you do?*
> *a) I press the key combination <Ctrl> + <Enter>, klick on <Restart> and choose <Restart carefully>.*
> *b) I press the key combination <Ctrl> + <Alt> + <Del>, klick on <Shutdown> and choose <Restart>.*
> *c) I press the key combination <End> + <Enter>, klick on <Restart> and choose <Careful start>.*
> *d) I press the key combination <Ctrl> + <Alt> + <End>, klick on <Quit> and choose <Warm start >.*
> *e) I don't know.*

The reliabilities of the TECOWI scale (Cronbach's α: .65) as well as for the PRACOWI scale (Cronbach's α: .70) were acceptable.

Computer Anxiety. Computer anxiety, representing feelings and thoughts of anxiety while acting with computers (e.g., *If my computer has crashed, I start to panic*), was assessed by eight items on a 5-point rating scale ranging from -2 = "I do not agree at all" to 2 = "I do agree" (Richter et al., 2010). The reliability was good (Cronbach's α: .79).

Analyses

Structural equation models for categorical variables were used to assess the psychometric properties (dimensionality) of the ICT engagement scale. First, the measurement model was developed through an exploratory factor analysis (EFA) with promax rotation using a random half of the sample (Hypothesis 1). Second, the results based on the exploratory findings were cross-validated through confirmatory factor analyses (CFA) using the other half of the sample. Two different models were specified, that is, a multi-factor model based on the results from the EFA to cross-validate them (Hypothesis 2), and, furthermore, a more parsimonious hierarchical g-factor model (g-factor CFA), assuming one general latent second-order factor (ICT engagement) representing the correlations among the first-order factors. Thus, in the multi-factor model the latent first-order factors were allowed to correlate, whereas the covariance among the first-order factors in the g-factor model was hypothesized to be explained fully by their regression onto the second-order factor (g-factor CFA).

For both CFA models, each manifest indicator was constrained to load on the first-order factor that it was designed to measure following the EFA-model results. As an indicator for reliability, Cronbach's alpha was computed for the items of each ICT engagement dimension as a measure of internal consistency. Furthermore, construct validity of ICT engagement dimensions was examined by correlating them with practical and theoretical computer knowledge as well as computer anxiety (Hypothesis 3).

As a result of our analysis, we give an overview of all items proposed to be included in the final measure of ICT engagement in Table A1 (Appendix).

All exploratory (EFA) and confirmatory analyses (CFA) were conducted using structural equation modeling techniques with Mplus 7.0 (Muthén & Muthén, 1998-2012). Factors resulting from EFA were extracted by considering the residuals, the amount of variance explained and the interpretability of the results (Asparouhov & Muthén, 2009; Park, Dailey & Lemus, 2002). For the CFA, robust weighted least squares estimator was applied (WLSMV) using the diagonal weight matrix with robust standard errors and mean- variance-adjusted χ^2 test statistics (Brown, 2006; Flora & Patrick, 2004). Several fit statistics were used to evaluate the estimated model, therein the χ^2 statistic (Schermelleh-Engel, Moosbrugger & Müller, 2003). Because this test statistic is sensitive to sample size, other commonly used (descriptive) fit indices were considered as well. To further evaluate model fit, we used the Root Mean Square Error of Approximation (RMSEA), indicating an adequate fit if the value is less than 0.08 and a good fit if it is less than 0.05 (Browne & Cudeck, 1993); the Confirmatory Fit Index (CFI), and Tucker-Lewis Index (TLI) which both indicate good fit if their values exceed 0.95 (Hu & Bentler, 1999); and last, the Weighted Root Mean Square Residual (WMRM), indicating a good fit if it is less than 1.0.

6. Results

In the following, we first present results on Hypothesis 1 which are based on an explorative factor analysis. Then, to investigate Hypotheses 2 and 3 the findings from two confirmatory factor analyses are presented.

H1: Exploring the Factor Structure of the ICT Engagement measure. Although we assumed three facets of ICT engagement, the EFA of the 48 ICT engagement items revealed five dimensions of ICT engagement. The five factor model fit the data well (χ^2 = 1347.14 [898, $N_{Sample1}$ = 222], p < .001; RMSEA=.047). Table 1 shows the rotated factor loadings and the latent correlations can be found in Table 2.

Items with non-significant, multiple high factor loadings *or* factor loadings smaller than .40 were excluded, ensuring a simple structure solution as well as short and efficient measurement instruments. Following this, 12 items were excluded (Items 1, 6, 9, 15, 21, 30, 32, 34, 37, 41, 42, 48) from the factor solution and the following analyses.

The self-concept items yielded a positive self-concept factor (Factor 1) and a negative self-concept factor (Factor 2), comprising eight items and three items, respectively. The factor Positive self-concept related to the use of ICT represented the feeling of competence when dealing with ICT, whereas the factor Negative self-concept related to the use of ICT displayed uncomfortable and unconfident self-evaluations when confronted with ICT-related troubles. Note, given how the items were coded, the Negative self-concept factor has the same polarity as the Positive self-concept factor, that is, a high value in the Negative self-concept factor means that the self-concept is little negative. The factor Social exposure to ICT (Factor 3) was empirically defined by 12 items representing mostly the wish to share and communicate ICT-related experiences and knowledge with others.

Insert Table 1

The remaining two factors were interpreted as factors of ICT interest. The factor Interest in computers (Factor 4) represented a personal orientation toward computers (which explicitly means desktop computers), whereas the items of the second factor Interest in mobile devices (Factor 5) mainly focused on mobile devices, such as smartphones or tablet computers.

The following picture emerged when inspecting the correlations among the five explored latent factors (see Table 2): Except for two non-significant correlations between the factors Interest in computers and Negative self-concept related to the use of ICT ($r \leq .03$) as well as Interest in mobile devices and Negative self-concept related to the use of ICT ($r \leq -.06$), moderate correlations could be found. Note that all correlations with Interest in mobile devices were negative ($r \geq -.06$ to $r \leq -.36$), which is assumed to be due to a reversed metric of the factor (cf. the negative loadings on Factor 5 in Table 1) and not due to substantive reasons.

Insert Table 2

H2: Confirming the Factor Structure of the ICT Engagement measure. In a second step, two confirmatory factor analyses were conducted on the second half of the sample. The first CFA model, with five first-order factors (five-factor CFA), including Positive self-concept (eight manifest indicators) and Negative self-concept (three manifest indicators) related to the use of ICT, Social exposure to ICT (12 manifest indicators), Interest in computers (six manifest indicators) and Interest in mobile devices (seven manifest indicators), fitted the data well, χ^2 (584, $N_{Sample2}$ = 223) = 862.99, $p < .001$; RMSEA = .046; CLI = .91; TLI = .91. The factor loadings are reported in Figure 1, latent correlations among the five factors are presented in Table 2.

Altogether, the first-order factor loadings were significant and mostly equal or above .30 (except for item F3_9), with the majority of the loadings above .60. Further, the latent correlations ranged from $r = .19$ to $r = .80$ (see Table 2), and, thus, were moderately high except for the correlation between Interest in mobile devices and Negative self-concept ($r = .19$). The highest correlation of $r = .80$ was obtained for Positive self-concept and Negative self-concept related to the use of ICT. Especially, the correlations with Interest in mobile devices seemed to be smaller, suggesting that this factor represents a rather distinct content-specific facet of engagement.

Additionally, internal consistencies were calculated indicating a sufficiently good reliability for Positive self-concept related to the use of ICT (Cronbach's $\alpha = .88$), Social exposure to ICT (Cronbach's $\alpha = .87$), Interest in mobile devices (Cronbach's $\alpha = .77$), Interest in computers (Cronbach's $\alpha = .73$) as well as a moderate internal consistency for Negative self-concept related to the use of ICT (Cronbach's $\alpha = .61$).

As a comparison model, a second CFA model (g-CFA model) was estimated. As shown in Figure 2, the higher order model of ICT engagement consisted of one second-order factor (ICT engagement) and five first-order factors defined by the same 36 manifest indicators used in the five-factor CFA model. All first-order factors were constrained to load onto a common second order factor.

Insert Figure 2

Although the g-factor model was more restrictive than the five-factor CFA model, it still fitted the data quite well, χ^2 (590, $N_{Sample2}$ = 223) = 90.06, p < .001; RMSEA = .047; CLI = .90; TLI = .89. However, the model difference test yielded statistical significance, χ^2 (6, $N_{Sample2}$ = 223) = 922.958, p < .001, suggesting that the g-CFA model fit the data worse that the five-factor CFA model with correlated factors. In the g-CFA model, the first-order factor loadings were comparable to the ones of the five-factor CFA model. That is, all factor loadings were above .30 except for two items (F2_2 and F3_9), and mostly above .60. All second-order factor loadings except the one of factor Interest in mobile devices were above .70. The lower loading of this factor reflects that its content, that is, mobile devices, is much more specific than the content of the other four computer-related factors.

H3: Construct Validity of the ICT Engagement Measure. To obtain first evidence whether the ICT engagement scores from the five scales can be interpreted as indicator of the respective construct, we investigated the correlation of Positive and Negative ICT-related self-concept related to the use of ICT, Social exposure to ICT, Interest in computers, and Interest in mobile devices with ICT-related cognitive (theoretical computer knowledge), behavioral (practical computer knowledge) and emotional (computer anxiety) constructs. The latent correlations between all constructs are displayed in Table 3.

Insert Table 3

As expected, we found positive relations between practical as well as theoretical computer knowledge and all dimensions of ICT engagement, whereas the correlations between computer anxiety and ICT engagement dimensions were all negative. More specifically, a higher score in Positive self-concept related to the use of ICT went along with higher scores in technical computer knowledge (r = .62, p < .001), higher scores in practical computer knowledge (r = .75, p < .001) and lower scores in computer anxiety (r = -.87, p < .001). The correlations of negative self-concept were a little bit lower. Furthermore, Interest in computers was moderately and positively related to theoretical (r = .37, p < .001) as well as practical computer knowledge (r = .49, p < .001), and was negatively correlated with computer anxiety (r = -.50, p < .001). Inspecting the correlations of Social exposure to ICT revealed positive associations with theoretical (r = .58, p < .001) and practical (r = .61, p < .001) computer knowledge as well as a negative correlation with computer anxiety (r= -.45, p < .001). Finally, the corresponding correlations of Interest in mobile devices were smaller but still significant. There were positive correlations with theoretical (r = .29, p < .001) and practical computer knowledge (r = .22, p < .001), as well as a negative correlation to computer anxiety (r = -.42, p < .001).

The revealed correlations of ICT engagement factors with theoretical and practical computer knowledge as well as computer anxiety were in line with our theoretical expectations, and, therefore, provide first evidence for the construct validity of the ICT engagement measure.

Users engaged in ICT showed better (practical as well as theoretical) computer knowledge, and lower computer anxiety when it comes to the use of ICT.

7. Conclusion & Future Work

This article presents the newly developed concept of ICT engagement, a new measurement of ICT engagement, and first empirical results on the measure's dimensional structure and construct validity. The study adds significantly to the research field of ICT-related competencies by focusing and structuring metacognitive and motivational context variables which are regarded as facilitating factors of intrinsically motivated and self-regulated ICT activities including the continuous development and adaptation of ICT knowledge and skills through life span.

Previous research has addressed how the use of technology might support student engagement in school (e.g., McDowell, 2014), ICT self-efficacy beliefs (e.g., Turel, Calik, Doganer, 2015) or how student's general learning engagement can be enhanced through the use of ICT (cf. Coates & Friedmann, 2009; Varol, 2013). However, to our knowledge no systematic empirical approach has explicitly focused metacognitive and motivational context variables of ICT literacy yet, although they can be expected to have a major effect on ICT literacy (e.g., Senkbeil et al., 2013, p. 157). We rooted the proposed construct of ICT engagement theoretically in self-determinations theory (Ryan & Deci, 2000) and the construct of reading engagement (Guthrie, 1996). ICT engagement integrates the conceptually distinct dimensions of ICT-related interest, Self-concept related to the use of ICT, and Social Exposure to ICT.

The presented theoretical underpinnings of ICT engagement suggested three factors which guided the item development process. Given the novelty of the construct and the items we decided to explore the dimensional structure in a first step (Hypothesis 1). The EFA revealed a five-factor model which overall was in line with our expectations. The model included the factor Social exposure to ICT, and differentiated two factors for self-concept and interest, respectively. More specifically, the model suggested to distinguish Positive and a Negative self-concept related to the use ICT as well as to separate Interest in computers and Interest in mobile devices.

The self-concept factors were highly correlated and linked to negatively and positively worded items. This gives rise to question of whether they both are actually meaningful factors or “artifactors” (Marsh, 1996). An alternative model keeping the notion of one self-concept factor would include one substantive (self-concept) factor across all items and one method effect factor associated with negatively worded items (Pohl & Steyer, 2010).

The emergence of the distinct factor Interest in mobile devices emphasizes interest in mobile devices does not imply a more general interest in computers (and vice versa). Thereby, it is supported to refer to “ICT engagement” instead of referring to “Computer engagement”. The finding also suggests to distinguish digital devices, for instance, desktop computers, laptops, tablet computers or smartphones, when definiting concepts related to ICT. However, it also seems obvious that the separability of the factor Interest in mobile devices may be tied to the specific practices and purposes a smartphone is used for (e.g., certain kinds of social networking). Further research is needed to figure out whether this specific facet of ICT interest can be supported.

A confirmatory factor analysis based on an independent sample confirmed the five-factor model (Hypothesis 2). A general (second-order) ICT engagement factor could be established by means of the g-factor model showing an acceptable fit. The five-factor model highlights the distinctiveness the ICT engagement facets, whereas the g-factor model emphasizes the common variance across the five factors of ICT engagement. However, a model comparison revealed that the g-factor model fits data worse than the five-factor model. Thus, it is more appropriate to describe adolescents with respect to several (distinguishable) dimensions of ICT engagement instead of only one. The scales showed acceptable to good reliabilities as indicated by internal consistency estimates.

Finally, the ICT engagement dimensions correlated with cognitive, behavioral as well as emotional ICT constructs as expected providing first evidence on construct validity (Hypothesis 3). We found positive associations between computer knowledge and all ICT engagement dimensions, indicating extensive connections between individual's capacity building in ICT and their motivational and metacognitive ICT attributes. Results also showed negative relations of computer anxiety and ICT engagement dimensions.

Taken together, the empirical evaluation of the newly developed scale based on the proposed construct definition of ICT engagement was positive. Nevertheless, there is room for improvement. Conceptually, the construct of ICT engagement should be extended by the individual's perceived autonomy and internal locus of causality, respectively, when dealing with ICT. As explicated by self-determination theory (cf. Ryan & Deci, 2000), feelings of competence together with perceived autonomy enhance intrinsic motivation. Based on this conceptual extension items are to be developed and empirically evaluated. Further items should also be created for the Negative self-concept scale if it can be supported as a substantive meaningful factor. Instead it may be preferable to assume just one self-concept factor which is defined by positively worded items only.

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Appendix

Table A1

Items of the proposed five-factor ICT engagement model

Item	*Label*
I have the notion that I can handle computers confidently.	F1_1
Given appropriate time, I can solve my computer problems on my own.	F1_2
I think that most of the computer programs are easy to understand.	F1_3
With my computer at home I get on easily.	F1_4
I get on with computers that I normally never use.	F1_5
It's easy for me to get familiar with new computer programs.	F1_6
I am able to install new programs on my computer without any help.	F1_7
I can handle the majority of my computer programs confidently.	F1_8
If my computer doesn't work, I soon get tired of dealing with the computer.	F2_1
If I have problems operating my mobile phone, I can't solve them.	F2_2
If I am faced with a computer problem I often don't know what to do.	F2_3
I like to talk to my friends about recent developments in computers.	F3_1
I am very interested when friends show me new things on a computer.	F3_2
I discuss with friends when I have a question about my computer or my mobile phone.	F3_3
To learn news about computer or video games, I like to talk with my friends.	F3_4

Table A1 (continued)

Items of the proposed five-factor ICT engagement model

Item	*Label*
On internet platforms, I exchange views with others on computers, video games or mobile phones.	F3_5
I discuss with others on internet platforms how to solve computer problems.	F3_6
Sometimes I go to LAN-parties.	F3_7
I go to computer fairs with friends (e.g. Cebit, Games Convention).	F3_8
I am or was participating with schoolmates in a computer project group.	F3_9
I am or was a member in a clan (union of computer players).	F3_10
I like dealing with computer topics.	F3_11
I am interested in new features of new program versions.	F3_12
I prefer doing my homework on a computer.	F4_1
I would like it if I had to do more things on a computer.	F4_2
The computer helps me a lot, for example, when doing my homework.	F4_3
It is important for me to be able to work with a computer, for example, to find information on the internet.	F4_4
Working with computers brings me a lot of fun.	F4_5
The internet is very useful to find practical information.	F4_6
I am interested in tablet computers (e.g., iPad).	F5_1

Table A1 (continued)

Items of the proposed five-factor ICT engagement model

Item	*Label*
I am always curious when new smartphones are released.	F5_2
I am interested in the latest mobile phones and smartphones.	F5_3
I easily forget about the time when I am dealing with a computer.	F5_4
I know how to download new apps for a mobile phone from the internet.	F5_5
I think that I can handle mobile phones confidently.	F5_6
I think that I can handle tablet computers (e.g., iPad) confidently.	F5_7

Note. The response options ranged from 1 = Strongly disagree to 4 = Strongly agree. The original scale was developed in German, the version translated to English has not been evaluated yet.

Table 1

Exploratory factor analysis of the ICT engagement items

	Factor Loadings				
Item	Factor 1 (Positive self-concept related to the use of ICT)	Factor 2 (Negative self-concept related to the use of ICT)	Factor 3 (Social exposure to ICT)	Factor 4 (Interest in computers)	Factor 5 (Interest in mobile devices)
Item 1	.31	.35	.09	.01	.09
Item 2	.19	**.59**	.15	.21	.08
Item 3	.01	**.44**	-.11	.06	-.09
Item 4	.26	**.57**	.09	-.09	-.05
Item 5	**.51**	.29	-.03	.32	-.03
Item 6	.41	.42	.28	.08	-.01
Item 7	.33	.02	-.18	-.10	**-.44**
Item 8	.13	.13	.10	-.15	**-.54**
Item 9	.45	.47	.33	.04	.06
Item 10	**.72**	.05	.15	.04	.07
Item 11	**.71**	.20	-.36	.27	-.04
Item 12	**.73**	.10	-.01	.06	.00
Item 13	**.74**	-.05	.27	-.10	-.01
Item 14	.26	.12	-.08	-.05	**-.52**
Item 15	.38	.32	.38	-.09	-.11
Item 16	**.71**	.08	.07	-.08	-.01
Item 17	**.74**	.00	.02	.07	.08
Item 18	.07	.04	**.80**	.00	-.06
Item 19	.01	-.05	**.71**	.27	.11
Item 20	-.22	-.02	**.63**	.24	-.05
Item 21	-.07	-.13	.33	.24	-.37
Item 22	.01	-.02	**.80**	.06	.01
Item 23	-.28	.21	**.85**	-.01	-.08
Item 24	-.23	.36	**.77**	.07	-.09
Item 25	.05	-.02	**.78**	-.18	.00

Table 1 (continued)

Exploratory factor analysis of the ICT engagement items

Item	Factor 1 (Positive self-concept related to the use of ICT)	Factor 2 (Negative self-concept related to the use of ICT)	Factor 3 (Social exposure to ICT)	Factor 4 (Interest in computers)	Factor 5 (Interest in mobile devices)
Item 26	.25	.03	**.76**	-.22	-.01
Item 27	.04	.01	**.57**	-.05	-.08
Item 28	.33	-.11	**.77**	-.22	.02
Item 29	.25	.05	**.52**	.21	.02
Item 30	.12	.01	.34	.10	.02
Item 31	-.02	.06	.03	**.62**	-.18
Item 32	.10	-.09	.27	.28	-.14
Item 33	-.04	-.02	-.07	.12	**-.91**
Item 34	.08	-.40	.04	.29	-.40
Item 35	-.07	-.02	-.09	**.48**	-.37
Item 36	.00	.06	.07	**.64**	-.17
Item 37	-.03	-.11	.14	.06	-.82
Item 38	.00	-.12	.07	**.65**	.04
Item 39	-.09	-.01	-.20	**.42**	-.39
Item 40	.05	.03	.02	**.67**	.13
Item 41	.17	-.39	.22	.24	-.15
Item 42	.39	-.10	.30	.14	-.03
Item 43	-.21	.10	.09	-.01	**-.66**
Item 44	.08	.19	-.01	**.70**	-.07
Item 45	.12	-.03	-.17	**.60**	.21
Item 46	.21	.13	**.59**	.32	.14
Item 47	.21	.05	**.61**	.17	.02
Item 48	.17	.16	.47	.43	.12

Note. Major factor loadings are printed in bold. The results are based on sample 1.

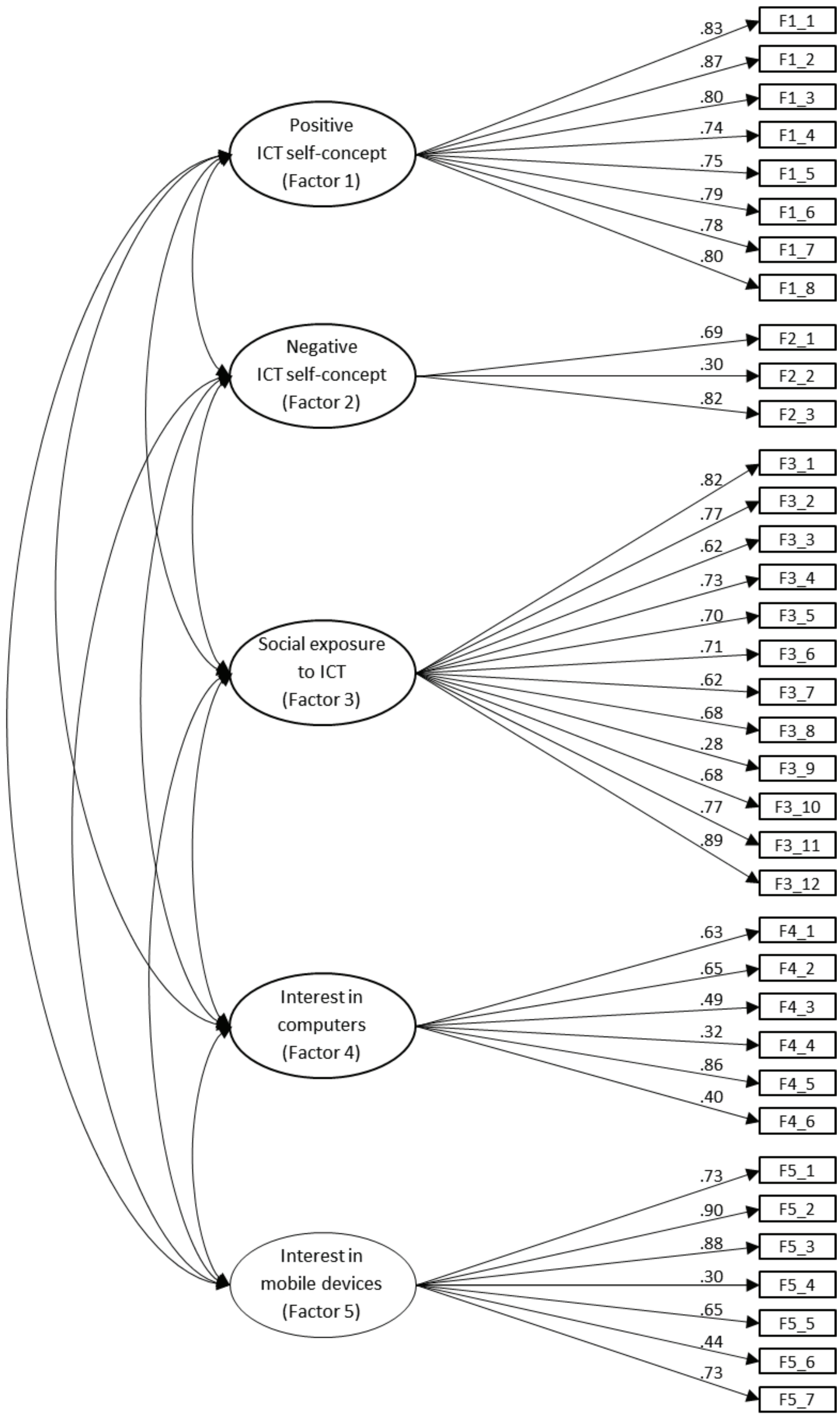

Figure 1. *Five-factor CFA model of ICT- Engagement (based on sample 2)*

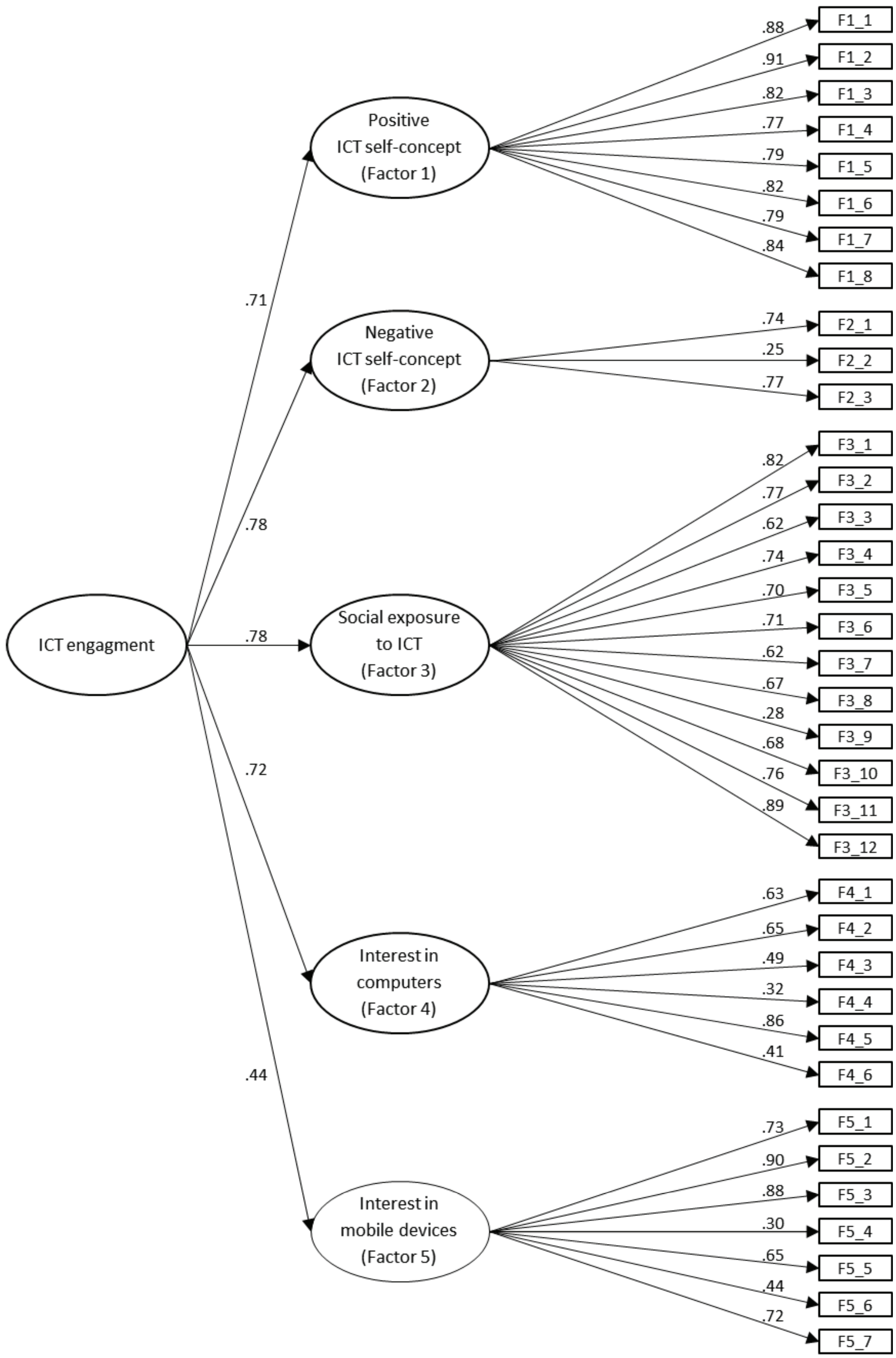

Figure 2. *g-factor CFA model of ICT engagement (based on sample 2)*

Table 2: *Latent correlations among the five dimensions of ICT engagement as obtained from the EFA and the five-factor CFA model*

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1 *(Positive self-concept related to the use of ICT)*	1	.23*	.46**	.39**	-.20*
Factor 2 (*Negative self-concept related to the use of ICT*)	.80**	1	.11	.03	-.06
Factor 3 *(Social exposure to ICT)*	.64**	.39**	1	.37**	-.34**
Factor 4 (*Interest in computers*)	.56**	.49**	.53**	1	-.36**
Factor 5 (*Interest in mobile devices*)	.37**	.19*	.31**	.37**	1

Note: Correlations above the diagonal = EFA correlation (based on sample 1); Correlations below diagonal = CFA latent correlations (based on sample 2); ** = $p < .001$; * = $p < .05$

Table 3: *Latent correlations between the five dimensions of ICT engagement and theoretical computer knowledge, practical compute knowledge, and computer anxiety*

	1	2	3	4	5	6	7	8
1 – Positive self-concept related to the use of ICT	1							
2 – Negative self-concept related to the use of ICT	.80**	1						
3 – Social exposure to ICT	.65**	.40**	1					
4 – Interest in computers	.56**	.49**	.54**	1				
5 – Interest mobile devices	.37**	.19*	.31**	.37**	1			
6 – Theoretical computer knowledge	.62**	.56**	.58**	.37**	.29**	1		
7 – Practical computer knowledge	.75**	.67**	.61**	.49**	.22**	.91**	1	
8 – Computer anxiety	-.87**	-.83**	-.45**	-.50**	-.42**	-.56**	-.56**	1

Note: ** = p < .001. The results are based on sample 2.