Measuring Digital skills

From Digital Skills to Tangible Outcomes project report

2014

Alexander J.A.M. van Deursen, Ellen J. Helsper and Rebecca Eynon

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

UNIVERSITY OF TWENTE.

Oxford Internet Institute
University of Oxford

Measuring Digital Skills

From Digital Skills to Tangible Outcomes project report

When quoting this report please use the following reference:

Van Deursen, A.J.A.M., Helsper, E.J. & Eynon, R. (2014). *Measuring Digital Skills.* From Digital Skills to Tangible Outcomes project report. Available at: www.oii.ox.ac.uk/research/projects/?id=112

Correspondence	Alexander van Deursen
E-mail	a.j.a.m.vandeursen@utwente.nl
Web	http://www.alexandervandeursen.nl
Correspondence	Ellen Helsper
E-mail	e.j.helsper@lse.ac.uk
Web	http://www.lse.ac.uk/media@lse/whosWho/AcademicStaff/EllenHelsper.aspx
Correspondence	Rebecca Eynon
E-mail	Rebecca.Eynon@oii.ox.ac.uk
Web	http://www.oii.ox.ac.uk/people/eynon/

Acknowledgements: The authors are grateful for financial support for this project from the John Fell Fund (University of Oxford), the Department of Media and Communications (London School of Economics and the Department of Communication science (University of Twente)

TABLE OF CONTENTS

Tables and Figures 6

1. INTRODUCTION 7

2. LITERATURE OVERVIEW 9
   2.1 Conceptualization of Internet skills 9
   2.2 Methods employed to measure Internet skills 10
   2.3 Scales used to measure Internet skills 11
   2.4 Measuring Internet skills 12

3. COGNITIVE INTERVIEWS 15
   3.1 Procedure 15
   3.2 Results 15

4. SURVEY PILOT TEST RESULTS 17
   4.1 Exploratory analysis 17
   4.2 Discriminant validity 24
   4.3 Confirmatory factor analysis and invariance 25
   4.4 Conclusions 26

5. POPULATION SURVEY TEST RESULTS 27
   5.1 Sampling 27
   5.2 Confirmatory factor analysis 28
   5.3 External validity 29
   5.4 Conclusions 34

6. MEASURING DIGITAL SKILLS: CONCLUSIONS 37

REFERENCES 41

APPENDICES 44

TABLES AND FIGURES

Table 1.Conceptualised Internet skills items based on theoretical framework 12

Table 2. Demographic profile UK and NL Internet users pilot sample 17

Table 3. Full scale characteristics 18

Table 4. Short scale characteristics 18

Table 5. Correlations between full scales 19

Table 6. Chi-square differences (df=1) for paired construct test 25

Table 7. Factorial invariance tests
(Operational, Information Navigation, Social and Creative scales) 25

Table 8. Model fit on CFA for the individual factors 25

Table 9. Demographic profile Dutch Internet user sample 27

Table 10. Scale characteristics in Dutch Internet user population 28

Table 11. CFA fit for long and short scales in the Dutch population 28

Table 12. Short scale characteristics in the Dutch population 29

Table 13. Factor correlation and AVE^2 (on diagonal) 31

Table 14. Convergent and discriminant validity indicators skills scales 31

Table 15. Reliability (α) of short skills scales in different groups 32

Table 16. Correlations between short scales in population survey 33

Table 17 Proposed items and factors to measure Internet skills 38

Figure 1. Ten item Operational skills scale 19

Figure 2. Three item Mobile skills scale 20

Figure 3. Eight item Information Navigation skills scale 21

Figure 4. Six item Social skills scale 22

Figure 5. Eight item Creative skills scale 23

Figure 6. Skills comparison for Gender and Age groups 29

Figure 7. Skill averages for different education groups 30

Figure 8. Skills averages by occupational group 31

1. INTRODUCTION

As the Internet becomes part of everyday life, policy makers have developed a range of initiatives to try to ensure that all individuals have Internet access to benefit from a wide range of online learning, employment, networking, and informational opportunities. Simultaneously, academic research in this field has proliferated rapidly, and we now have a great deal of research that demonstrates the complexity of factors that help us understand how and why people use the Internet. However, there is recognition amongst researchers in this field that the measures typically used in empirical work are not sufficiently nuanced. They do not fully reflect current theoretical thinking about digital inclusion and have not kept up with the changes in the ways that people use and understand the Internet.

In 2014, the authors of this report started a project with the main objective to develop an instrument that follows the theoretical model proposed by Helsper (2012). This model hypothesises that the digital and social are related for similar (economic, cultural, social and personal) types of fields. The influence of offline exclusion on engagement with digital activities is mediated by access, skills and attitudinal or motivational aspects; and the relevance, quality, ownership and sustainability of engagement with these activities is said to mediate their influence on offline outcomes. The project's objective was to develop measures that allow for testing of the model's suggested paths from social to digital inclusion and vice versa by constructing indicators for digital engagement and outcomes and a set of digital skills that influences these links.

The focus of this report is to propose a set of new measures of Internet skills. Internet skills form a key part of digital inclusion. Yet at present few measures have been developed that examine skills within a wider framework that makes theoretical links between individuals' skills, types of engagement with online services and activities, and the tangible outcomes achieved from this engagement. Our focus on this more holistic view, has led to a search for instruments that are capable of measuring which skills people have, how these are related to certain types of engagement and how these subsequently might impact specific aspects of everyday life. Such measures are essential in order to properly track who is or who is not digitally included, to assess the effectiveness of interventions designed to support digital inclusion and to provide better models of the relationships between Internet skills, engagement and outcomes. In this report, we focus on measurements for Internet skills. Further outputs, based on measures of engagements and outcomes, will follow later in 2014. The main research question is:

> ***What is the best set of reliable measures of Internet skills for use in research, practical, and policy impact evaluation settings?***

While nationally representative surveys are one of the most appropriate ways to collect data on Internet skills when testing generalizable models of digital inclusion, we have found four key challenges with the current measures available: 1) incompleteness – often only some skills are measured and digital skills related to more recent web 2.0 activities are not always fully explored; 2) conceptually blurred – as skills questions can be closely linked to Internet use (e.g. are you good at blogging / how often do you blog); 3) over-simplified – as Internet skills are often measured as a

single dimension; and 4) reliant on self-reported measures that are context dependent and positively biased.

The aim of this study is to propose a more elaborate conceptualization of Internet skills that aims to overcome these challenges, while taking into account the role skills play in a broader model of digital inclusion, and test the proposed scales for reliability and validity. In order to construct such an instrument, we took several steps. First, we conducted a systematic literature review of skills related studies, and developed our Internet skills framework and associated instrument based on this work (summarised in section 2). Then, we tested this instrument in three stages: cognitive interviews held in the UK and the Netherlands to refine the scales (section 3); online survey pilot tests of the instrument in the UK and in the Netherlands, to test the internal validity of the scales through both exploratory and confirmative factor analysis (section 4); and conducting a full survey in the Netherlands to test the skills framework for both internal and external validity (section 5). The concluding section (section 6) proposes two types of instruments for Internet skills: a short version and a more extensive version that could be used in future surveys. The focus on two countries, the UK and the Netherlands enabled the research team to begin to explore the cross-cultural validity of our proposed scale.

2. LITERATURE OVERVIEW

The focus of this report is on the creation of a set of reliable measures of Internet skills among the population at large. From our review, it seems that empirical studies concerning Internet skills that consider a broad perspective (not just educational settings) are scarce. Studies that do exist, often apply inadequate methods in terms of validity and reliability. Three aspects need to be accounted for when creating an Internet skill set: The conceptualization of Internet skills, methods employed to measure Internet skills, and the scales used.

2.1 Conceptualization of Internet skills

Several of the existing Internet skill measurements focus merely on the technicalities of Internet use (e.g., Bunz, Curry & Voon, 2007; Hargittai & Hsieh, 2012; Krueger, 2006; Potosky, 2007). These technicalities are often referred to as so-called 'button knowledge.' However, it is now widely acknowledged that Internet skills are a more elaborate concept. Several conceptualizations stress that when measuring Internet skills, both basic skills necessary to use the Internet, and skills required to comprehend and use online content should be accounted for (Bawden, 2008; Brandtweiner, Donat & Kerschbaum, 2010; Eshet-Alkalai & Amichai-Hamburger, 2004; Ferrari, 2012; Gui & Argentin, 2011; Helsper, 2008; Mossberger, Tolbert & Stansbury, 2003; Spitzbeg, 2006; Steyaert, 2002; Van Deursen & Van Dijk, 2009, 2010; Van Dijk & Van Deursen, 2014; Warschauer, 2003). By considering medium-related Internet skills and content-related Internet skills, a technologically focused view is avoided.

Several conceptualizations have broken Internet skill into more specific skills, yet most interpretations are still limited in the sense that primarily add skills related to information searching to technical aspects of use. Although this is a valuable addition to the concept itself, several scholars stress that measures should also incorporate the communication and socio-emotional skills required for the use of social media (Calvani, Fini, Ranieri & Picci, 2012; Eshet-Alkalai, 2004; Haythornthwaite, 2007; Helsper & Eynon, 2013; Jenkins, Purushotma, Weigel, Clinton & Robinson, 2009; Litt, 2012; Van Deursen, Courtois & Van Dijk, 2014; Van Dijk & Van Deursen, 2014). Additionally, content creation skills, or creative skills, are nowadays mentioned as an important addition of Internet skills concepts (Ferrari, 2012; Helsper, 2008; Van Dijk & Van Deursen, 2014).

Ferrari (2012) considers digital competence as a combination of Information skills, Communication skills, Content Creation skills, Safety skills, and Problem Solving skills. Her Operationalization of Communication skills, however, is technically oriented; based on the number of devices used for online communication. Content Creation is considered as the skill to produce content in different formats, platforms, and environments. Helsper and Eynon (2013) defined four broad skill categories; Technical, Social, Critical, and Creative skills. This classification is based on media literacy research which suggests that skills should be measured beyond the basic technical level and in relation to the ability to work with communication technologies for social purposes. Van Deursen and Van Dijk (2009a, 2009b, 2010) measured Internet skill using the following domains: Operational, 'the skills to operate digital media'; Formal, 'the skills to handle the special structures of digital media such as menus and hyperlinks'; Information, 'the skills to search, select and evaluate information in digital media'; and Strategic, 'the skills to employ the information contained in digital media as a means to

reach a particular personal or professional goal. Recently, Van Dijk and Van Deursen (2014) completed this framework by adding both Communication and Content creation skills. They defined Communication Internet skills as the ability to encode and decode messages to construct, understand, and exchange meaning with other humans using message systems such as e-mail, chat boxes, or instant messaging. This entails searching, selecting, evaluating, and acting upon contacts online, encoding, decoding, and exchanging messages online, attracting attention online, profiling, the capacity of online experimentation for better decision-making, the social ability to pool knowledge and exchange meaning with others in peer-to-peer networking and the ability to exchange meaning to reach decisions and realize transactions while understanding the meanings of others/partners. The concept generally matches with the elaborate concept of Communication skills proposed by Spitzberg (2006), who considered coordination, attentiveness, expressiveness, composure, selectivity, appropriateness, effectiveness, clarity, satisfaction, attractiveness, efficiency/productivity and general usage/experience. Van Dijk and Van Deursen (2014) consider Content creation skills to be the skills to create content of acceptable quality to be published on the Internet. It is about textual, music and video, photo or image, multimedia and remixed content. Derived from the framework of Van Dijk and Van Deursen (2014), and adjusted in correspondence with findings of several of the mentioned studies, we propose a framework consisting of five different types of Internet skills. These are listed in table 1 in section 2.4.

2.2 Methods employed to measure Internet skills

Overall, three basic methods are employed to investigate levels of Internet skills:

1. Surveys with questions that ask for the use of the Internet or the applications engaged in, which are assumed to deliver indirect evidence for the command of skills. When an individual uses an application that is conceived to be difficult to use, this is held to be an indication of a high level of skills.
2. Surveys with questions that request self-assessments of skills. This is the most commonly used method.
3. Performance tests in a laboratory or other controlled environments that provide subjects with particular assignments to observe their command of Internet skills.

The main problem with the first method is that the relation between use of the Internet and Internet skills is unclear (Van Deursen & Van Dijk, 2010). However, this method is common in large benchmarks such as Eurostat. Since the aim of this report is part of a larger project in which skills, use, and Internet outcomes are considered, it is not feasible to put use on par with skills. After all, we are interested in clarifying how different skills relate to different types of engagement and different outcomes of Internet use.

The second method also has problems. Self-assessments lead to overrating and underrating of the skills possessed (Hargittai, 2005; Merrit, Smith & Renzo, 2005; Van Deursen & Van Dijk, 2010; Talja, 2005). However, they are one of the most prevalent ways of measuring Internet skills. The main advantages are being able to present a large number of questions on a wide range of skills in a relatively short time, simple scoring, fast processing, and cost effectiveness (Kuhlemeier & Hemker, 2007). Thus, since our goal is to create items that can be reused in many contexts, here we propose

items that use self-assessments, although several of the items used are derived from proxy-items based on actual performances (Van Deursen, Van Dijk & Peters, 2012). Furthermore, we try to limit the problems with self-assessments by using very carefully worded items and correspondingly appropriate scales for measuring Internet skills.

Of the three methods, the final type, i.e. performance tests, show the most internal validity a prerequisite to develop measurements of skill. Hargittai (2002) was the first to conduct such experiments from a sociological point of view in the USA. Based on her methods, Van Deursen and Van Dijk (2009a, 2009b, 2010, 2011a, 2011b, 2012) conducted such tests among large samples of the Dutch population between 2008 and 2011. Over 300 people took part in the tests. The tests revealed the status quo in Internet skills and the problems people experienced. However, performance testing is also very costly and time-consuming which makes it less suitable for large-scale population-wide surveys. The best alternative for performance tests are questions that have been validated by using actual performances as benchmarks. Van Deursen, Van Dijk & Peters (2012), for example, proposed proxy questions that reflect Operational, Formal, Information, and Strategic Internet skills. The items used to measure these skills were derived from the performance tests conducted in the Netherlands and we incorporated these into the measurement instrument we tested.

2.3 Scales used to measure Internet skills

Studies using self-reports to measure Internet skills use a variety of scales. Examples of scales used are (for a more complete overview, see Litt, 2012):

- Self-reported skills, response items ranging from “very poor” to “excellent”
- Self-reported skills, response items “beginner,” “average,” “advanced” or “expert”
- Self-reported agreement on skill items, responses ranging from “not agree” to “agree”
- Self-reported familiarity with skills, response items ranging from “very familiar” or “somewhat familiar”
- Self-reported “Do you know how to”-items, with responses “Yes” and “No”
- Self-reported truth about skill levels, responses items ranging from “not at all true of me” to “very true of me”
- Self-reported frequency of skill related actions, response items ranging from “never” to “several times per day”

In the current study, we decided to use the Likert-type format to allow subjects more flexibility. Furthermore, we choose to use response items using truth claims. Spitzberg (2006) applied the scales “Not at all true of me,” “Not very true of me,” “Neither true nor untrue of me,” “Mostly true of me,” and “Very true of me,” in terms of the respondents’ behaviour related to Internet skills. Participants indicated the extent to which they believed each item to be true of them. Based on prior experiences of cognitive interviews, we suggest that the wording of this scale, invites a more neutral and objective response from participants, compared to scales which used more emotive and personal discourse like “poor.” It also encourages the respondent to reflect on themselves, rather than using terms that more easily evoke comparison with others (e.g., “expert”). Finally, we decided to take the mean of the items that make up one Internet skill. This procedure is most common, and since we do

not have the exact same number of items in each Internet skill construct, summing scores does not provide a comparable scale in-between Internet skill types.

2.4 Measuring Internet skills

For each of the five skill areas in the framework, we used, adapted and derived items from previous research by Van Deursen, Van Dijk and Peters (2012), Helsper and Eynon (2013), Sonck, Livingstone, Kuiper and De Haan (2011), and Macheroni and Olaffson (2014); while at the same time, designing items that met the objective of the larger project, namely relating online and offline engagement to differences in usage and the skills we need for this usage. Our original set of items was then refined as a result of the cognitive interviews (see section 3). The final set of items is outlined in table 1. Several of the proposed items in table 1 correspond with earlier proposed Operational, Formal and Information skills proxy items that showed high correlations with actual performances (Van Deursen, Van Dijk & Peters, 2012).

Table 1. Conceptualised Internet skills items based on theoretical framework

Medium-related Internet skills	
Operational Internet Skills	***Operating mobile Internet***
	I know how to connect to a WIFI network
	I know how to download apps to my mobile device
	I know how to turn my mobile phone off
	I know how to keep track of the costs of mobile app use
	I know how to install apps on a mobile device
	Operating the Internet environment
	I know how to open a new tab in my browser
	I know how to go to the previous page when browsing the Internet
	I know how to use the refresh function
	I know how to use shortcut keys (e.g. CTRL-C for copy, CTRL-S for save)
	I know how to bookmark a website
	I know how to download files
	I know how to upload files
	I know how to adjust privacy settings
	I know how to download/save a photo I found online
	I know how to open downloaded files
	I know which apps/software are safe to download
	I know how to make pop-ups or ads disappear
	I know some good ways to avoid computer viruses
	If a technical problem occurs while I am using the Internet, I usually know how to fix the problem
	Operating Internet-based search engines
	I know how to open a Web address directly without using a search engine like Google
	I know how to complete online forms
Formal Internet Skills	I tend to have no problems finding my way around a website
	I know where to click to go to a different webpage
	I find it hard to find a website I visited before
	Sometimes I end up on websites without knowing how I got there
	All the different website layouts make working with the Internet difficult for me
	I find the way in which many websites are designed confusing
	I get tired when looking for information online

Table 2. Contnd.

Content-related Internet Skills

Informational Internet Skills	It is easy for me to find information
	I should take a course on finding information online
	I know how to use a wide range of strategies when searching for information
	I find it hard to decide what the best keywords are to use for online searches
	I am confident selecting search results
	I normally look at more than the top three search results
	Sometimes I find it hard to verify information I have retrieved
	I feel confident in my evaluation of whether a website can be trusted
	I generally compare different websites to decide if information is true
	I carefully consider the information I find online
Communicational Internet Skills	I know when I should and shouldn't share information online
	I am careful to make my comments and behaviors appropriate to the situation I find myself in online
	I know how to change who I share content with (e.g. friends, friends of friends or public)
	I know how to remove friends from my contact lists
	I am confident about writing a comment on a blog, website or forum
	I feel comfortable deciding who to follow online (e.g. on services like Twitter or Tumblr)
	I know how to use emoticons (e.g. smileys, emojis or text speak)
	I know which information I should and shouldn't share online
Content Creation Internet Skills	I would feel confident putting video content I have created online
	I would feel confident writing and commenting online
	I know how to create something new from existing online images, music or video
	I know how to make basic changes to the content that others have produced
	I know how to design a website
	I know which different types of licences apply to online content

For reasons described in section 2.3, each item is scored on a five point Likert scale with self-reported truth response items:

1) Not at all true of me
2) Not very true of me
3) Neither true nor untrue of me
4) Mostly true of me
5) Very true of me

Furthermore, we decided to give participants the option to choose "I do not understand what you mean by that," because not knowing what something is (e.g. WIFI network) is subtly, but importantly, different to knowing what something is but not knowing how to do it (e.g. connecting to the WIFI network). Allowing more flexibility in response options also ensures respondents feel less pressure to know certain things, and thus reduces the likelihood or respondent bias / exaggerating their level of skill.

3. COGNITIVE INTERVIEWS

3.1 Procedure

To test the proposed Internet skill questions, three steps were followed. The first step was the use of cognitive interviews to detect items that were not understood by respondents as intended by the survey developers. Cognitive interviews were conducted in both the UK and in the Netherlands with 25 participants. The interviews took place in November 2013-January 2014. The group of 25 participants in both countries contained varying ages and levels of education, and both men and women. The interviews helped us in evaluating whether the items proposed indeed measured the skill constructs we intended. We checked whether respondents with different socio-demographic backgrounds understood the question, found the question relevant, and were able to formulate an answer in the provided answer truth-scales. Originally, all questions were formulated in English. Two of the researchers are Dutch and independently translated the questionnaire into their mother tongue for the Dutch pilot study.

3.2 Results

The results of the cognitive interviews were used in two ways. First, we made sure that all problems regarding understanding and answer formulation were corrected before the survey pilot tests (discussed in the next section) started. Before fielding the pilot tests, we used the collected data to evaluate and adjust questions that surfaced as problematic in the cognitive interviews. Several spelling mistakes were corrected. Overall, items that appeared difficult to interpret in the English version were also difficult in the Dutch version.

For example, in some cases, questions were changed to better capture someone's knowledge of doing something rather than whether they had done it or not. For example, in operating mobile Internet devices the original item, 'It is difficult for me to turn off my mobile phone' was changed to, 'I know how to turn my mobile phone off.' As participant 5 explained, "*I know how to do a lot of these things but I just don't do them, if that makes sense*." As noted above, this was key to our approach, and echoed by a number of our interviewees who told us they knew how to do many of the tasks referenced in these sections but just did not do them.

In other items, we added examples or context as this assisted with participants understanding of the question. For example, in operating an Internet browser, the original item 'I know how to use shortcut keys' was changed to 'I know how to use shortcut keys (e.g. CTRL-C for copy, CTRL-S for save).'

Particularly within content-related skills, we had to revise some of the wording of items to make the questions easier to understand. For example, within informational Internet skills, our original item 'I am critical about the information I find online' was changed to 'I carefully consider the information I find online' as the word critical was often considered misleading as people understood the term as about judging a source negatively as opposed to the judgement of a source. Similarly, in communication skills, 'I am confident about publishing a comment on a blog, website or forum' was changed to 'I am confident about writing a comment on a blog, website or forum' as "publishing" was not clear and some participants felt, "*it could be simpler*."

Other items were revised as they simply were not clear. For example, one communication related skills item, 'I know who to follow in online information sharing places (e.g. like Twitter or Tumblr)' was changed to 'I feel comfortable deciding who to follow online (e.g. like Twitter or Tumblr)' as people felt the first question was simply asking about personal choice. As participant 5 asked, "…*are there people on Twitter that you shouldn't follow? That's a personal choice, surely. I know who to follow on-line and information sharing places. Well, I don't see how that… why would you not know? You just follow who you want to follow.*"

Other more minor changes included: ensuring that only one skill was asked about at one time, deleting items that participants felt were repeats of what they had already been asked (even when we felt they were subtly different as it caused unnecessary frustration), and addressing problems of cognitive load of moving between positive and negative statements.

Second, after analysing the data gathered in the survey pilot tests, we checked the items that surfaced as problematic by looking at the cognitive interview results. If the items that behaved differently than we expected appeared problematic in the interview results, we used these results to revise the item, or replace it with a newly developed one.

In the UK interviews, some of the informational items that were retained but problematic (see below) did cause a few problems for some participants, simply because their information seeking strategies were quite context dependent, and so their responses to these questions varied depending on which context they were thinking about. For example, participant 7 said, "*Carefully consider the information I find online?" (…) Depending what mood I'm in (…) or how important it is*".

Indeed, as will be discussed further below, context often matters. When answering the item "I know how to remove friends from my contact lists" participant 11 told us, "*So sometimes, yeah on my email account I probably do know how… I know how to delete contacts and things, remove them. On Facebook (…) I'm not like a pro on Facebook really.*"

4. SURVEY PILOT TEST RESULTS

Both in the UK and in the Netherlands we conducted pilot tests in May 2014. The aim of the pilots was testing the reliability of the constructed scales, and to check whether the pilots in both countries result in similar factor solutions. In the UK pilot, 324 respondents completed the online survey, and in the Dutch pilot 306 respondents. The fieldwork was done by Toluna, a marketing research organization who used an online sample panel recruited offline to represent the general population. The respondents represented a random sample of Internet users in both countries.

Table 3. Demographic profile UK and NL Internet users pilot sample

	UK		NL	
	N	%	N	%
Gender				
Male	159	49	152	50
Female	159	49	153	50
Age				
16 to 30 yrs.	62	19	80	26
31 to 45 yrs.	90	28	76	25
46 to 60 yrs.	83	26	100	33
61 yrs. and older	69	21	48	16
Occupation				
FT employed	130	40	108	35
PT employed	48	15	47	15
Unemployed	17	5	31	10
Student	16	5	35	11
Caretaker	68	21	35	11
Retired	28	9	23	8
Not able to work	10	3	25	8

Base: Internet Users (UK N=324, NL N=306)

We analysed the results in two steps. First, we conducted exploratory factor analyses by using a merged UK and NL dataset, and by analysing the UK and NL datasets separately. In the second step, we used structural equation modelling to conduct a confirmatory factor analysis (CFA) for the two independent samples.

4.1 Exploratory analysis

In the exploratory factor analysis, we based the factor solutions on the number of factors with eigenvalues that exceed 1.0, on the percentage of variance accounted for by the factors, and on the cohesiveness of the skill items within the identified factors. We used varimax rotation because we knew from previous research that digital skills are related and we, therefore, expected ambiguity in positioning some of the items which might make them load on more than one factor. Factor loadings of .40 were considered to be significant for inclusion of the items in a factor (Stevens, 1986).

Factor Analyses of the merged dataset (UK and Netherlands) resulted in a solution with eight factors with eigenvalues over 1.0, together explaining 68% of the variance. However, two factors of this eight fold structure did not contain any items with loadings over .40. We therefore repeated the maximum likelihood analysis with varimax rotation and forced a six-dimensional solution. This resulted in the identification of six conceptually distinct factors that together accounted for 64% of

the variance (goodness of fit: χ^2=3557.82, df=1029, p<.001). We then repeated the six factor solution analyses for both the UK (63% explained variance, goodness of fit: χ^2=2139.65, df=1029, p<.001) and the Netherlands (69% explained variance, goodness of fit: χ^2=2786.16, df=1029, p<.001). The factor loadings are presented in Appendix A1.

The ultimate goal was to create easy-to-use scales with no more than ten items for each construct. These scales should be reliable and valid and thus not contain items which were either theoretically or empirically inconsistent or ambiguous. We used the following procedure to decide on the items that would be used to construct the scale:

- We used the exploratory factor analysis of the merged dataset to come up with conceptualisations for the six factors and labelled these Operational, Navigational, Mobile, Informational, Social, and Creative. They represented the proposed theoretical framework.
- If there were items that were ambiguous, that is they loaded on a different factor than expected, we deleted them.
- We looked at the factor loadings in the UK and the Netherlands and if there were items that loaded on different factors in the UK than in the Netherlands we made a decision based on theory to delete them if these were difficult to reconcile with the way we had theorised the concepts.

The configuration and characteristics of the five final scales (the navigational skills scale was dropped – see deleted items section) are discussed in detail below as well as the decisions made to include or remove certain items from a particular scale.

The reliability scores for these five skill factors are high and the means do not differ significantly between the Netherlands and the UK (see table 3).

Table 4. Full scale characteristics

	Overall			UK			NL		
Skill type	α	M	SD	α	M	SD	α	M	SD
Operational	0.92	4.56	0.66	0.91	4.50	0.69	0.92	4.62	0.61
Mobile	0.94	3.96	1.31	0.95	3.94	1.33	0.92	3.98	1.29
Information Navigation*	0.92	3.68	1.04	0.93	3.72	1.02	0.91	3.63	1.05
Social	0.88	4.33	0.73	0.85	4.31	0.71	0.91	4.35	0.75
Creative	0.91	3.44	1.01	0.91	3.34	1.05	0.90	3.54	0.95

Base. Overall N= 622, UK N=317, NL N=305;
*The Information Navigation skill was reversed since it contained negatively worded items.

Table 5. Short scale characteristics

	Overall			UK			NL		
Skill type	α	M	SD	α	M	SD	α	M	SD
Operational	0.86	4.65	0.66	0.83	4.55	0.70	0.89	4.75	0.61
Information Navigation*	0.90	3.70	1.08	0.91	3.74	1.05	0.89	3.66	1.11
Social	0.88	4.40	0.70	0.85	4.39	0.68	0.91	4.41	0.73
Creative	0.89	3.10	1.18	0.90	2.97	1.23	0.88	3.24	1.11

Base. Overall N= 622, UK N=317, NL N=305
*The Information Navigation skill was reversed since it contained negatively worded items.

We also created short scales for each of these scales of five items (except the Mobile skills scale since it had only 3 items). All the short scales also showed good reliability and no significant differences between the Netherlands and the UK. See table 4.

Since we used varimax rotation, the factors were significantly correlated indicating that those who are good in one skill area are also good in another area (see table 5). The correlations with the Information Navigation skills were the lowest, in the case of the correlation with Creative skills this was in fact very low. This confirms earlier research by Helsper and Eynon (2013) which also found that informational skills can be clearly identified as a separate concept.

Table 6. Correlations between full scales

	Operational	Mobile	Information Navigation	Social	Creative
Operational	1				
Mobile	.608**	1			
Information Navigation	.261**	.138**	1		
Social	.631**	.555**	.248**	1	
Creative	.579**	.637**	.084*	.640**	1

*Significant at the 0.05 level (2-tailed). **Significant at the 0.01 level (2-tailed).

4.1.1 Operational skills

Based on the exploratory factor analysis we identified ten items that loaded together on what we labelled Operational skills.



Figure 1. Ten item Operational skills scale

N=622 (doesn't include those who answered 'I don't know what this means')
Note. All questions had response options ranging from 1 'Not at all true of me' to 5 'very true of me'

The five highest loading items on this scale (in dark blue in figure 1) which should be used to create a *short scale* were:

- I know how to open downloaded files (λ=.723)
- I know how to download/save a photo I found online (λ=.696)
- I know how to use shortcut keys (e.g. CTRL-V) (λ=.669)
- I know how to open a new tab in my browser (λ=.667)
- I know how to bookmark a website (λ=.664)

From the other items that loaded on this factor in the combined dataset of the Netherlands and the UK, we decided to remove the item 'I know how to turn my mobile phone off' since it did not fit well with the other items conceptually and did not load with the mobile device items as we expected it to. Furthermore, we decided to remove two items ('I know how to make a pop-up disappear' and 'If a technical problem occurs while I am using the Internet, I usually know how to fix the problem') because, while theoretically they fall on this scale, empirically they grouped with the Creative skills items.

4.1.2 Mobile Internet skills

Figure 2 shows that the Mobile skills scale loaded clearly with three items in the Netherlands, UK and the merged dataset. Since it has only three items there was no need to create a shorter scale.

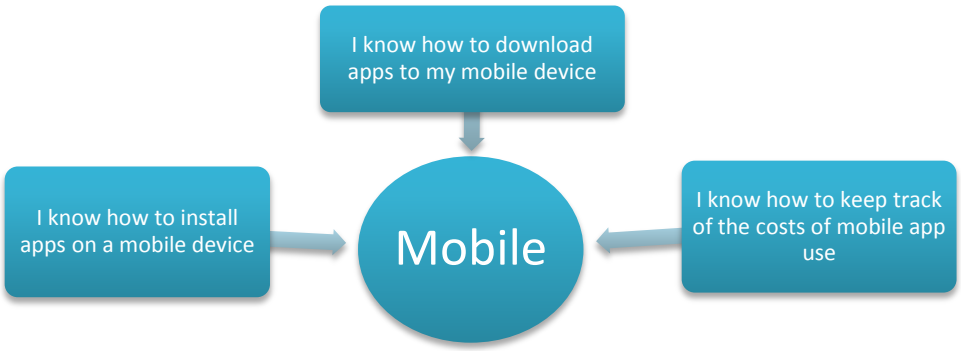


Figure 2. Three item Mobile skills scale

N=620 (doesn't include those who answered 'I don't know what this means')
Note. All questions had response options ranging from 1 'Not at all true of me' to 5 'very true of me'

Important to note is that the mobile skills caused the most problems in the exploratory factor analysis, they loaded heavily on Creative skills. In the Netherlands they grouped with operational and navigational items. We decided to keep this as a separate scale since it is related to a newer application and there is a lot of current desire to understand the importance of and distribution of skills in using mobile devices.

4.1.3 Information navigation skills

The formal and informational skill items seem to correspond to a similar factor, which can be explained by the fact that navigational issues primarily rise when looking for information. We therefore labelled this factor *Information Navigation skills.* This factor consists the eight items presented in figure 3.

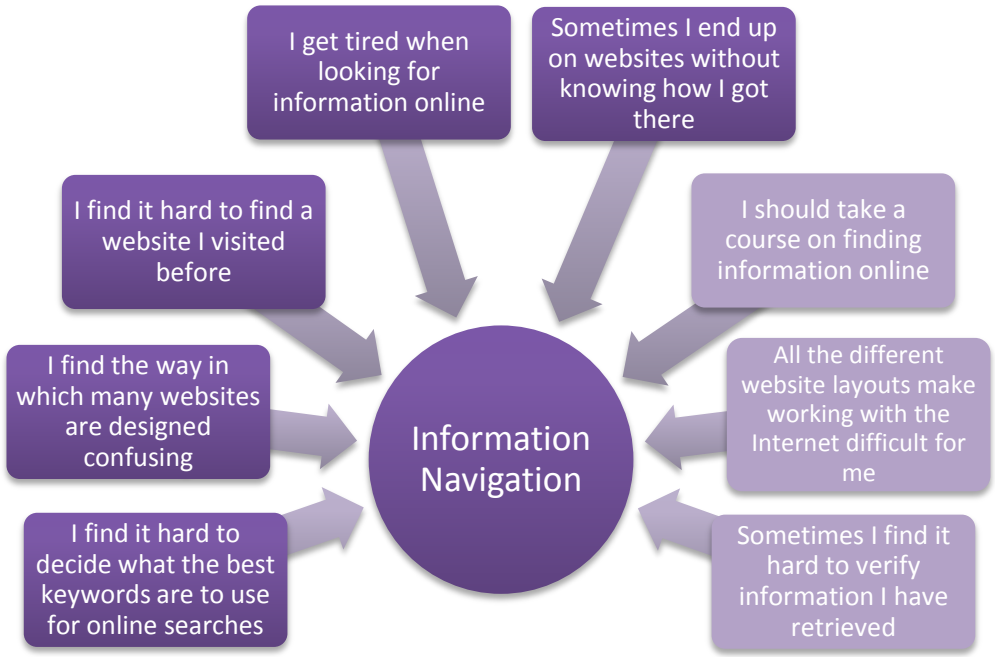


Figure 3. Eight item Information Navigation skills scale

N=621 (doesn't include those who answered 'I don't know what this means')
Note. All questions had response options ranging from 1 'Not at all true of me' to 5 'very true of me'

The five highest loading items on this scale (in dark purple in figure 3) which can be used to create a *short scale* were:

- I find it hard to decide what the best keywords are to use for online searches (λ=.840)
- I find it hard to find a website I visited before (λ=.806)
- I get tired when looking for information online (λ=.803)
- Sometimes I end up on websites without knowing how I got there (λ=.788)
- I find the way in which many websites are designed confusing (λ=.775)

As regards the information navigation items, it is important to note that they are all negatively formulated. This phrasing was based on external validity testing through performance test in the Netherlands. We recommend that future research use positively formulated items measuring the same skills.

There were a number of information searching items that did not load high enough on this scale to be included but which theoretically we might have expected to be a part of this scale:

- I feel confident in my evaluation of whether a website can be trusted
- I know how to use a wide range of strategies when searching for information
- I generally compare different websites to decide if information is true
- I carefully consider the information I find online
- I know how to open a Web address directly without using a search engine like Google
- I tend to have no problems finding my way around a website
- I am confident in selecting search results
- I normally look at more than the top three search results

Some of these items could be argued to signify critical skills which were highlighted as problematic in the cognitive interviews as they relate to contextual issues. For example, "I generally compare different websites to decide if information is true." As noted in section 3, a number of interviewees pointed out that the extent to which they were critical depended on the nature of the information being sought and the relative importance of that information. For example, making a quick search to help inform a light hearted discussion about a celebrity was undertaken in a very different way to searching for information for a health problem or for college work. Overall, items that try and measure metacognitive processes prove to be problematic. In addition, items such as "I am confident in selecting search results" easily lead to overestimation of the respondent. Furthermore, some of these items, for example, "I normally look at more than the top three search results," do not necessarily reflect a skill level. If someone uses well thought-through search queries, it might not be necessarily to look at more than the first three results. So all of the items listed above are not included in the final scale. However, given the importance of critical skills, we recommend that they are included in future research if there is space in the survey instrument and further work needs to be carried out to determine a strong set of more contextually specific items.

4.1.4 Social skills

More recent research has emphasised the importance of social and communicative digital skills for many of the activities that take place on digital platforms. The factor analysis showed six items clearly loading on this type of scale in both the Netherlands and the UK (see Figure 4).

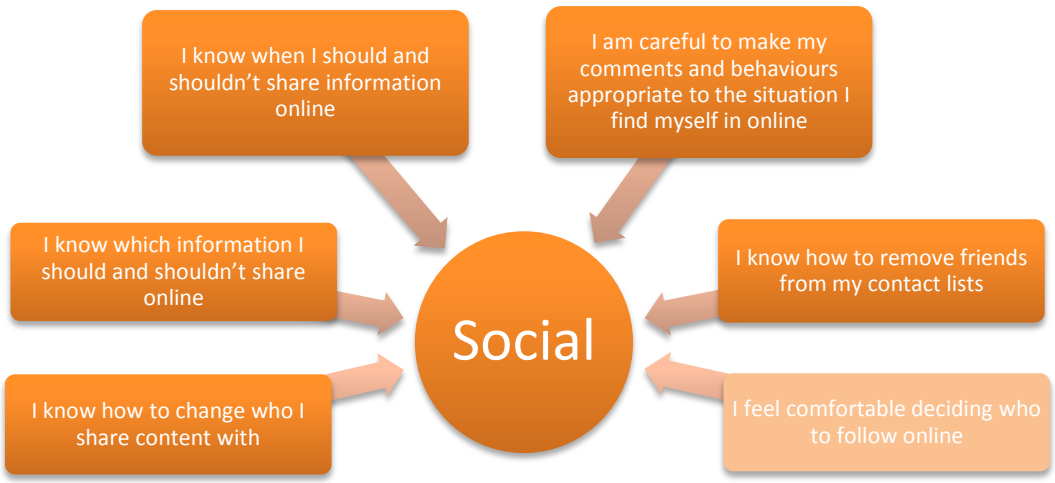


Figure 4. Six item Social skills scale

N=619 (doesn't include those who answered 'I don't know what this means')
Note. All questions had response options ranging from 1 'Not at all true of me' to 5 'very true of me'

The five highest loading items on this scale (in dark orange in figure 4) which can be used to create a *short scale* were:

- I know which information I should and shouldn't share online (λ=.725)
- I know when I should and shouldn't share information online (λ=.689)
- I am careful to make my comments and behaviours appropriate to the situation I find myself in online (λ=.677)

- I know how to change who I share content with (e.g. friends, friends of friends or public (λ=.569)
- I know how to remove friends from my contact lists (λ=.553)

We removed two items ('I know how to use a wide range of strategies when searching for information' and 'I feel confident in my evaluation of whether a website can be trusted') because while they loaded on the Social factor in the UK they loaded on the Creative factor in the Netherlands and theoretically we expected them to load on the information skills scale.

4.1.5 Creative skills

The exploratory factor analysis also brought up an eight item Creative skills scale (see figure 5).



Figure 5. Eight item Creative skills scale

N=621 (doesn't include those who answered 'I don't know what this means')
Note. All questions had response options ranging from 1 'Not at all true of me' to 5 'very true of me'

The five highest loading items on this scale (in dark red in figure 5) which can be used to create a *short scale* were:

- I know how to create something new from existing online images, music or video (λ=.816)
- I know how to make basic changes to the content that others have produced (λ=.803)
- I know how to design a website (λ=.744)
- I know which different types of licences apply to online content (λ=.697)
- I would feel confident putting video content I have created online (λ=.693)

There were two items that loaded on the Creative factor but which theoretically we had expected to be on the Operational scale:

- I know how to make pop-ups disappear

- If a technical problem occurs while I am using the Internet, I usually know how to fix the problem

We decided not to include these but it could be argued that they are about creating a personal, comfortable technological environment rather than content. Later publications will explore this issue.

4.1.6 Items that were dropped

Our process of selection led to the deletion of three items that could be labelled as Navigational in the six factor solution of the merged dataset. In the UK and the Netherlands either the Operational skills scale or the Information Navigation scale showed high loadings for these items. In neither country could these really be identified as a separate scale. This ambiguity led us to decide to leave out the following three items that loaded on the Navigational scale in the merged dataset[1]:

- I know how to go to the previous page when browsing the Internet
- I know how to use the refresh function
- I know how to download files

As can be seen in Appendix A2, several of the items did not load on the expected skill factor, or loaded on different factors in the NL as compared to the UK. Based on these results we made the decision to further remove the following items:

- I know how to use emoticons
- I know some good ways to avoid computer viruses
- I know how to go to the previous page when browsing the Internet
- I know how to use the refresh function
- I know how to download files
- It is easy for me to find information

4.2 Discriminant validity

To test whether the factors measured truly different constructs a simple discriminant analysis was performed by doing a Chi-square difference or paired construct test (Anderson & Gerbing 1988; Segards, 1997). This test compares the chi-square scores of a Confirmatory Factor Analysis (CFA) model where two factors are correlated with those of a CFA model where the same two factors are not correlated, if the chi-square difference is significant the factors can be considered to exhibit discriminant validity.

All of the chi-square differences were significant at $p<.001$ except the differences between Information Navigation and Creation skills and between Information Navigation and Mobile skills which were significant at $p<.01$ (see table 6). This means that all the factors can be identified as separate constructs.

[1] The first two items have both ambiguity and loading issues across countries. We therefore would not recommend using them.

Table 7. χ^2 differences (df=1) for paired construct test

	Operational	Information Navigation	Social	Creative
Information Navigation	37.99**			
Social	320.39**	37.96**		
Creative	315.58**	6.98*	373.02**	
Mobile	285.89**	9.96*	212.61**	325.00**

*χ^2 difference significant at p<.01; ** χ^2 difference significant at p<.001

4.3 Confirmatory factor analysis and invariance

The next step was to test whether the factor structures proposed in the previous section (4.1) fit similarly in the UK and the Netherlands. We conducted confirmatory factor analysis (CFA) using AMOS with tests for factorial invariance. We tested for configural, metric, scalar and uniqueness invariance[2] . For the purposes of scale construction we were interested mostly in configural and metric invariance because we needed, at the very least, the same factors to be identifiable within the Netherlands and the UK and for the items to load similarly on these different constructs.

The full model including all factor structures (see Appendix B1 for coefficients and B2 for covariances and correlations) has a moderate to good fit[3] for complex model indicators on the merged database ($\chi^2_{(510)=}$1667.93, X^2/df=3.27; CFI=.93; RMSEA=.06 (ci. 0.057-0.063); AIC=1977.93).

Table 8. Factorial invariance tests (Operational, Information Navigation, Social and Creative scales)

Model	χ^2	df	X^2/df	CFI	RMSEA	ci. (90%)		p	AIC
Configural	2599.85	1020	2.55	0.91	0.050	0.047	0.052	0.589	3219.85
Metric	2699.90	1050	2.57	0.91	0.050	0.048	0.052	0.490	3259.90
Scalar	2908.97	1085	2.68	0.90	0.052	0.049	0.054	0.103	3398.97
Uniqueness	2957.86	1100	2.69	0.89	0.052	0.050	0.054	0.087	3417.86

Note: All X^2 are significant at p<.001. This is not surprising since the factorial model is quite complex.

The results in table 7 show that the proposed factor structure (see Appendix B) fit similarly in the Netherlands and the UK in terms of configural and metric invariance on the CFI and RMSEA indicators which take the complexity of the model into account. The same analysis was performed for each individual factor. The fit of the models in the merged dataset was good for all factors (see table 8).

Table 9. Model fit on CFA for the individual factors

	χ^2	df	p	X^2/df	CFI	RMSEA	ci. (90%)		p
Operational	24.42	16	0.08	1.53	0.998	0.029	0.000 -	0.051	0.94
Information Navigation	5.36	10	0.87	0.54	1.000	0.000	0.000 -	0.023	1.00
Social	5.16	3	0.16	1.72	0.999	0.034	0.000 -	0.082	0.64
Creative	18.44	8	0.02	2.31	0.996	0.046	0.018 -	0.073	0.56

[2] Configural invariance indicates the same factor structure, Metric invariance indicates the same factor loadings, Scalar invariance indicates the same item intercepts, Uniqueness indicates the same unique error terms.

[3] Moderate to good fit criteria χ^2/df>3; CFI>.90;RMSEA <.08 (ci <.10). Excellent fit CFI>.95; RMSEA <.05 (ci <.10). (Kline, 2005)

The results of the invariance comparison for individual factors indicated excellent invariance for comparisons on χ^2/df and CFI indicators and moderate to good invariance on RMSEA for configural invariance with the exception of Social skills:

- *Operational skills*: Excellent on Configural, Metric, Scalar and Uniqueness invariance on X^2/df and CFI indicators, Moderate to good on the RMSEA for configural invariance only.
- *Information Navigation skills*: Excellent on Configural, Metric, Scalar and Uniqueness invariance for CFI and on Configural and Metric on RMSEA, moderate to good for all on X^2/df and for scalar and uniqueness on RMSEA.
- *Social skills*: Excellent on Configural, Metric, Scalar and Uniqueness invariance on X^2/df, Moderate to good on the CFI and poor on RMSEA.
- *Creative skills*: Excellent on Configural, Metric, Scalar and Uniqueness invariance on X^2/df and CFI indicators and Moderate to good on the RMSE for all of these.

4.4 Conclusions

The factor analysis suggest that five to six digital skills can be reasonably identified taking reliability, internal validity and cross-national invariance into account. These five skills reflect earlier thinking about digital skills but also change the perspective on how we operationalise and theorise about skills to a certain extent. The two main theoretical frameworks we started out with were Van Dijk and Van Deursen's (2014) medium and content related conceptualisation and the media literacy framework as tested by Helsper and Eynon (2013).

The results show that digital skills are partly about managing the technology (i.e. Operational skills as identified by Van Deursen and Van Dijk) and partly about different substantial areas related to different types of content and activities (merging Van Deursen & Van Dijk, and Eynon & Helsper's approach). We did not find evidence of a separate type of formal skills but did find consistent existence of Operational skills. The Formal skills were embedded to some extent in the other substantial skills, especially in skills related to judging and finding information which we labelled Information Navigation.

We did find evidence, counter to our expectations, that there were specific platform skills related to mobile technologies. We caution against assuming that this skill is indeed completely separate and suggested that platform specific skills might be observed when a certain technology has only recently found widespread diffusion, such as was the case for mobile platforms such as tablets and smartphones at the time of our research.

We settled on a final theoretical, empirically and cross nationally consistent framework of five skills: **Operational, Information Navigation, Social, Creative** and **Mobile** skills. We suggested longer scales for most of these, consisting of between six to ten items, and shorter scales consisting of five items. The Mobile skills scale (the least theoretically grounded) consisted of only three items.

5. POPULATION SURVEY TEST RESULTS

This section looks at whether the scales constructed during the pilot research show reliability, internal, and external validity across different subsamples of the population of Internet users in the Netherlands[4]. We also give basic descriptive analysis of how different socio-demographic groups compare on the five scales.

5.1 Sampling

The full survey study draws on a sample collected in the Netherlands over a period of two weeks in July 2014 using an online survey. To obtain a representative sample of the Dutch population, we made use of the Dutch panel of PanelClix, a professional international organization for market research that consists of over 108,000 people. This panel is believed to be a largely representative sample of the Dutch population. Members receive a very small incentive of a few cents for every survey question they answer. Invitations were sent out in three waves to ensure that the final sample represented the Dutch population, in gender, age, and education. In total, we obtained complete responses from 1,107 individuals (response rate 27%). During the data collection, amendments were made to ensure that the Dutch population was represented in the final sample. We used external aggregate data (i.e., the national population census) to estimate calibration weights based on age, gender, and education. The time required to answer the survey questions was approximately 25 minutes (as the survey also asked for types of usage and Internet outcomes). Table 9 summarizes the demographic characteristics of the respondents.

Table 10. Demographic profile Dutch Internet user sample

	N	%
Gender		
Male	514	46.4
Female	593	53.6
Age		
16-30	145	13.1
31-45	281	25.4
46-60	362	32.7
60+	319	28.8
Education		
Primary (low)	309	27.9
Secondary (Medium)	498	45.0
Tertiary (High)	300	27.1
Occupation		
FT employed	383	34.6
PT employed	182	16.4
Unemployed	72	6.5
Student	55	5
Caretaker	98	8.9
Retired	222	20.1
Not able to work	95	8.6

Base: Dutch Internet Users (N= 1,107, Weighted N=1,337)

[4] We received funding for one full population study in the Netherlands. At the time of writing we are looking for additional funding to conduct population studies in other countries.

5.2 Confirmatory factor analysis

To test whether the scales as constructed in the pilot show high reliability and good fit we tested the factor structures on the Dutch population survey. A simple scale reliability analysis shows that all the different scales are also a good fit in the general Dutch Internet User population sample.

Table 11. Scale characteristics in Dutch Internet user population

Skills scale	Mean	Minimum	Maximum	Variance	α	α short scale
Operational (10)	4.57	4.28	4.79	0.04	0.92	0.86
Information Navigation (8)	3.56	3.96	3.17	0.08	0.91	0.89
Social scale (6)	4.31	3.99	4.53	0.04	0.88	0.88
Creative (8)	3.44	2.63	4.17	0.27	0.90	0.90
Mobile (3)	3.98	3.66	4.19	0.08	0.91	n/a

Annotation. Skills scales (number of items on long scale); Base. N=1,337 (weighted full population)

Table 10 shows that the shorter five item scales have alphas that are more or less equal to those of the longer scales. The short scales can therefore be used with confidence in measuring the range of skills. The largest difference was found for the longest scale, the Operational skills scale. To look at the general fit of the model to the data, we conducted a Confirmatory Factor Analysis (CFA) using AMOS .

Table 12. CFA fit for long and short scales in the Dutch population

Long scales	χ^2	df	p	CFI	RMSEA	ci. (90%)		p	AIC
Operational	92.20	22	0.00	0.99	0.05	0.04 -	0.07	0.28	178.20
Information Navigation	28.92	12	0.00	1.00	0.04	0.02 -	0.05	0.92	92.92
Social	83.09	6	0.00	0.98	0.11	0.09 -	0.13	0.00	125.09
Creative	44.66	11	0.00	0.99	0.05	0.04 -	0.07	0.37	110.66
Short scales	χ^2	df	p	CFI	RMSEA	ci. (90%)		p	AIC
Operational	0.90	2	0.64	1.00	0.00	0.00 -	0.05	0.96	36.90
Information Navigation	5.02	4	0.29	1.00	0.02	0.00 -	0.05	0.95	37.02
Social	10.43	1	0.00	1.00	0.09	0.05 -	0.15	0.06	48.43
Creative	1.45	2	0.49	1.00	0.00	0.00 -	0.05	0.93	37.45
Overall short scales	822.76	210	0.00	0.96	0.05	0.05 -	0.06	0.27	1000.76

Base. N=1,337 (weighted full population)

Table 11 shows that the individual factors fit the general population data excellently on indicators for complex models for all except the Social skills scale[5]. The Social skills scale shows excellent fit on the CFI indicator but poor fit for the long scale and only moderate fit for the short scale. The combined short scales with covariance between the different factors also showed excellent fit.

[5] Moderate to good fit criteria CFI>.90; RMSEA <.08 (ci <.10). Excellent fit CFI>.95; RMSEA <.05 (ci <.10) (Kline, 2005)

5.3 External validity

To look at external validity, that is whether the scales have similar characteristics independent of the context or the population they are in, we take a three-fold approach. First, there is descriptive information on the averages across the scales for different socio-demographic groups (5.3.1). Second, we test for convergent and discriminant validity of the scales (5.3.2). And, third, we look at whether the scale characteristics are consistent through random resamples of the population using the bootstrapping technique and whether they relate similarly for different socio-demographic groups (5.3.3). In this section we use the short scales since they have been shown to have good reliability and fit to the data. The longer scales are very likely to have even better characteristics.

The characteristics of the scales in the general population indicate that people are most confident about their Operational skills, followed by their Social skills, their Mobile skills, their Information Navigation skills and last come the Creative skills (see table 12).

Table 13. Short scale characteristics in the Dutch population

	Mean	SD
Operational skills	4.51	0.81
Information Navigation skills	3.56	1.13
Social skills	4.36	0.77
Creative skills	3.11	1.22
Mobile skills	3.97	1.33

Base. Dutch Internet users, N=1,337

5.3.1. Descriptives for different groups

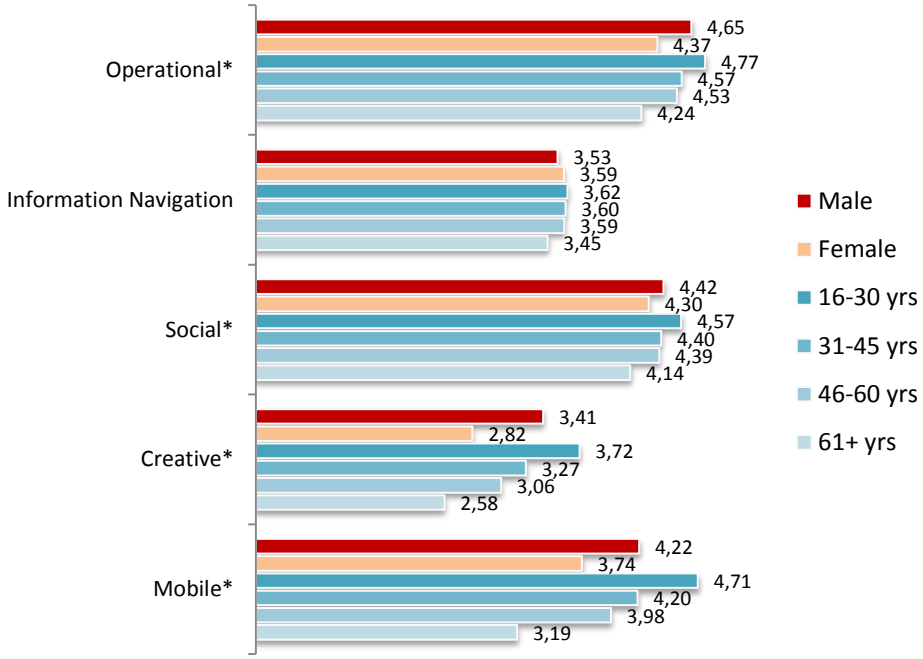


Figure 6. Skills comparison for Gender and Age groups

Base. Dutch Internet Users. N=1,338 (weighted)
*Differences significant at p<.01

In digital inclusion literature a few key predictors have been described for the level of skill an individual professes to have. In this section we look at how these are related to the five different skills measures created and tested for this report. We look at age, gender, education, and occupation (e.g., Hargittai, 2002; Helsper, 2010; Van Deursen & Van Dijk, 2014; Van Dijk, 2005).

Figure 6 shows the differences between men and women and between the different age groups. All differences were significant, except that of Information Navigation skills. In addition, the differences were in the direction that might be expected by the literature, that is, men estimate their own skills higher than women and the younger generations estimate their skills higher than the older generations.

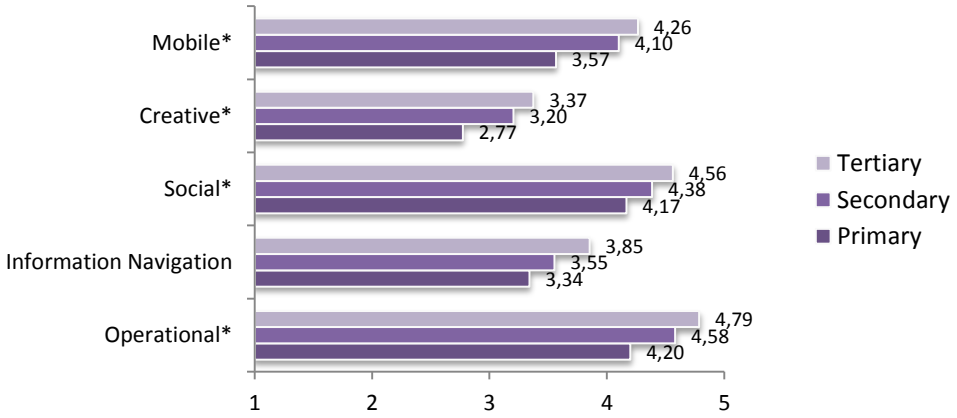


Figure 7. Skill averages for different education groups

Base. Dutch Internet Users. N=1,338 (weighted)
*Differences significant at p<.01

The differences between educational groups were also as predicted by the literature (see figure 7). That is, those with higher educational levels were significantly more confident for all skills, including the Information Navigation skills.

The descriptive analysis of occupational groups mostly confirms the literature around inequalities in skill levels (see figure 8). For all skills, the full time employed and students indicate having the highest skill levels, with the exception of Information Navigation skills where differences were not significant. However, it should be noted that there is little difference between those who work part-time and those who are unemployed and the retired population indicates lower skill levels than those who are unable to work. This maybe could be due to the current economic climate where many people work part-time out of necessity and not choice and many part-time jobs are underpaid. It is important to note that separate analysis (not depicted) showed that disabled people only differ significantly from non-disabled people on the Operational and Mobile skills.

These analyses indicate that the scales show consistency with previous general research and theoretical thinking around how digital skills relate to inequalities and differences between socio-cultural groups.

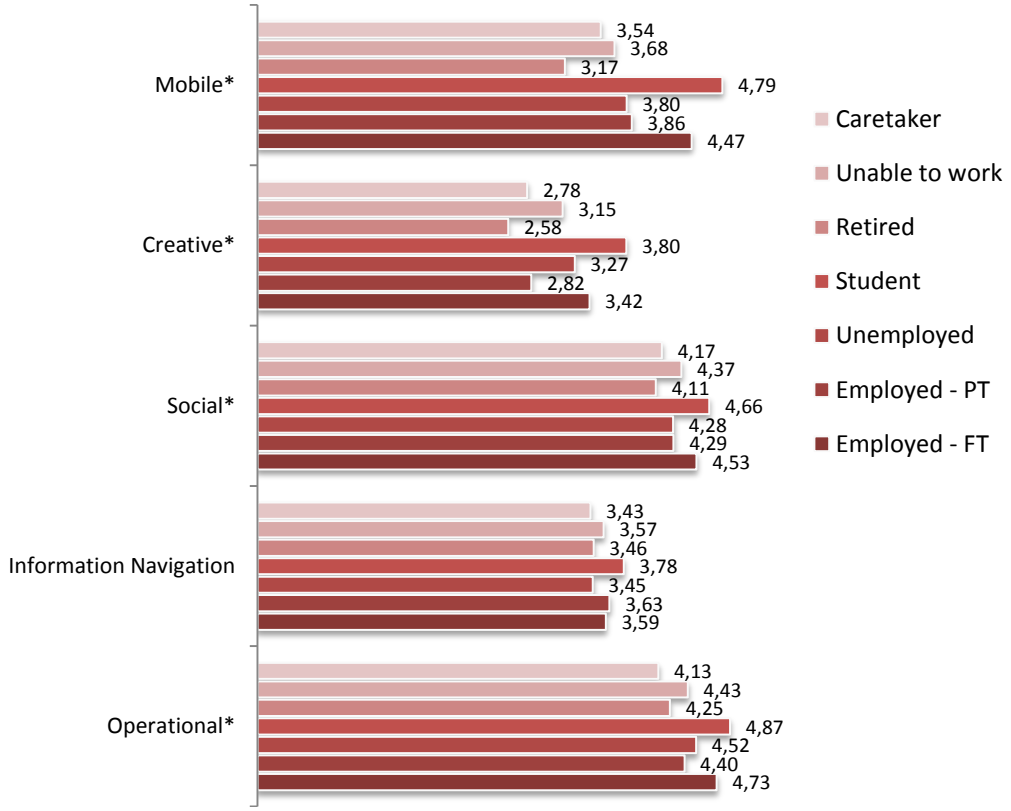


Figure 8. Skills averages by occupational group

Base. Dutch Internet Users. N=1,338 (weighted)
*Differences significant at p<.01

5.3.2 Convergent and discriminant validity

To understand whether in the full population the factor models fit as they did in the pilot and whether they show convergent and discriminant validity (see Fornell & Larcker, 1981): Composite Reliability (CR), Average Variance Extracted (AVE), Maximum Shared Variance (MSV), and Average Shared Variance (ASV) tests were run (using James Gaskin's 2011 tools based on AMOS output).

Table 14. Factor correlation and AVE[2] (on diagonal)

	Operational	Information Navigation	Social	Creative	Mobile
Operational	0.74				
Information Navigation	-0.29	0.78			
Social	0.73	-0.32	0.77		
Creative	0.51	-0.14	0.59	0.78	
Mobile	0.62	-0.18	0.54	0.55	0.89

Table 15. Convergent and discriminant validity indicators skills scales

	CR	AVE	MSV	ASV
Operational	0.86	0.55	0.53	0.32
Information Navigation	0.88	0.60	0.10	0.06
Social	0.88	0.60	0.53	0.32
Creative	0.89	0.61	0.34	0.23
Mobile	0.92	0.80	0.38	0.25

Table 13 and 14 show that the proposed five factor structure is valid in the sense that both the convergent and discriminate validity are high (Hair, Black, Babin & Anderson, 2010).[6] This means that the items on the scales correlate highly with each other (convergent) and that the items correlate more highly with each other than they do with items that are on other factors (discriminatory). In other words, the factors are internally coherent and can be externally distinguished meaningfully from other factors.

5.3.3. Scale characteristics and consistency

To understand whether the factor solution was stable, a Bollen-Stine (1992) test was conducted for the full factor model. To be able to do this, we had to transform the variables because the 'I don't understand' categories had been set as missing. For the purposes of this analysis, we converted these missing values to 0 assuming that if someone did not know what a particular action, platform or activity entailed, they would definitely not be able to do this particular activity and therefore lack the skill. Except for on the Information Navigation items where the corresponding response is 6 instead of 0 since the scales for these items were reversed. In all 2000 bootstrap samples the fit was better than in the original model[7]. Therefore, we can be confident that the model shows a good fit and is a stable solution for the full population.

However, another step that has to be taken is to compare the characteristics of the scales in different segments of the population.

Reliability comparison between socio-demographic groups

Reliability analysis shows that overall the scales are very similar in their reliability across different socio-demographic groups (see table 15).

Table 16. Reliability (α) of short skills scales in different groups

	Operational	Information Navigation	Social	Creative	Mobile
Men	0.85	0.89	0.87	0.87	0.91
Women	0.84	0.88	0.90	0.88	0.91
16-30	0.90	0.91	0.91	0.89	0.81
31-45	0.85	0.89	0.89	0.87	0.85
46-60	0.83	0.89	0.89	0.87	0.92
61+	0.83	0.85	0.88	0.87	0.92
Primary	0.86	0.89	0.90	0.88	0.93
Secondary	0.82	0.89	0.88	0.88	0.91
Tertiary	0.76	0.86	0.86	0.88	0.89
Employed (full time)	0.84	0.90	0.87	0.86	0.85
Unemployed	0.82	0.88	0.86	0.84	0.92
Retired	0.84	0.84	0.87	0.88	0.93
Student	0.72	0.92	0.91	0.90	0.61

Base. Dutch Internet Users (N=1,337)

[6] Reliability: CR > 0.7; Convergent Validity: CR > (AVE) and AVE > 0.5; Discriminant Validity: MSV < AVE and ASV < AVE

[7] P<.001 but this is to be expected with a large dataset and a complex model.

In three instances, the fit in one group was considerably lower than in the others:

- Those with tertiary education and the students showed a fit lower than .80 for the Operational skills scale. The reliability was still good at .76 for those with tertiary education and .72 for students.
- Students have a low reliability for Mobile Skills of only .61. Looking at the item scale characteristics it is clear that for the Mobile skills scale the item 'I know how to keep track of the costs of mobile app use' brings down the alpha considerably. This might be because many students are not responsible for paying the bill of their mobile phone and it is therefore not a skill.

Correlation matrixes comparison

Table 16 shows the correlations between the short skill scale constructs in the population survey. We also examined correlations between factors within the different socio-demographic groups. Differences between the correlation matrixes were mostly not significant when using Fisher's r-to-z transformation test. None of the differences between the men and women's correlations was significant.

Table 17. Correlations between short scales in population survey

	Operational	Information Navigation	Social	Creative
Information Navigation	.25	1		
Social	.60	.28	1	
Creative	.45	.10	.51	1
Mobile	.57	.16	.50	.52

Base. Dutch Internet Users (N=1,337)

When the age groups were compared there were a number of significant differences in the correlation matrixes:

- The correlation between *Operational* and *Social* skills was larger for the 61+ (r=.62) and 46 to 60 (r=.65) than for the 31 to 45 (r=.49) and the 16 to 30 (r=.42) age groups.
- The correlation between *Operational* and *Creative* skills was larger for the 61+ (r=.44), the 46 to 60 (r=. 48), and the 31 to 45 (r=.39) than for the 16 to 30 (r=.20) age group.
- The correlation between *Operational* and *Mobile* skills was smaller for the 61+ (r=.54), the 46 to 60 (r=.53) and the 31 to 45 (r=.51) than for the 16 to 30 (r=.77) age group.
- The correlation between *Information Navigation* and *Creative* skills was significantly larger for the 61+ age group (r=.24) than for those between 46 and 60 (r=.08) and between 31 and 46 (r=.03).
- The correlation between *Information Navigation* and *Mobile* skills was significantly larger for the 61+ age group (r=.23) than for those between 31 and 46 (r=.06).
- The correlation between *Creative* and *Mobile* skills was significantly larger for the 61+ age group (r=.54) than for those between 31 and 46 (r=.41) and between 16 and 30 (r=.26).

In summary, in comparing the correlations between the different skills scales across age groups, the Operational and Creative skills scales are causing the most trouble with different correlations between the older and the younger generations. For the Operational skills scale it was mostly the 16 to 30 year olds that were different from the rest in how the constructs related to each other. For the Creative skills scale it was mostly the oldest (61+) age group that had different correlations between factors.

When comparing the different educational levels there were few significant differences in the correlation matrixes:

- The correlation between *Operational* and *Social* skills was smaller for those with tertiary (r=.46) than for those with secondary (r=.60) and primary (r=.62) education.
- The correlation between *Operational* and *Information Navigation* skills was larger for those with secondary (r=.28) than for those with primary education (r=.13).

When comparing those with different occupational statuses a number of differences were found:

- The correlation between the *Operational* and *Social* skills was larger amongst the retired (r=.66) than amongst the employed (r=.51) people.
- The correlation between the *Information Navigation* and the *Creative* skills scales was larger for the retired (r=.25) than for the employed (r=-.01) and unemployed (r=-.10).
- The correlation between the *Information Navigation* and the *Mobile* skills scales was larger for the retired (r=.25) than for the employed (r=.03) group.
- The correlation between the *Creative* and *Mobile* skills scale was larger for the retired (r=.59) and the unemployed (r=.57) than for the students (r=.17) and the employed (r=.37) groups.

Amongst the different occupational groups it is not clear that one type of skills scale is more problematic than another in causing differences between correlation matrixes. In this case, the differences were mostly caused by the correlations in the retired group being different from the other groups.

5.4 Conclusions

This section examined consistency of the five Internet skill scales and their characteristics when measured in a representative sample survey of Dutch Internet users. Overall, there were few problems in terms of scale consistency when looking at a representative sample of the population. The reliability and validity of the scales as well as indicators of convergent and discriminant characteristics were good. We, therefore, recommend the use of the Operational, Information Navigation, Social, Creative and Mobile skills scales in general population research.

Nevertheless, the short scales were not fully consistent in their characteristics when compared across different socio-demographic groups. All correlations were in the same direction and significant, however, the effect sizes differed significantly between to age and occupation groups. We consider it most important that all scales have internal consistency, high reliability and fit the overall data in each group well. However, it is important to note that the external validity is not completely stable in cases where the scales are used to compare different age and occupational groups. For

example, we found that the link between Operational and Information Navigation skills are stronger in older age groups than in younger groups. It would be very interesting to focus on these findings in future research. We expect that these differences relate to the ways that people view the Internet and the ways that they learn to use it which may be different among age groups and occupational settings. More qualitative studies, or studies with more subjects in all age and occupational groups, might reveal the meaning of the observed differences.

Furthermore, it is not yet possible for us to conclude whether the observed differences would also occur in population surveys in other countries. Future comparative studies should most definitely be conducted to establish cross-cultural validity especially in countries where the Internet and related technologies are less widely adopted as compared to the Netherlands where high speed broadband access to the Internet is saturated.

6. MEASURING DIGITAL SKILLS: CONCLUSIONS

Research in the field of digital inclusion and literacy has developed rapidly over the last decade. Increasingly, scholars think about prerequisites for and impacts of engagement with digital technologies such as the Internet. However, as noted in the introduction, there is a need for more theoretically informed, reliable and valid instruments that are able to measure developments in this area.

Helsper (2012) developed a framework which theorised about the pathways between specific types of social exclusion and specific types of digital exclusion. She argued that access, digital skills and motivations mediate the relationship between specific offline characteristics and engagement with technologies. The research presented here is a key part of a wider research project that used this framework as a starting point and aimed to develop measures of outcomes of Internet use, different types of engagement with the Internet and the skills needed to engage in this way. This particular report focuses on testing whether reliable and valid scales could be developed that measure digital skills.

To come up with such an instrument, we took a critical look at the existing digital skills literature. Moreover, our own experience and work related to digital skills helped us in building an elaborate skills framework including specific skill indictors. Two main theoretical approaches the proposed framework was built on were the skill distinctions as set out by Van Deursen and Van Dijk (2009a, 2009b, 2010; Van Dijk & Van Deursen, 2014) and measures tested by Helsper and Eynon (2013). For several types of skills proposed in these approaches we were able to define corresponding items. We ensured that all items reflected typical Internet use that everyone might imagine him or herself doing. Furthermore, we avoided contextual items related to specific platforms or activities. This should allow these items to be used for a considerable amount of time because they are not dependent on what type of activity is trending or on new platforms becoming popular. The only exceptions are the items that were introduced regarding mobile skills, as a consequence these items might have to be adjusted or integrated into other skills as mobile platforms become more mainstream.

All items used a scale that gave statements about things that a person was able to do with answer formats that ranged from ‘Not at all true of me’ to ‘Very true of me,’ and furthermore included a ‘I do not understand what this means’ option.

After the development of a first full survey instrument, we used a three-fold approach to test the validity and reliability of the latent skill constructs and the corresponding items. The first step consisted of cognitive interviews held in both the UK and the Netherlands. Based on the cognitive interview results, we made several amendments to the proposed skill items to improve clarity.

The second step consisted of a pilot survey of digital skills, both in the UK and in the Netherlands (at this stage we also measured uses and outcomes of Internet use, the results of this will be reported later in 2014). The result of the second step was a final theoretical, empirically and cross nationally consistent framework consisting of five types of digital skills: **Operational, Information Navigation,**

Social, Creative and **Mobile** skills (see figures 1-5 and table 17). We suggested longer scales for most of these, consisting of between six to ten items, and shorter scales consisting of five items. The Mobile skills scale (the least theoretically grounded) consisted of only three items.

Table 18. Proposed items and factors to measure Internet skills

Skill	Item
Operational	I know how to open downloaded files
	I know how to download/save a photo I found online
	I know how to use shortcut keys (e.g. CTRL-C for copy, CTRL-S for save)
	I know how to open a new tab in my browser
	I know how to bookmark a website
	I know where to click to go to a different webpage
	I know how to complete online forms
	I know how to upload files
	I know how to adjust privacy settings
	I know how to connect to a WIFI network
Information Navigation	I find it hard to decide what the best keywords are to use for online searches
	I find it hard to find a website I visited before
	I get tired when looking for information online
	Sometimes I end up on websites without knowing how I got there
	I find the way in which many websites are designed confusing
	All the different website layouts make working with the internet difficult for me
	I should take a course on finding information online
	Sometimes I find it hard to verify information I have retrieved
Social	I know which information I should and shouldn't share online
	I know when I should and shouldn't share information online
	I am careful to make my comments and behaviours appropriate to the situation I find myself in online
	I know how to change who I share content with (e.g. friends, friends of friends or public)
	I know how to remove friends from my contact lists
	I feel comfortable deciding who to follow online (e.g. on services like Twitter or Tumblr)
Creative	I know how to create something new from existing online images, music or video
	I know how to make basic changes to the content that others have produced
	I know how to design a website
	I know which different types of licences apply to online content
	I would feel confident putting video content I have created online
	I know which apps/software are safe to download
	I am confident about writing a comment on a blog, website or forum
	I would feel confident writing and commenting online
Mobile	I know how to install apps on a mobile device
	I know how to download apps to my mobile device
	I know how to keep track of the costs of mobile app use

Note I. Items in black make up the proposed short scales, blue items are added for the long scales.
Note II. There is also a set of Critical (literacy) skills that are not included because they were shown to be individual context dependent and not easy to measure in general population survey research
Note III. The information navigation items are all negatively formulated. We recommend that future research use positively formulated items measuring the same skills.

We recommend the use of the shorter five item scales in larger research projects that need to include a variety of skills. However, if researchers want to focus on skills only or on a specific skill in relation to other variables, they should use the longer scales which offer more variance and the

opportunity to study them in detail by, for example, distinguishing different operational skills. If researchers or evaluators do not care about distinguishing different skills, it would be possible to take two items (the highest loading or most relevant ones) from each short scale and create one ten item scale. However, we strongly recommend against this approach. Past research shows that analysis of the causes and consequences of digital literacy is complicated when using these limited scales (Helsper & Eynon, 2013).

During the final step, we examined the consistency of the five Internet skill scales and their characteristics when measured in a representative sample survey of Dutch Internet users. This step revealed that reliability and validity of the scales as well as indicators of convergent and discriminant characteristics were good. As a result of this work, we recommend the use of the Operational, Information Navigation, Social, Creative and Mobile skills scales in general population research. While we believe these scales are a significant contribution to research that measures digital skills, it is important that further research is carried out to understand the different relationships these skills have with one another within different socio-demographic groups. As noted in section 5, we suspect that there might be underlying differences in experience and meaning between these groups that underlie slight variations in the digital skills landscape, even when all the skills are valid ways of classifying the abilities people need to use Information and Communication Technologies.

As noted above, the key purpose of this report is to put forward a set of valid digital skills measures that are of value to survey researchers working in this field[8]. We very much welcome feedback and comments from readers who are interested in testing these scales in a range of countries.

[8] Please get in touch with the authors if you have any questions about the construction of the instrument and use of the instrument

REFERENCES

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological bulletin, 103*(3), 411.

Bawden, D. (2008). Origins and Concepts of Digital Literacy. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: Concepts, policies, and practices* (pp. 15-32). New York, NY: Peter Lang.

Brandtweiner, R., Donat, E., & Kerschbaum, J. (2010). How to become a sophisticated User: a two-dimensional approach to e-literacy. *New media & society, 12*(5), 813-833.

Bollen, K. A., & Stine, R. A. (1992). Bootstrapping goodness-of-fit measures in structural equation models. *Sociological Methods & Research, 21*(2), 205-229.

Bunz, U., Curry, C., & Voon, W. (2007). Perceived versus actual computer-email-web fluency. *Computers in Human Behavior, 23*(5), 2321-2344.

Calvani, A., Fini, A., Ranieri, M., & Picci, P. (2012). Are young generations in secondary school digitally competent? A study on Italian teenagers. *Computers & Education, 58*(2), 797-807.

Eshet, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia, 13*(1), 93-106.

Eshet-Alkali, Y. E., & Amichai-Hamburger, Y. (2004). Experiments in digital literacy. *CyberPsychology & Behavior, 7*(4), 421-429.

Eynon, R., & Helsper, E. (2011). Adults learning online: digital choice and/or digital exclusion*?. New media & society, 13*(4), 534-551.

Eynon, R., & Helsper, E. (2014). Family dynamics and Internet use in Britain: What role do children play in adults' engagement with the Internet?. *Information, Communication & Society*, (ahead-of-print), 1-16.

Ferrari, A. (2012). *Digital Competence in practice: An analysis of frameworks.* Sevilla: JRC IPTS.(DOI: 10.2791/82116).

Fornell, C., & Larcker, F. D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39-50.

Gaskin, J. (2011). Multigroup moderation in AMOS made easy. Available at: http://www.youtube.com/watch?v=ZMYS90AU8bs

Gui, M., & Argentin, G. (2011). Digital skills of internet natives: Different forms of digital literacy in a random sample of northern Italian high school students. *New Media & Society, 13*(6), 963-980.

Hair, J., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate data analysis: a global perspective*. Pearson Education.

Hargittai, E. (2002). Second-level digital divide: Differences in people's online skills*. First monday, 7*(4).

Hargittai, E., & Hsieh, Y. P. (2012). Succinct survey measures of web-use skills. *Social Science Computer Review, 30*(1), 95-107.

Haythornthwaite, C. (2007). Social networks and online community. In A. Joinson (Ed*.*) *The Oxford handbook of Internet psychology* (pp. 121-137. Oxford University Press

Helsper, E and Eynon, R (2013) Distinct skill pathways to digital engagement. European Journal of Communication 28(6) 696-671.

Helsper, E.J. (2010). Gendered internet use across generations and life stages. *Communication Research, 37*(3), 352-374.

Jenkins, H., Purushotma, R., Weigel, M., Clinton, K. & Robinson, A.J. (2009). *Confronting the challenges of participatory culture. Media education for the 21st century.* The MIT Press, Cambridge.

Kline, R.B. (2005). *Principles and Practice of Structural Equation Modeling*. New York: The Guilford Press.

Krueger, B. S. (2006). A comparison of conventional and Internet political mobilization. *American Politics Research, 34*(6), 759-776.

Kuhlemeier, H., & Hemker, B. (2007). The impact of computer use at home on students' Internet skills. *Computers & Education, 49*(2), 460-480.

Litt, E. (2013). Measuring users' internet skills: A review of past assessments and a look toward the future. *New Media & Society, 15*(4), 612-630.

Mascheroni, G. and Ólafsson, K. (2014). *Net Children Go Mobile: risks and opportunities.* Milano: Educatt.

Merritt, K., Smith, D., & Renzo, J. C. D. (2005). An investigation of self-reported computer literacy: Is it reliable. *Issues in Information Systems, 6*(1), 289-295.

Mossberger, K., Mary, K. M. C. J. T., Tolbert, C. J., & Stansbury, M. (2003). *Virtual inequality: Beyond the digital divide.* Georgetown University Press.

Potosky, D. (2007). The Internet knowledge (iKnow) measure. *Computers in Human behavior, 23*(6), 2760-2777.

Sonck, N., Livingstone, S., Kuiper, E., and de Haan, J. (2011) *Digital literacy and safety skills.* London, UK : EU Kids Online Network. (http://eprints.lse.ac.uk/33733/)

Spitzberg, B. H. (2006). Preliminary Development of a Model and Measure of Computer-Mediated Communication (CMC) Competence. *Journal of Computer-Mediated Communication, 11*(2), 629-666.

Stevens, J. (1986). *Applied multivariate statistics for the social sciences.* Hillsdale, NJ, USA: L. Erlbaum Associates Inc.

Steyaert, J. (2002). Inequality and the digital divide: myths and realities. In S. Hick & J. McNutt (Eds.), *Advocacy, activism and the internet* (pp. 199-211). Chicago: Lyceum Press.

Talja, S. (2005). The social and discursive construction of computing skills. *Journal of the American Society for Information Science and Technology, 56*(1), 13-22.

Van Deursen, A. (2010). *Internet skills, vital assets in an information society.* Enschede: Univeristy of Twente.

Van Deursen, A.J.A.M. (2012). Internet skill-related problems in accessing online health information and services. *International Journal of Medical Informatics, 81*(1), 61-72.

Van Deursen, A.J.A.M. & Van Dijk, J.A.G.M. (2009a). Using the Internet: Skill Related Problems in Users' Online Behavior. *Interacting with Computers, 21*, 393-402.

Van Deursen, A.J.A.M. and J.A.G.M. Van Dijk (2009b). Improving digital skills for the use of online public information and services. *Government Information Quarterly, 26*, 333-340.

Van Deursen, A.J.A.M. & Van Dijk, J.A.G.M. (2010). Measuring Internet skills. *International Journal of Human-Computer Interaction, 26*(10), 891-916.

Van Deursen, A.J.A.M. & Van Dijk, J.A.G.M. (2011a). Internet Skills and the Digital Divide. *New Media & Society, 13*(6), 893-911.

Van Deursen, A.J.A.M. & Van Dijk, J.A.G.M. (2011b). Internet skills performance tests: Are people ready for eHealth? *Journal of Medical Internet Research, 13*(2), e35

Van Deursen, A.J.A.M. & Van Dijk, J.A.G.M. (2014). The digital divide shifts to gaps of usage. *New media & Society, 16*(3), 507-526.

Van Deursen, A., Courtois, C. & Van Dijk, J. (2014). Internet Skills, Sources Of Support And Benefiting From Internet Use. *International Journal of Human-Computer Interaction, 30*(4), 278-290.

Van Deursen, A.J.A.M., Van Dijk, J.A.G.M. & Peters, O. (2011). Rethinking Internet skills. The Contribution Of Gender, Age, Education, Internet Experience, And Hours Online To Medium- And Content-Related Internet Skills. *Poetics, 39,* 125-144.

Van Deursen, A., Van Dijk, J., Peters, O. (2012). Proposing a Survey Instrument for Measuring Operational, Formal, Information and Strategic Internet Skills. *International Journal of Human-Computer Interaction, 28*(12), 827-837.

Van Dijk, J. (2005). *The deepening divide. Inequality in the information society.* London: Sage Publications.

Van Dijk, J.A.G.M. & Van Deursen, A.J.A.M. (2014). *Digital skills, unlocking the information society*. New York: Palgrave Macmillan.

Warschauer, M. (2003). Demystifying the digital divide. *Scientific American, 289*(2), 42-47.

Appendix A1. Factor Loadings of the items on the scales resulting from the Exploratory Factor Analysis

	NL & UK						NL						UK					
	C	O	I	S	M	N	M	C	S	I	O	O	C	I	O	S	N	M
I know how to create something new from existing online images, music or video	0.82							0.68					0.86					
I know how to make basic changes to the content that others have produced	0.80							0.70					0.84					
I know how to design a website	0.74							0.66					0.71					
I know which different types of licences apply to online content	0.70							0.65					0.62					
I would feel confident putting video content I have created online	0.69							0.50					0.72					
I know which apps/software are safe to download	0.60						0.43	0.55					0.43		0.47			
I am confident about writing a comment on a blog, website or forum	0.57			0.41				0.42	0.59				0.55					
I would feel confident writing and commenting online	0.55							0.40	0.51				0.54					
I know which information I should and shouldn't share online				0.73					0.74							0.71		
I know when I should and shouldn't share information online				0.69					0.64							0.71		
I am careful to make my comments and behaviors appropriate to the situation I find myself in online				0.68					0.69							0.55		
I know how to change who I share content with (e.g. friends, friends of friends or public)	0.43			0.57					0.73							0.59		
I know how to remove friends from my contact lists				0.55					0.70							0.58		
I feel comfortable deciding who to follow online (e.g. on services like Twitter or Tumblr)	0.55			0.41					0.59				0.47			0.40		
I know how to open downloaded files		0.72									0.74				0.63		0.40	
I know how to download/save a photo I found online		0.70					0.45				0.67				0.65			
I know how to use shortcut keys (e.g. CTRL		0.67										0.81			0.44			
I know how to open a new tab in my browser		0.67										0.91					0.68	
I know how to bookmark a website		0.66										0.85			0.46			
I know where to click to go to a different webpage		0.66									0.59	0.43				0.44	0.55	
I know how to complete online forms		0.64									0.65				0.46			
I know how to upload files	0.46	0.57					0.66								0.67			
I know how to adjust privacy settings	0.54	0.55					0.57								0.72			
I know how to connect to a WIFI network		0.44					0.68								0.41			
I find it hard to decide what the best keywords are to use for online searches			0.84							0.85				0.83				
I find it hard to find a website I visited before			0.81							0.80				0.80				
I get tired when looking for information online			0.80							0.84				0.79				
Sometimes I end up on websites without knowing how I got there			0.79							0.76				0.80				
I find the way in which many websites are designed confusing			0.78							0.75				0.79				
All the different website layouts make working with the Internet difficult for me			0.77							0.75				0.79				
I should take a course on finding information online			0.72							0.70				0.75				
Sometimes I find it hard to verify information I have retrieved			0.68							0.66				0.69				
I know how to install apps on a mobile device	0.43				0.74		0.81											0.84
I know how to download apps to my mobile device	0.45				0.77		0.71											0.83
I know how to keep track of the costs of mobile app use	0.53				0.62		0.60	0.43					0.42					0.73
Alpha	0.91	0.91	0.92	0.88	0.94													

Note: O= Operational; N=Navigation; I= Information; S= Social; C=Creative; M=Mobile

Appendix A2. Factor Loadings of the items that were removed from scales.

	NL & UK						NL						UK					
	C	O	I	S	M	N	M	C	S	I	O	O	C	I	O	S	N	M
I know how to use a wide range of strategies when searching for information	0.43			0.49				0.54			0.40					0.56		
I feel confident in my evaluation of whether a website can be trusted	0.42			0.43				0.56								0.60		
I know how to turn my mobile phone off		0.59										0.86					0.73	
I know how to make pop-ups disappear	0.56						0.46	0.51					0.39		0.45	0.45		
If a technical problem occurs while I am using the Internet, I usually know how to fix the problem	0.57	0.39				0.46	0.62	0.50					0.47		0.58			
I know how to go to the previous page when browsing the Internet						0.78	0.59	0.48									0.80	
I know how to use the refresh function		0.40				0.63	0.77										0.70	
I know how to download files		0.58				0.45	0.71								0.62		0.41	
I know some good ways to avoid computer viruses																		
I know how to use emoticons (e.g. smileys, emojis or text speak)	0.54							0.53							0.48			
I generally compare different websites to decide if information is true	0.52								0.56				0.58					
I carefully consider the information I find online								0.45										
I know how to open a Web address directly without using a search engine like Google				0.48				0.39			0.41					0.50		
I tend to have no problems finding my way around a website		0.59									0.64							
I am confident selecting search results		0.53									0.60							
I normally look at more than the top three search results				0.50												0.48		
It is easy for me to find information		0.39		0.39								0.42						

Note: O= Operational; N=Navigation; I= Information; S= Social; C=Creative; M=Mobile

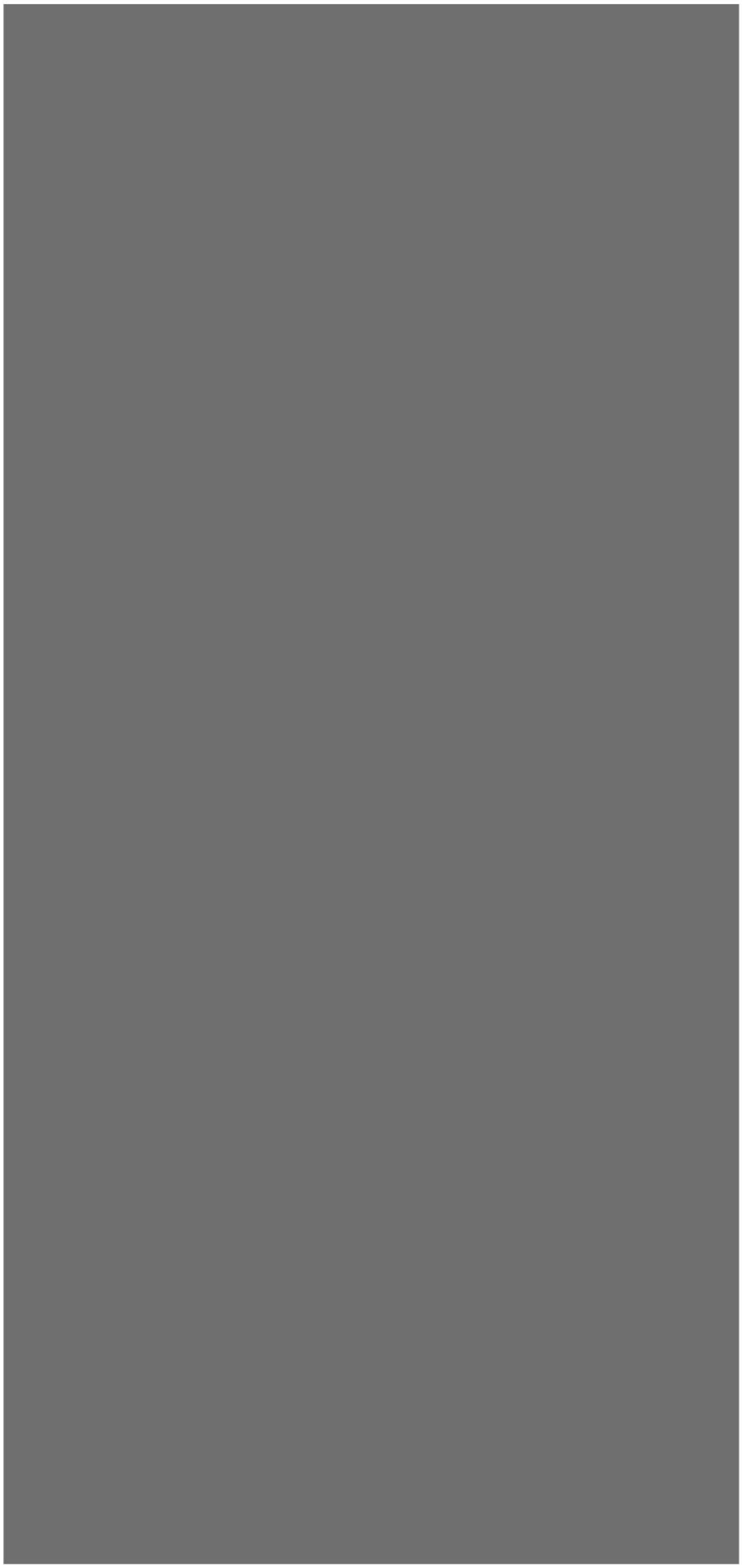
Appendix B1. Factor structure CFA factor analysis

Skill		Item	b	sd	β
Operational	→	Adjust privacy settings	1.56	0.07	0.85
	→	Upload files	1.53	0.06	0.88
	→	connect to a WIFI network	1.34	0.07	0.69
	→	open a new tab in my browser	0.65	0.05	0.56
	→	use shortcut keys (e.g. CTRL	1.02	0.07	0.61
	→	bookmark a website	0.98	0.07	0.59
	→	click to go to a different webpage	0.72	0.04	0.63
	→	complete online forms	0.90	0.04	0.68
	→	download/save a photo I found online	1.32	0.05	0.81
	→	open downloaded files	1.00		0.78
Information Navigation	→	website layouts make working with the Internet difficult for me	1.01	0.05	0.78
	→	the way in which many websites are designed confusing	0.93	0.05	0.75
	→	find a website I visited before	0.91	0.04	0.78
	→	I get tired when looking for information online	0.90	0.04	0.75
	→	I should take a course on finding information online	0.87	0.04	0.73
	→	decide what the best keywords are to use for online searches	1.00		0.85
	→	Sometimes I find it hard to verify information I have retrieved	0.82	0.04	0.70
	→	Sometimes I end up on websites without knowing how I got there	0.95	0.05	0.77
Social	→	change who I share content with (e.g. friends, friends of friends or public)	1.38	0.07	0.85
	→	I feel comfortable deciding who to follow online (e.g. on services like Twitter or Tumblr)	1.57	0.09	0.74
	→	when I should and shouldn't share information online	1.05	0.05	0.71
	→	I am careful to make my comments and behaviors appropriate to the situation I find myself in online	0.78	0.06	0.60
	→	remove friends from my contact lists	1.24	0.07	0.76
	→	which information I should and shouldn't share online	1.00		0.73
Creative	→	writing and commenting online	0.75	0.04	0.70
	→	writing a comment on a blog, website or forum	0.77	0.04	0.72
	→	apps/software are safe to download	0.74	0.04	0.76
	→	putting video content I have created online	0.98	0.05	0.75
	→	different types of licences apply to online content	0.82	0.05	0.62
	→	design a website	0.80	0.05	0.59
	→	make basic changes to the content that others have produced	1.00	0.04	0.78
	→	create something new from existing online images, music or video	1.00		0.75
Mobile	→	install apps on a mobile device	0.96	0.03	0.93
	→	download apps to my mobile device	1.00		0.94
	→	keep track of the costs of mobile app use	0.98	0.03	0.91

Appendix B2. Construct and error term covariates and correlations CFA

			b	S.E.	r
OP	<-->	SO	0.24	0.02	0.74
OP	<-->	INF	-0.16	0.03	-0.28
SO	<-->	CR	0.50	0.04	0.81
OP	<-->	CR	0.44	0.04	0.75
INF	<-->	SO	-0.17	0.03	-0.27
INF	<-->	CR	-0.17	0.05	-0.15
MO	<-->	OP	0.49	0.04	0.67
MO	<-->	SO	0.47	0.04	0.62
MO	<-->	CR	1.02	0.08	0.73
MO	<-->	INF	-0.19	0.06	-0.14

			b	S.E.	P	r
e18	<-->	e19	0.34	0.03	***	0.61
e21	<-->	e23	0.08	0.01	***	0.34
e22	<-->	e23	0.08	0.01	***	0.33
e14	<-->	e21	0.06	0.01	***	0.22
e21	<-->	e22	0.06	0.01	***	0.19
e14	<-->	e17	-0.08	0.01	***	-0.28
e15	<-->	e17	-0.07	0.01	***	-0.30
e15	<-->	e18	-0.08	0.02	***	-0.24
e15	<-->	e19	-0.11	0.02	***	-0.33
e15	<-->	e20	-0.03	0.01	*	-0.11
e17	<-->	e18	0.13	0.02	***	0.33
e17	<-->	e19	0.14	0.02	***	0.36
e17	<-->	e22	-0.03	0.01	**	-0.11
e17	<-->	e21	-0.02	0.01	*	-0.07
e20	<-->	e21	0.05	0.01	***	0.18
e20	<-->	e23	0.04	0.01	***	0.15
e27	<-->	e28	0.34	0.05	***	0.46
e29	<-->	e30	0.16	0.04	***	0.24
e29	<-->	e31	0.15	0.03	***	0.23
e30	<-->	e32	0.15	0.04	***	0.27
e33	<-->	e34	0.30	0.04	***	0.39
e30	<-->	e31	0.11	0.04	**	0.15
e26	<-->	e24	-0.14	0.03	***	-0.46
e27	<-->	e32	-0.12	0.02	***	-0.21
e29	<-->	e32	0.10	0.03	**	0.20
e29	<-->	e33	0.07	0.03	*	0.10
e8	<-->	e12	0.08	0.02	***	0.26
e9	<-->	e12	0.05	0.02	*	0.10
e12	<-->	e13	0.06	0.01	***	0.17
e10	<-->	e13	0.13	0.02	***	0.39
e1	<-->	e35	0.19	0.03	***	0.30
e3	<-->	e35	0.21	0.03	***	0.28
e3	<-->	e7	0.15	0.03	***	0.18
e4	<-->	e7	0.20	0.04	***	0.19
e4	<-->	e5	0.58	0.06	***	0.44
e5	<-->	e6	0.25	0.04	***	0.25
e6	<-->	e7	0.40	0.04	***	0.49
e5	<-->	e7	0.33	0.05	***	0.30
e4	<-->	e35	-0.13	0.03	***	-0.15
e5	<-->	e35	-0.16	0.04	***	-0.16





LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

UNIVERSITY OF TWENTE.

Oxford Internet Institute
University of Oxford