Computers & Education 78 (2014) 1–9

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Developing and validating of a perceived ICT literacy scale for junior secondary school students: Pedagogical and educational contributions

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A R T I C L E I N F O

Article history:
Received 9 September 2013
Received in revised form
21 April 2014
Accepted 27 April 2014
Available online 6 May 2014

Keywords:
ICT literacy scale
Junior secondary school students
Reliability
Validity
Gender differences

A B S T R A C T

Educators in the 21st century increasingly argue for the importance of information and communication technology (ICT) literacy and ask how it can be acquired formally and informally for students' effective participation in this highly technology-dependent society. There are, however, insufficient empirical measures to assess students' ICT literacy. In this study, a three-factor, 17-item perceived ICT literacy scale (3F-PICTLS) assessing information literacy (information), internet literacy (communication), and computer literacy (technology) was developed and validated using a stratified random sample of 826 junior secondary school students from 36 schools in Hong Kong. Results indicated that the scale demonstrated good reliability and validity. We discussed the pedagogical and educational contributions of the scale.

1. Introduction

In recent curriculum reforms worldwide, educators have made tremendous efforts to improve student achievement. For instance, the No Child Left Behind Act of 2001 (NCLB) in the U.S. aims to narrow the achievement gap through various mechanisms so that no child is left behind academically. Despite all these concerted efforts, there remains a profound gap between the knowledge and skills that students acquire in schools and the knowledge and skills that they need to live and work in the 21st century. Critics suggest that a holistic view of 21st century teaching and learning that combines student learning outcomes (a blending of specific skills, content knowledge, expertise, and literacies) with innovative support systems is necessary to prepare students for effective participation in this century (The Partnership for 21st Century Skills, n.d.). In this digital era, information literacy, internet literacy, and computer literacy are particularly important (Kong, 2007, 2009). Although the concept of literacy has been defined and studied extensively in educational research, defining literacy seems to be painstaking and challenging since different researchers tend to work in isolation and to address different aspects of the concept.

This study used the collective term "information and communication technology (ICT) literacy" to encompass information literacy (information), internet literacy (communication), and computer literacy (technology), which formed the conceptual framework of the ICT literacy scale to be developed and validated. In terms of measurement, the scale was considered to be a unitary construct with three correlated subscales representing the three aforementioned literacies. The following paragraphs explain and elaborate on our conceptualisation of ICT literacy.

In 2001, the Educational Testing Service (ETS) convened an international panel of experts from various government and non-government organisations and educational institutions to investigate the relationship between ICT and literacy. Their task was to develop a framework for ICT literacy, which led to the design of a large-scale ICT assessment instrument. Eventually, the panel defined ICT literacy as follows: "ICT literacy is using digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (ICT Literacy Panel, 2007, p. 2). This definition underscores the importance of information literacy and digital literacy. As central topics in the information sciences and 21st century education, information literacy and digital literacy have

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http://dx.doi.org/10.1016/j.compedu.2014.04.016
0360-1315/

been discussed in research studies with varied terminologies and meanings (Koltay, 2011; Lee, Lau, Carbo, & Gendina, 2013). Among the different definitions of digital literacy (e.g. Eshet-Alkalai, 2004; Hargittai, 2003; Zhong, 2011), Hargittai (2003) argued that digital literacy should be understood as the ability to use the internet and computers efficiently and effectively. Thus, according to this view, the concept of digital literacy includes internet literacy and computer literacy. In other words, ICT literacy should incorporate information literacy, internet literacy, and computer literacy.

Another contentious issue concerning literacy is whether it should be regarded as a set of abilities, skills, or competencies. Some researchers tend to distinguish between skills, competence, and literacy. For example, Hatlevik and Christophersen (2013) asserted that skills focus on the technical conditions of use, whereas competence and literacy are broader concepts that emphasise the importance of skills, understanding, and critical reflection. Another approach that has emerged in the literature is to express literacy in terms of sets of particular abilities to be shown, skills to be learnt, and competencies to be demonstrated (Bawden, 2001; Zhong, 2011). Bawden (2001) conducted a comprehensive review of the concept of literacy, and opined that literacy can refer to abilities, knowledge, skills, and competencies. Zhong (2011) assessed adolescents' digital literacy using the self-assessment scale for ICT use that was employed in the Program for International Student Assessment (PISA) surveys in 2003 and 2006. In order to complete the items in the scale, students need certain ICT abilities, skills, and competencies. Since the participants in the present study are only junior secondary school students, and it may not be appropriate to require their critical evaluation and reflection of their ICT use (Zhong, 2011), it is justifiable to interpret literacy as abilities, skills, or competencies in this context although we are aware that other researchers may approach the term differently.

The present study views information literacy as the capacity to identify information needs, assess information quality, manage information, use information effectively and ethically, and create and communicate knowledge through the application of information (Catts & Lau, 2008). The authors also argued that this definition of information literacy is appropriate for all domains of human development. For internet literacy, van Deursen (2010) used the term internet skills instead and contended that they comprise medium-related and content-related skills. The former skills include operational skills for using internet browsers, search engines, and forms, and formal internet skills for navigating on the internet and maintaining a sense of location. The latter skills include information internet skills for locating, selecting, and evaluating information, and strategic information skills for successful goal-oriented activities on the internet. The author further explained that the proposed definition takes a less technologically deterministic perspective by integrating the technical side about the use of the internet and the content side of the internet. This conception of internet skills presupposes a sequential and conditional relationship between medium-related and content-related skills in which the latter skills are dependent on the former skills to a certain extent.

According to Bawden's (2001) review, computer literacy can be understood as the operational skills needed for a range of computer applications software including word processing, databases, and spreadsheets as well as some general information technology skills like copying disks and generating hard-copy printout.

Interestingly, whereas many studies have focused on the definitions and conceptualisation of ICT literacy, there is a surprising lack of research on developing measures of literacy. Arnone, Small, and Reynolds (2010) noted that although there have been instruments designed for assessing children's information self-efficacy, adults' perceived information competence, and college students' perceived information literacy skills, no instrument has ever been developed for adolescents to understand their perceived competence in information literacy skills.

2. Importance of ICT literacy

Despite the controversy over the definitions of literacy (Bawden, 2001) and whether literacy should be viewed as a set of skills, a process, a way of thinking, or a practice (Herring, 2009), there is almost unanimous consensus that information literacy, internet literacy, and computer literacy are forms of literacy that are indispensable in many aspects of people's lives in the 21st century. Koltay (2011) argued that information plays a vital role in the development of democracy, cultural participation, and active citizenship, and that information literacy is increasingly important, particularly for those knowledge workers who make heavy use of the internet and computing tools. Lloyd and Williamson (2008) reviewed how information literacy is understood in educational, workplace, and community contexts, and contended that the context is influential in determining the phenomenon and shaping the practices within it. The authors proposed a research agenda for information literacy that focuses on the number of issues such as understanding the conceptualisation of information literacy in different contexts; grasping the similarities and differences of information literacy experience across contexts; and identifying the role information literacy plays for formal learning as well as for the transfer of processes and practices from formal to informal learning environments.

Regarding the importance of internet literacy, Lee and Chae (2012) remarked that this type of literacy helps to protect children from the negative influences of the media, decrease the inequality in information, and engage children fully in creative and social activities. Buckingham (2007) stressed that internet literacy should go beyond the ability to access and locate information, and that equally important is the ability to evaluate and use information critically. The author asserted that it involves questioning the sources of information, its producers' interests, and how it is represented in reality. It also demands our understanding of how technological developments are tied to broader social and economic forces.

Poynton (2005) summarised the effects of computer literacy across the lifespan at three stages (childhood, young and middle adulthood, and older adulthood) from a developmental perspective. In his review, Poynton found that the more time children spend on using computer programs, the better they perform in most of the measures of emergent literacy skills. For young adults, computer literacy is positively associated with scores on computer-based tests. Older adults, particularly those who are not computer literate at early ages, often need explicit training and instruction to develop their computer literacy skills in order to maintain equitable information access and use. Although it is increasingly being realised that the development of ICT literacy is crucial, there are few studies that aim to develop empirical measures of ICT literacy.

3. Measures of ICT literacy

The growing awareness of the importance of ICT literacy has prompted national and international organisations to develop standards and items for measuring ICT literacy. The International Society for Technology in Education (ISTE), drawing on expertise from the field, developed the National Educational Technology Standards (NETS) and promoted their use among educators. NETS represent the "standards for learning, teaching and leading in the digital age, and are widely recognized and adopted worldwide" (International Society for Technology in Education, 2012). There are NETS for teachers, administrators, coaches, and computer science educators. For students, NETS focus on six components: creativity and innovation; communication and collaboration; research and information fluency; critical thinking, problem solving, and decision making; digital citizenship; and technology operations and concepts. The Educational Testing Service (ETS) (Educational Testing Service, 2003) proposed an ICT proficiency framework, which identifies seven key components of ICT proficiency: the ability to define, access, manage, integrate, evaluate, create, and communicate information. The Australian Council for Educational Research (ACER) (Australian Council for Educational Research, 2012) conducted a national assessment of ICT literacy for students at years 6 and 10 based on a framework with six key processes in ICT literacy. These are: accessing information, managing information, evaluating information, developing new understandings, communicating, and using ICT appropriately. Irrespective of the underlying frameworks used by these organisations, ICT literacy is conceived as a unitary construct with a number of operational components.

On the other hand, some researchers tend to differentiate ICT literacy into different literacies and measure them separately. Brown (2005) developed a Student Information Literacy Self-efficacy Report (SILSER) scale to measure students' (aged 9–12) self-reported efficacy in 11 different information literacy phases: developing a topic, planning, self-management, locating sources, selecting sources, retrieving information, analysing information, evaluating information, synthesising knowledge, presenting knowledge, and self-evaluation. The 22-item scale was strongly internally consistent (Cronbach's alpha = .95), and confirmatory factor analysis (CFA) validated its 11-factor structure, chi square (χ^2) = 529.68; degree of freedom (df) = 198; the Tucker–Lewis fit index (TLI) = .940; and the root mean square error of approximation (RMSEA) = .058. Arnone et al. (2010) described the development and validation of a Perceived Competence in Information Skills (PCIS) instrument using a large sample of 8th grade students in the U.S. The instrument, which consisted of 17 items and one factor, was highly reliable (Cronbach's alpha = .93), and correlated significantly with the actual information literacy knowledge measure ($r = .41$, $p < .01$) and the general perceived competence in learning measure ($r = .74$, $p < .001$). This lends support to the predictive validity of the instrument.

Tsai and Tsai (2010) constructed an Internet Self-Efficacy Scale (ISES) to examine junior high school students' internet self-efficacy including online exploration (explorative ISE) and online communication (communicative ISE) dimensions. Cronbach's alpha for the scale (9 items) was .92, and Cronbach's alphas for the online exploration (5 items) and online communication (4 items) subscales were .91 and .92 respectively. Leung and Lee (2012) developed an inventory of 15 items from the information literacy framework proposed by Shapiro and Hughes (1996) to assess the internet literacy of children and adolescents aged 9–19. Exploratory factor analysis (EFA) revealed that the inventory consisted of 5 factors: tool literacy, critical literacy, publishing literacy, emerging technology literacy, and social-structural literacy. It was internally consistent, with Cronbach's alphas ranging from .77 to .84.

Voogt (1987) administered a Dutch version of the Minnesota Computer Literacy Awareness Assessment, called "Computer Alfabetisme Schalen Twente" (CAST), to a group of secondary school students aged 12–16. The cognitive test of the CAST with 25 items gave a reliability alpha of .77. Wecker, Kohnle, and Fischer (2007) used an adapted Computer Literacy Inventory to assess secondary school students' competency using the following three scales: procedural computer-related knowledge (12 items); familiarity with computers scale (7 items); and self-confidence in using the computer (11 items). The authors reported sufficient internal consistency (Cronbach's alpha) of the three scales as .60, .83, and .62 respectively.

In spite of the above measures, however, to our knowledge, there are still insufficient scales to date developed specifically to measure students' perceived ICT literacy at the secondary school level. Our study was unique in the way that we conceptualised ICT literacy as a unitary construct with three correlated subscales. The goal of the present study was to develop and validate a scale for measuring students' perceived ICT literacy, as Hargittai (2005) suggested that the self-reported ratings of specific digital skills could be used as a proxy for actual skill measures. Specifically, the research questions answered in this study were: Does the ICT literacy scale developed in this study demonstrate an appropriate level of reliability and validity? Are there relationships among the three literacies in the proposed ICT literacy framework?

4. Method

4.1. Item generation

A list of initial items of ICT literacy was established through a synthesis of findings of related studies (Hinkin, 1998). In particular, items for information literacy were developed with reference to the frameworks of Educational Testing Service (2003) and Catts and Lau (2008). Items for internet literacy were developed based on the definition by van Deursen (2010) with a focus on the medium-related skills because the content-related skills included in the definition were evaluated in the information literacy subscale. Finally, items for computer literacy were constructed after consulting the work of Bawden (2001). The skill-based approach (Bawden, 2001) to developing items for the scale was deemed appropriate in this setting since the research sample comprised adolescents (rather than adults or IT specialists), and the skills tested were those used on a daily basis, for example, for study and entertainment (Zhong, 2011). However, it is noted that this approach may not address the other facets of ICT literacy. For example, in some studies (e.g., Leung & Lee, 2012), the notion of internet literacy also refers to the critical evaluation and use of information. This limitation should be addressed in future research.

To ensure that the items can be well understood by the potential respondents, focus group interviews (about 6–8 members per group) were organised to collect data from students, teachers, and parents on issues concerning ICT literacy. These interviews aimed to identify appropriate indicators for the development of the scale focusing on the facets of ICT literacy. Two schools were invited to take part. For each school, two groups of Secondary 2 (Grade 8) students, one group of teachers, and one group of parents were invited to participate. Altogether, eight focus group interviews were conducted that lasted for an average of 45 min (Yu, Yuen, & Park., 2012a, 2012b). All the interviews were audio-recorded. During each interview, trained research assistants holding master's degree conducted the interview and took field notes during discussion for later transcription. Audio data from interviews were transcribed into text verbatim. Content analysis was used to identify codes in an iterative process (Miles & Huberman, 1994). For the purpose of item generation, specific words and descriptions that emerged from codes were then converted into statements by the authors in this study and they were collected into an item pool. We went through our initial item list separately and together in order to reach consensus about the items that should be included in the scale.

Then the scale was developed based on the aforesaid methods. The scale demonstrated good face validity from the perspective of the students and good content validity as the items covered the important elements of ICT literacy as judged by the researchers and the teachers. The items of the scale were then piloted with Secondary 2 students from three schools. Seventeen items were retained for subsequent validation.

4.2. Data collection

The target population consisted of Hong Kong Secondary 2 students in the 2011/2012 academic year, during which the schools were implementing the local curriculum. The sampling frame contained the school identity number, school size for the target grade, and the overall student ability levels (high, middle and low). The target sample comprised 36 secondary schools. Stratified random sampling was conducted based on a broad categorisation of the general academic ability of students in these schools in order to provide a sample that reflected the profiles of all students in the territory. Only one implicit stratum, the overall student ability level, was adopted in the sampling process. For each sample school, two replacement schools were selected to ensure that a matching replacement school would be available in the event that any sample school chose to withdraw from the study.

One intact Secondary 2 class was invited from each of the sample schools to participate in the study. As it can generally be assumed that class sizes are very similar within the same school in Hong Kong, only random sampling was conducted at the class level for each sample school to select one class out of all the classes at the same level in the school. The resulting sample consisted of 826 students after data verification with 396 males and 430 females respectively. Their mean age was 13 (SD = .773).

A briefing session was conducted for each class of students to explain the detailed procedures of data collection of the study. Students were invited to respond to an online survey. The survey was a self-reported questionnaire on ICT use and related issues including students' perceived ICT literacy. Students completed the survey during class in about 60 min.

5. Results

5.1. Exploratory factor analysis

The data were divided randomly into two equal halves. Before EFA, we performed Bartlett's test of sphericity (Bartlett, 1954) to investigate the factorability of the data, and the Kaiser-Meyer-Olkin (KMO) test (Kaiser, 1958) to measure the sampling adequacy. Results indicated a significant test statistic for Bartlett's test of sphericity, $\chi^2(136) = 4133.529$, $p < .001$, and a KMO value of .931, meaning that the data were suitable for structure detection. EFA of the first half of the data ($n = 413$) using the principal component extraction method and a promax rotation of all the 17 items revealed three factors with eigenvalues over 1.0 (Table 1). The first factor called 'information literacy', with an eigenvalue of 7.806, included seven items (Cronbach's alpha = .906). The second factor called 'internet literacy', with an eigenvalue of 1.293, included five items (Cronbach's alpha = .877). The third factor called 'computer literacy', with an eigenvalue of 2.092, included five items (Cronbach's alpha = .856). The three factors accounted for 65.825% of the total variance, and Cronbach's alpha of the scale was .923. This finding provided some support to conceptualise ICT literacy as a unitary construct with three subscales. The scale and its subscales were

Table 1
Results of EFA of the 17-item perceived ICT literacy scale.

Factor	ICT literacy	Loadings and cross-loadings			Eigen value	Cumulative variance explained	Cronbach's alpha
		INFL	INT	COML			
INFL	Information literacy				7.806	65.825%	.906
INFL1	I am able to identify appropriately the needed information from question.	.813	.355	.358			
INFL2	I am able to collect/retrieve information in digital environments.	.823	.413	.429			
INFL3	I am able to use ICT to process appropriately the obtained information.	.849	.456	.401			
INFL4	I am able to interpret and represent information, such as using ICT to synthesise, summarise, compare and contrast information from multiple sources.	.798	.411	.386			
INFL5	I am able to use ICT to design or create new information from information already acquired.	.731	.334	.349			
INFL6	I am able to use ICT to convey correct information to appropriate targets.	.806	.469	.453			
INFL7	I am able to judge the degree to which information is practical or satisfies the needs of the task, including determining authority, bias, and timeliness of materials.	.778	.451	.457			
INTL	Internet literacy				1.293		.877
INTL1	I am able to set a homepage for an internet browser.	.467	.790	.531			
INTL2	I am able to search for information on the internet using a search engine (e.g. Yahoo, Google, Baidu).	.520	.867	.548			
INTL3	I am able to use email to communicate.	.410	.807	.598			
INTL4	I am able to use instant messaging software (e.g. MSN, QQ) to chat with friends.	.338	.816	.413			
INTL5	I am able to download files from the internet.	.424	.833	.457			
COML	Computer literacy				2.092		.856
COML1	I am able to set header/footer in word processor software (e.g. Microsoft Word).	.477	.529	.861			
COML2	I am able to plot a graph and chart using spreadsheet software (e.g. Microsoft Excel).	.427	.458	.863			
COML3	I am able to insert an animation in presentation software (e.g. Microsoft PowerPoint).	.447	.537	.842			
COML4	I am able to edit a photo using image processing software (e.g. Photo Editor, Photo Impact, Photo Shop).	.371	.459	.746			
COML5	I am able to set up a printer (e.g. installing printer drivers).	.296	.416	.688			

All the items are measured on a 5-point Likert scale (1: strongly disagree to 5: strongly agree).

considered to be highly internally consistent. All item loadings were greater than .50, which show practical significance (Hair, Black, Babin, & Anderson, 2010).

5.2. Confirmatory factor analysis

CFA was conducted on the second half of the data ($n = 413$), using AMOS 20.0.0, to establish the structural validity of the scale. Maximum likelihood estimation with the option to estimate means and intercepts was chosen to handle missing data. Before the analysis, we eliminated the invalid responses (e.g., the ones filled with only 1s and 5s). This resulted in the deletion of 12 cases. The assumptions of normality and absence of outliers were evaluated. Following Kline's (2005) suggestion that only variables with absolute values of skewness greater than 3 and absolute values of kurtosis greater than 10 are of concern, none of the variables was problematic, and the data could be treated as univariate normally distributed. Mardia's coefficient, which measures multivariate normality, was 140.611. It was less than the recommended value of $p(p+2) = 17(19) = 323$, where p is the total number of observed indicators (Raykov & Marcoulides, 2008), and thus the requirement of multivariate normality was met. Univariate outliers were examined using box plots. For multivariate outliers, Mahalanobis distances of all cases were calculated and compared with the critical value of $\chi^2(17) = 40.79$ at the alpha level of .001. Using this criterion, 15 cases were removed from the data set and the final sample size was 386. We hypothesised a correlated three-factor model to be confirmed in a measurement model. The theoretical model is presented in Fig. 1. The model fit indices including $\chi^2/\mathrm{df} = 2.244$, the comparative fit index (CFI) = .964, TLI = .958, and RMSEA = .057 indicate a good fit between the model and the observed data (Browne & Cudeck, 1993; Carmines & McIver, 1981; Hoyle, 1995). Unstandardized and standardized parameter estimates are provided in Table 2 and are all statistically significant at the alpha level of .001. The R^2 values show the amount of variance of the items explained by the respective constructs. Cronbach's alphas of the subscales ranged from .844 to .908, and Cronbach's alpha of the scale was .916. Significant correlations existed between the factors (.51–.64).

5.3. Convergent and discriminant validity

To obtain further evidence of construct validity, Hinkin (1998) suggested that convergent and discriminant validity of new scales should be examined after their factor structures are confirmed. Convergent validity assesses the degree to which theoretically similar measures are in fact related to each other. According to Fornell and Larcker (1981), there are three criteria for convergent validity: (1) the factor loading of an item should be .7 or greater on its respective construct (Carmines & Zeller, 1979), implying that it shares more than 50% of variance with the construct than the error term as the loadings are in fact correlations; (2) composite reliability (CR) (Werts, Linn, & Jöreskog, 1974), which is computed as the square of the sum of all the loadings divided by the square of the sum of all the loadings plus the sum of error variance, should be at least .7 for 'modest' reliability in the early stages of research (Nunnally, 1978); and (3) average variance extracted (AVE), which is a measure of the average variance shared between a construct and its measures, and which is computed as the sum of the square of all the loadings divided by the sum of the square of all the loadings plus the sum of error variance, should be greater than .5. With regard to our present model, the constructs showed evidence of convergent validity. First, most items had a factor loading of .7 or greater on their respective constructs (Carmines & Zeller, 1979). CR values for information literacy, internet literacy, and computer literacy were .909, .898, .862 respectively, which reached the value of .7 for 'modest' reliability in the early stages of research recommended by Nunnally (1978). The AVE for the above three constructs were .590, .640, and .566 respectively and also met the minimum requirement of .5 suggested by Fornell and Larcker (1981).

Discriminant validity evaluates the degree to which theoretically dissimilar measures are in fact not related to each other. Different methods are used to test discriminant validity; for example, Barclay, Higgins, and Thompson (1995) suggested that the AVE of a construct should be greater than the variance shared between the construct and other constructs in the model. In practice, if the diagonal elements of the correlation matrix of the constructs, as replaced by the square root of the AVE, are significantly greater than the off-diagonal elements in the corresponding rows and columns, then adequate discriminant validity can be assumed. However, a more rigorous approach using the structural equation modelling (SEM) technique is to run the unconstrained model (the correlation between two constructs is free) and also the constrained model, in which the correlation between the constructs is set to 1.0. If the two models show no statistically significant difference based on a chi-square difference test, then it can be concluded that the constructs do not differ, and discriminant validity cannot be accepted (Bagozzi, Youjae, & Lynn, 1991). In the event that there are more than two constructs, this procedure must be applied to each pair of constructs one at a time. Following this idea, in testing the information literacy and internet literacy pair, the chi-square difference test between the two models, $\Delta\chi^2(1) = 799.226$, $p < .001$, affirmed the discriminant validity of the constructs. Similar results were observed for the information literacy and computer literacy pair, $\Delta\chi^2(1) = 498.537$, $p < .001$, and the internet literacy and computer literacy pair, $\Delta\chi^2(1) = 610.787$, $p < .001$. Therefore, discriminant validity of the scale was confirmed.

5.4. A second-order confirmatory factor analysis

In order to test whether the three factors belonged to a single broader latent factor of ICT literacy, a second-order CFA was conducted on the data. This procedure has been used in scale development in previous studies (Parasuraman, Zeithaml, & Malhotra, 2005; Wu, Tao, Yang, & Li, 2012) so that first-order factors may undergo a second factor analysis to examine the existence of second-order factors.

According to Chen, Sousa, and West (2005), second-order models have a number of potential advantages over first-order models. First, second-order models test whether the hypothesised higher order factor can in fact explain the pattern of relationships between the first-order factors. Second, second-order models can account for the covariance between the first-order factors parsimoniously with fewer parameters. Third, second-order models divide variance due to specific factors from measurement error so that the estimation of the specific factors can be made theoretically without error. Finally, second-order factor models simplify the interpretation of complex measurement structures.

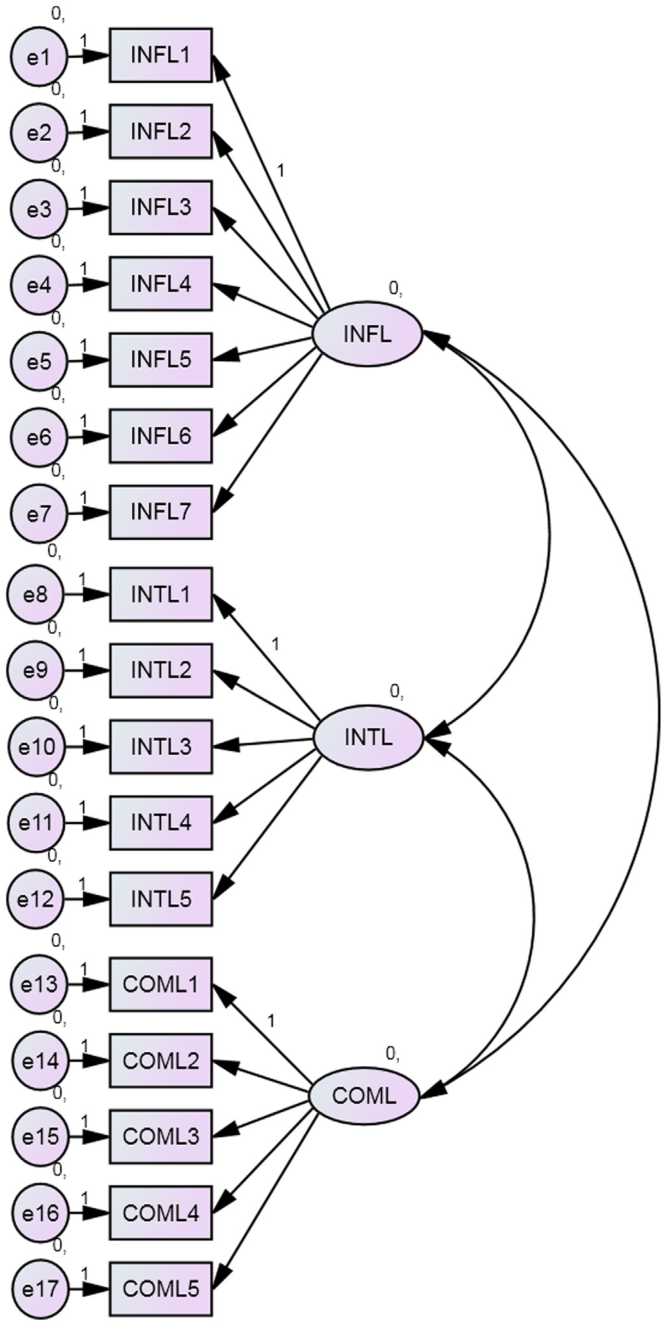

Fig. 1. A three-factor model of the 17-item perceived ICT literacy scale.

By loading the three first-order factors onto a second-order factor of ICT literacy, a CFA was conducted and results suggested a good fit: $\chi^2/\text{df} = 2.244$, CFI = .964, TLI = .958, RMSEA = .057. The standardized regression weights between the second-order factor and the three first-order factors (information literacy, internet literacy, and computer literacy) were .764, .667, and .836 respectively, and were all statistically significant at the alpha level of .001. This complies with Chin's (1998) recommendation that a high proportion of the second-order loadings should be at least .7 in a second-order construct and overall, this analysis provides empirical evidence to consider ICT literacy as a unitary construct with three correlated but distinct literacies.

5.5. Gender differences in ICT literacy

To examine whether there were any gender differences in the three factors of the perceived ICT literacy scale, a multivariate analysis of variance (MANOVA) for the three factors was performed using the whole sample. This procedure explores any evidence of known group differences based on gender, which is another aspect of construct validity (Wise, Cameron, Yang, & Davis, 2009). There was a significant gender effect, Wilks's $\lambda = .963$, $F(3, 821) = 10.516$, $p < .001$. ANOVAs revealed a significant gender effect only for internet literacy and computer literacy (Table 3). Female students reported a higher level of internet literacy than did male students. The same result was found for computer literacy.

Table 2
Results of CFA of the 17-item perceived ICT literacy scale.

Item	Unstandardized estimate	Standardized estimate	t-value	R^2	Cronbach's alpha
INFL					.908
INFL1	1	.752	[a]	.566	
INFL2	1.229	.795	16.002	.632	
INFL3	1.267	.863	17.549	.745	
INFL4	1.162	.793	15.961	.629	
INFL5	1.05	.667	13.165	.445	
INFL6	1.202	.79	15.878	.624	
INFL7	1.018	.701	13.899	.491	
INTL					.890
INTL1	1	.737	[a]	.544	
INTL2	0.951	.89	17.411	.792	
INTL3	1.065	.84	16.446	.706	
INTL4	1.021	.703	13.607	.494	
INTL5	1.075	.816	15.947	.665	
COML					.844
COML1	1	.88	[a]	.774	
COML2	1.01	.881	22.688	.776	
COML3	0.95	.788	19.015	.621	
COML4	0.812	.636	13.865	.404	
COML5	0.767	.503	10.309	.253	

[a] This value was fixed at 1.00 for model identification purpose and thus no critical ratio was calculated.

6. Discussion

For successful implementation of ICT-based innovative pedagogical practice, it is generally agreed that practice should be theme-based, which draws on multiple skills such as higher-order thinking skill and problem-solving skill (Al-Khatib, 2009). Eventually, this prepares students to develop as members of learning community. Teachers act as coaches in facilitating and collaborating with students and in providing support for solving problems. Students are autonomous in learning in the sense that they are able to determine their own learning goals and strategies, and their progress is evaluated and monitored by peers and teachers. However, the basic premises behind the above goals are that students should have acquired a certain level of ICT literacy (Arnone et al., 2010; Brown, 2005; Leung & Lee, 2012; Tsai & Tsai, 2010; Voogt, 1987; Wecker et al., 2007), and that teachers should be able to assess students' ICT literacy empirically and accurately and to integrate ICT into teaching and learning (Hsu, 2010).

It is intriguing to find that female students in the present study perceived their internet literacy and computer literacy to be higher than did male students. One possible explanation for this could be that female students tended to engage in more learning-related activities and social networking using ICT at home than did male students. For learning-related activities, students were asked to respond to three items measured on a 5-point Likert scale (1: never to 5: always): "discussion with classmates about matters on learning", "doing an assignment/a report on designated topic", and "searching for learning materials" (Cronbach's alpha = .770). Female students scored significantly higher than did male students on this construct, $t(823) = 4.541$, $p < .001$. For social networking, there were also three items measured on a 5-point Likert scale (1: never to 5: always): "downloading songs/movies/photos/pictures", "chatting with net friends (via chatroom/MSN/Skype/QQ)", and "browsing social networking sites (e.g. Facebook/Weibo)" (Cronbach's alpha = .734). Again, female students scored significantly higher than did male students on this construct, $t(823) = 2.994$, $p < .01$. As female students used ICT more for learning and leisure purposes at home than did male students, this might have enhanced their perceived internet literacy and computer literacy. Information literacy might not be influenced so much by the use of computers/the internet since it can be acquired without using ICT to a certain extent and therefore, no gender difference in this literacy was found.

Another possible reason why female students perceived their internet literacy and computer literacy to be higher than did male students could be the gender-stereotyped effect in senior years. Tsai and Tsai (2010) found in their study that female students reported a higher efficacy in online communication than did male students in Taiwan. As explained by the authors, most junior secondary school students in Hong Kong take almost the same subjects until they enter senior secondary school, when they need to specialise in some areas. The majority of male students opt for science and technology subjects in senior secondary school, whereas most female students choose art and humanities subjects instead. It is thus reasonable to believe that male students would find themselves more ICT literate compared with their female counterparts. Since this gender-stereotyped effect does not occur in the junior years, female students might feel more efficacious than male students in terms of internet literacy and computer literacy due to the above reason. Future research should investigate other factors that might cause these gender differences. For example, a cross-lagged panel study could be undertaken to identify causal relationships between potential factors across time.

Table 3
Descriptive statistics and *F* test of gender on the three subscales of the perceived ICT literacy scale.

	Total		Gender				*F*	*p*	Partial eta squared
			Male		Female				
	M	SD	*M*	SD	*M*	SD			
INFL	3.633	.637	3.653	.705	3.616	.568	.705	.401	.001
INTL	4.386	.731	4.280	.825	4.486	.614	16.728	.000	.020
COML	3.810	.823	3.726	.908	3.890	.729	8.262	.004	.010

ICT literacy is a form of literacy that influences teaching and learning significantly in this century. This study conceptualised a construct of ICT literacy, and developed and validated a generic scale with desirable psychometric properties in an authentic setting. The validated 17-item perceived ICT literacy scale (PICTLS) consists of three subscales: information literacy, internet literacy, and computer literacy. From the convergent and discriminant validity analyses, it can be inferred that the three subscales are correlated but distinct. Conceptually, this means that one form of literacy involves some of the desired dimensions that are applied to another form of literacy. For example, the items, "I am able to identify appropriately the needed information from the question" and "I am able to collect/retrieve information in digital environments" in the information literacy subscale are closely associated with the item, "I am able to search for information on the internet using a search engine (e.g. Yahoo, Google, Baidu)" in the internet literacy subscale. The implication is that any discussion of ICT literacy should focus on both the uniqueness of the respective subscales and their interrelatedness so as to allow these nuances to appear.

This parsimonious scale has the potential to provide researchers with a comprehensive understanding and evaluation of students' ICT literacy. As mentioned previously, there is a lack of empirical measures for assessing ICT literacy, and this study helps to fill this gap. If the scale is found to predict students' ICT performance, it can be utilised as a proxy for performance measures with the advantage of ease of administration and scoring. Future studies should examine whether the scale is equally reliable and valid for different cohorts of student population. It is important too to identify the antecedents and consequences of ICT literacy. Testing for configural invariance, measurement invariance, and structural invariance of the scale across demographic variables such as gender and socioeconomic status (Byrne, 2001) is also recommended.

This empirically validated PICTLS shows the importance of a multidimensional view of ICT literacy. It is therefore necessary for teachers to focus on various manifestations of ICT literacy (information literacy, internet literacy, and computer literacy), and how these interact in the learning process. Pedagogically, while the scale can provide an overall assessment of ICT literacy, it can also be used to compare individual performance in each dimension. In this case, teachers may conduct a more thorough analysis and initiate appropriate remedial actions for improvement if students are found to be weak in any of these dimensions. Schools should reinforce ICT literacy education (Lavy & Or-Bach, 2011) in the light of the findings. Currently, the subject of computer literacy is offered in the junior secondary curriculum in schools in Hong Kong, but it is often marginalised due to the tight teaching schedule. More effort is required to implement ICT literacy education with special attention paid to how various factors influence ICT literacy acquisition. Teachers should also adopt a more student-based approach to cater to the diversified needs of students.

In fact, Lavy and Or-Bach (2011) contended that it is vital to address ICT literacy education within a broader framework. Although their study focused on college students, some of their arguments are still pertinent to our current context. Firstly, as students become more and more heterogeneous in terms of their demographic backgrounds and cognitive and metacognitive abilities, this results in their differences in using ICT effectively. Secondly, ICT literacy is closely related to other literacies, such as numeracy and reading, and to other cognitive skills, and its development is thus crucial. Thirdly, a wider perspective on ICT literacy can be linked to the issue of digital divide (Compaine, 2001), which has increasingly been not only about access and use of information, but also about its effective use to empower students (van Dijk & Hacker, 2003). Finally, ICT literacy is regarded as a job skill, and employees are expected to learn new ICT skills from time to time. Based on the above considerations, schools should implement ICT literacy education for students' academic and employment needs.

7. Conclusion

Venezky and Davis (2002) found that ICT alone was not a catalyst for school wide improvements. It must be supplemented with a careful plan for implementation. The diffusion of ICT followed the traditional pattern with a small group of innovators followed by a larger group of early adopters, which in turn was followed by an even larger group of early majority and so on. Both ICT infrastructure and teachers' ICT competencies were determinants of successful ICT implementation in schools. However, without students' ICT literacy, it is hard to believe that students today learn better and more than before. This study makes theoretical and practical contributions to ICT in education by developing and validating a perceived ICT literacy scale, which was shown to demonstrate good reliability and validity. Nevertheless, research efforts should be expended on testing, refining, and revising the scale in a variety of educational contexts in order to enhance its robustness and flexibility.

Acknowledgements

This research is funded by a grant from the project "Educational Inequality and ICT Use in Schools: Bridging the Digital Divide" (HKU7025-PPR-10) of the Research Grants Council of the Hong Kong Special Administrative Region Government. The research team would like to thank the students, teachers, and school principals in the 36 schools for contributing data for analysis.

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