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

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Alexander J.A.M. van Deursen, Ellen J. Helsper & Rebecca Eynon
University of Twente, London School of Economics and Political Science, Oxford University

Alexander J.A.M. van Deursen
University of Twente / Dep. of Media, Communication and Organization
7500 AE Enschede
The Netherlands
a.j.a.m.vandeursen@utwente.nl

Ellen J. Helsper
London School of Economics and Political Science
Department of Media and Communications
Houghton Street
London WC2A 2AE
e.j.helpser@lse.ac.uk

Rebecca Eynon
University of Oxford
Oxford Internet Institute, 1
St Giles, Oxford, OX1 3JS
rebecca.eynon@oii.ox.ac.uk

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Abstract

Although a number of instruments have been used to measure Internet skills in nationally representative surveys, there are several challenges with the measures available: incompleteness and over-simplification, conceptual ambiguity, and the use of self-reports. Here, we aim to overcome these challenges by developing a set of reliable measures for use in research, practice, and policy evaluations based on a strong conceptual framework. To achieve this goal, we carried out a literature review of skills related studies to develop the initial Internet skills framework and associated instrument. After the development of this 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. 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. The result is a theoretical, empirically and cross nationally consistent instrument consisting of five types of Internet skills: operational, navigation information, social, creative, and mobile.

Keywords

Internet skills, Digital Skills, Interviews, Scale Construction

1. INTRODUCTION

Internet skills form a key part of digital inclusion (e.g., Helsper 2012; Litt, 2013; Mossberger, Tolbert, & Stansbury, 2003; Van Dijk & Van Deursen, 2014; Warschauwer, 2003). Internet skills should be considered as distinct from computer skills, as use of the Internet requires more skills than the use of a computer, for example, when people search for information, when they have to practice online communication or when they create online content. Given the key role of Internet skills in explaining different types of engagement with the Internet, it is important to develop accurate measures that can be used across populations. A number of instruments have been used to measure Internet skills in nationally representative surveys (e.g., Bunz, 2004, 2009; Eastin & LaRose, 2000; Hargittai, 2005, 2012; Helsper & Eynon, 2013; Potosky, 2007; Spitzberg, 2006; Van Deursen, Van Dijk, & Peters, 2012). There are, however, several challenges with the measures available: problems of incompleteness and over-simplification (for example, skills related to recent web 2.0 activities are not always included, and often the focus is on the technicalities of Internet use as opposed to a broad range of skills), conceptual ambiguity (for example, when skills questions are put in par with Internet usage), and the use of self-reports that easily lead to individuals overrating or underrating their level of skills (Hargittai, 2005; Merrit, Smith, & Renzo, 2005; Talja, 2005; Van Deursen & Van Dijk, 2010). The aim of this study is to overcome these challenges by proposing an elaborated conceptualization of Internet skills, and developing a set of reliable measures for use in research, practice, and policy impact evaluation. The instrument is specifically designed to capture a full range of Internet skills from basic to advanced levels. To create this instrument, we took the following approach:

1. A literature review of related studies to develop an Internet skills framework and associated instrument. Both the conceptualization of Internet skills and the scales used are discussed in Section 2.
2. Conducting cognitive interviews in the UK and the Netherlands to refine the proposed instrument. The focus on two countries enabled us to start exploring cross-cultural validity of the instrument. The cognitive interviews are discussed in Section 3.
3. Conducting online survey pilot tests of the proposed instrument in the UK and in the Netherlands to test the internal validity of the instrument. The pilots are discussed in Section 4.
4. Conducting a full survey in the Netherlands to test for internal and external validity. This is discussed in Section 5.

2. INITIAL INSTRUMENT DEVELOPMENT

2.1 Conceptualization

Several of the existing Internet skill measurements focus merely on the technicalities of Internet use such as being able to open a browser (e.g., Bunz, Curry, & Voon, 2007; Hargittai & Hsieh, 2012; Krueger, 2006; Potosky, 2007). When measuring Internet skills, however, 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; Mossberger et al., 2003; Spitzberg, 2006; Steyaert, 2002; Van Deursen & Van Dijk, 2010; Warschauer, 2003). From this point of departure, several authors have suggested specific skills, mostly related to information searching. Although this is a valuable addition to the concept, measures should also incorporate

communication and socio-emotional skills, for example required for the use of social media (Calvani, Fini, Ranieri, & Picci, 2012; Eshet, 2004; Haythornthwaite, 2007; Helsper & Eynon, 2013; Jenkins, Purushotma, Weigel, Clinton, & Robinson, 2009; Litt, 2013; Van Deursen, Courtois, & Van Dijk, 2014; Van Dijk & Van Deursen, 2014). Additionally, content creation skills, or creative skills, should be considered (Helsper & Eynon, 2013; Ferrari, 2012; 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 definitions, however, are 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. Based on studies in the UK, 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. A range of studies conducted in the Netherlands (Van Deursen & Van Dijk, 2010, 2011, 2015) measured four types of Internet skills: 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 (1) 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; (2) searching, selecting, evaluating, and acting upon contacts online; (3) attracting attention online; (4) online profiling; (5) online experimentation for better decision-making; (6) the social ability to pool knowledge and exchange meaning with others in peer-to-peer networking; and (7) 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): a function of attentiveness, composure, coordination, and expressiveness skills translated into mediated contexts. 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 originally proposed a framework consisting of five different types of Internet skills relevant to a large segment of the population (i.e., gender neutral; not specific to subgroups): Operational, Formal, Information, Communication and Content Creation. For each of the five skill areas in the framework, we used, adapted and derived items from previous research (Helsper & Eynon, 2013; Macheroni & Olaffson, 2014; Sonck, Livingstone, Kuiper, & De Haan, 2011; Van Deursen, Courtois, & Van Dijk, 2014; Van Deursen, Van Dijk & Peters, 2012). Several of the items correspond with earlier proposed Operational, Formal, and Information skills proxy items that showed high correlations with actual performances (Van Deursen, Van Dijk, & Peters, 2012). We sought to include items with varying levels of difficulty that were not contingent upon each other.

2.2 Scales Used to Measure Internet Skills

Studies using self-reports to measure Internet skills use a variety of scales, e.g. response items ranging from 'very poor' to 'excellent,' or from 'never' to 'several times per day' (for an overview, see Litt, 2013). In the current study, like a great deal of previous research, we used the Likert-type format to allow participants flexibility. We choose response items used by Spitzberg (2006) that focus on truth claims ('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'), including a 'don't know' option. Results of cognitive interviews revealed that the wording of this scale invites a neutral and objective response from participants, especially compared to scales which used more emotive and personal discourse like 'poor.' Furthermore, the scale encourages respondents to reflect on themselves, rather than using terms that more easily evoke comparison with others (e.g., 'expert'). 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., a WIFI network) is 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 for response bias such as exaggerating the level of skill.

2.3 Cognitive Interviews

The second step of the process of improving our questionnaire design involved cognitive interviewing in both the UK and the Netherlands. Cognitive interviewing is a means of systematically developing survey questions through investigations that intensively probe the thought processes of individuals who are presented with those inquiries (Willis, 2005).

The interviews took place from November 2013 to January 2014. In both countries, 15 participants (containing varying ages and levels of education, and both men and women) were interviewed. In line with the cognitive interview technique, participants were asked to complete our original version of the survey questionnaire and were probed about their understanding, response logic and views of the questions throughout this process by the interviewer. The results of the interviews helped us in evaluating whether the items proposed measured the skill constructs we intended. We checked whether all respondents understood the question, found the question relevant, and were able to formulate an answer in the provided scales. Originally, all response items were formulated in English. Two of the researchers are Dutch and independently translated the questionnaire into their mother tongue for the Dutch pilot study.

The results of the cognitive interviews were used before and after conducting the pilot surveys (see Section 4). Before starting the pilot surveys, we made sure that all problems regarding understanding and answer formulation were corrected. Questions that surfaced as problematic were evaluated and adjusted. Overall we found that items that appeared difficult to interpret in the English version were also difficult in the Dutch version. In some cases, questions were altered to better capture someone's knowledge of doing something rather than whether they had done it or not. In other items, we added examples or context as this assisted with participants understanding of the question. For example, 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 information and communication 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 judgment of a source. 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.

3. PILOT SURVEY RESULTS

3.1 Samples

The third step of the instrument development was pilot testing the instrument in an online non-volunteer access panel managed by Toluna. Toluna's panel is a random sample of the population selected through offline random stratified sampling, then for our study a random sample of Internet users was drawn. The pilots in the UK and in the Netherlands were held in May 2014. The aim of the pilots was to test the reliability of the constructed scales, and check whether the pilots in both countries would result in similar factor solutions. The online survey was completed by 324 and 306 respondents completed in the UK and the Netherlands respectively. The respondents represented a random sample of Internet users in both countries; demographic characteristics are summarised in Table 1. In addition to the Internet skills items, the survey administered items related to types of Internet use and outcomes of Internet use, as we are also interested on how the identified skills relate to these. The results of this part of the survey are published elsewhere (Helsper, Van Deursen, & Eynon, 2015).

Table 1

Demographic profile (UK: N=324; NL: N=306)

	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	40.1	108	35.3
PT employed	48	14.8	47	15.4
Unemployed	17	5.2	31	10.1
Student	16	4.9	35	11.4
Caretaker	68	21.0	35	11.4
Retired	28	8.6	23	7.5
Not able to work	10	3.1	25	8.2

We analysed the results of the pilot tests in two steps: (1) exploratory factor analyses by using a merged UK and NL dataset, and by using separate datasets; (2) structural equation modelling to conduct a confirmatory factor analysis (CFA) for the two independent samples.

3.2 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 items within the identified skill factors. We used varimax rotation because we knew from previous research (Van Deursen, Van Dijk & Peters, 2012) that Internet 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 resulted in a solution with eight factors with eigenvalues over 1.0, explaining 68% of the variance. 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 accounted for 64% of the variance (goodness of fit: chi-square=3557.82, df=1029, $p<.001$). We repeated the six factor solution analyses for both the UK (63% explained variance, goodness of fit: chi-square=2139.65, df=1029, $p<.001$) and the Netherlands (69% explained variance, goodness of fit: chi-square=2786.16, df=1029, $p<.001$). We created long and short scales for each factor (See Table 13). However, as our ultimate goal was to create easy-to-use scales with a maximum of 5 items for each construct to enable them to be used in a range of surveys here we focus primarily on the short scales. More information about the full scales is contained in an earlier report (Van Deursen, Helsper & Eynon, 2014). In order to ensure these scales were reliable and valid we used the following procedure to decide on the items that would be used to construct the scale:

(1) the exploratory factor analysis of the merged dataset was used to develop the conceptualizations for the six factors and labelled these Operational, Navigational, Mobile, Informational, Social, and Creative. They represented the proposed theoretical framework.

(2) Items that were ambiguous, that is, they loaded on a different factor than we expected, were deleted.

(3) If there were items that loaded on different factors in the UK compared to the Netherlands we made a theoretically informed decision to delete them. The reliability scores for the resulting five skill factors are high and the means do not differ significantly between the Netherlands and the UK (See Table 2).

Table 2

Scale characteristics (Overall N= 622, UK N=317, NL N=305)

Skill type	Overall			UK			NL		
	α	M	SD	α	M	SD	α	M	SD
Operational (5)	0.86	4.65	0.66	0.83	4.55	0.70	0.89	4.75	0.61
Mobile (3)	0.94	3.96	1.31	0.95	3.94	1.33	0.92	3.98	1.29
Information Navigation (5)*	0.90	3.70	1.08	0.91	3.74	1.05	0.89	3.66	1.11
Social (5)	0.88	4.40	0.70	0.85	4.39	0.68	0.91	4.41	0.73
Creative (5)	0.89	3.10	1.18	0.90	2.97	1.23	0.88	3.24	1.11

*The Information Navigation skill was reversed since it contained negatively worded items.

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.

Based on the exploratory factor analysis we identified ten items that loaded together on what we labelled *Operational Skills*. The five highest loading items are:

- 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)

The *Mobile Skills* scale loaded clearly with three items in both the Netherlands and the UK and in the merged dataset. It is important to note 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.

- I know how to install apps on a mobile device (λ=.742)
- I know how to download apps to my mobile device (λ=.768)
- I know how to keep track of the costs of mobile app use (λ=.618)

The theoretically distinct formal and informational skill items seem to correspond to a similar factor. This can be explained by the fact that navigational issues primarily rise when looking for information. We therefore labelled this factor *Information Navigation skills*. The five highest loading items on this 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. [i] More importantly, most of the highest loading items refer to navigation. To our surprise, several of the items often used in information literacy scales loaded on different factors. We recommend that future research use positively formulated items measuring the same skills, and includes additional items for further investigation.

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 *Social Skills* scale in both the Netherlands and the UK. The five highest loading items 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) (λ=.569)
- I know how to remove friends from my contact lists (λ=.553)

The exploratory factor analysis also brought up eight items for *Creative Skills*. The five highest loading items 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 licenses apply to online content (λ=.697)
- I would feel confident putting video content I have created online (λ=.693)

3.3 Discriminant Validity

To test whether the factors measured truly different constructs, we conducted a simple discriminant analysis by doing a Chi-square difference or paired construct test (Anderson & Gerbing 1988; Segards, 1997). This test compares the chi-square scores of a 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 $p<.001$ apart from the differences between Information Navigation and Creation skills and between Information Navigation and Mobile skills which were significant at $p<.01$ (see Table 3). This means that all the factors can be identified as separate constructs.

Table 3

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

	Operational	Information Navigation	Social	Creative
Information Navigation	38.30**			

Social	227.05**	35.10**		
Creative	124.91**	0,54	144.45**	
Mobile	192.98**	8.105*	162.29**	242.07**

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

3.4 Confirmatory Factor Analysis and Invariance

The next step was to test whether the factor structures proposed in the previous section fit similarly in the UK and the Netherlands. We conducted CFA using AMOS with tests for factorial invariance. We tested for configural, metric, scalar, and uniqueness invariance. See Table 4. 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. 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 A for coefficients and B for covariances and correlations) has a moderate to good fit for complex model indicators on the merged database (Kline, 2005): χ^2 (510)=1667.93, χ^2 /df =3.27; CFI=.93; RMSEA=.06 (ci. 0.06-0.06); AIC=1977.93.

Table 4

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

Model	χ^2	df	X^2/df	CFI	RMSEA	ci. (90%)		p	AIC
Configural	912,43	400	2,28	0,95	0,045	0,041	0,049	0,98	1308,43

Metric	947,21	418	2,27	0,95	0,045	0,041	0,049	0,99	1307,21
Scalar	1108,66	441	2,51	0,94	0,049	0,046	0,053	0,65	1422,66
Uniqueness	1164,32	456	2,55	0,93	0,050	0,046	0,053	0,54	1448,32

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

The results in Table 5 show that the proposed factor structure 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.

Table 5

Model fit on CFA for the individual factors

	χ^2	df	p	χ^2/df	CFI	RMSEA	ci. (90%)		p
Operational	16,44	2	0,00	8,22	0,99	0,11	0,06	0,16	0,02
Information Navigation	9,818	5	0,08	1,964	1,00	0,04	0,00	0,08	0,64
Social	0,324	2	0,85	0,162	1,00	0,00	0,00	0,04	0,97
Creative	4,859	4	0,30	1,215	1,00	0,02	0,00	0,07	0,83

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 χ^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 χ^2/df and for scalar and uniqueness on RMSEA.
- Social skills: Excellent on Configural, Metric, Scalar and Uniqueness invariance on χ^2/df, Moderate to good on the CFI and poor on RMSEA.
- Creative skills: Excellent on Configural, Metric, Scalar and Uniqueness invariance on χ^2/df and CFI indicators and Moderate to good on the RMSE for all of these.

4. FULL TEST RESULTS

4.1 Sample and Setting

The final step of the instrument development was a full online survey that was conducted in the Netherlands over a period of two weeks in July 2014. To obtain a representative sample of the Dutch population, we made use of the Dutch online 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. Since the panel is a largely representative sample of the Dutch population, it contains beginners and advanced users with different Internet skill levels. 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 6 summarizes the demographic characteristics of the respondents.

Table 6

Demographic profile Dutch Internet user sample (N= 1,107, Weighted N=1,337)

	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

4.2 Confirmatory Factor Analysis

To test whether the scales that resulted from the pilot tests 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 a good fit in the general Dutch Internet User population sample. Table 7 shows high alphas.

Table 7

Scale characteristics in Dutch Internet user population

Skills scale	Mean	SD	Variance	α
Operational	4.51	0.81	0.04	0.86
Information Navigation	3.56	1.13	0.08	0.89
Social	4.36	0.77	0.04	0.88
Creative	3.11	1.22	0.27	0.90
Mobile	3.97	1.33	0.08	n/a

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 8 shows that the individual factors fit the general population data excellently on indicators for complex models for all except the Social skills scale (Kline, 2005). The Social skills scale shows excellent fit on the CFI indicator but only moderate fit on the RMSEA. The combined scales with covariance between the different factors also showed excellent fit.

Table 8

CFA fit (N=1,337; weighted full population)

	χ^2	df	p	CFI	RMS EA	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 scales	822.76	210	0.00	0.96	0.05	0.05 -	0.06	0.27	1000.76

4.3 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 took a three-fold approach: (1) examining descriptive information on the averages across the scales for different socio-demographic groups, (2) testing for convergent and discriminant validity of the scales, and (3) testing whether the scale characteristics were consistent through random resamples of the population using bootstrapping techniques and whether they relate similarly for different socio-demographic groups.

Table 7 shows that 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 lastly Creative skills.

In digital inclusion literature a few key predictors have been described for the level of skill an individual professes to have (Hargittai, 2002; Lit, 2012; Van Deursen & Van Dijk, 2011). Here, we look at age, gender, education, and occupation.

Table 9

Reliability (α) 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)

Differences between men and women and between different age groups are significant, except that of Information Navigation skills (See Table 9). The differences were in the direction that might be expected by the literature, that is, men estimate their own skills higher than women and younger generations estimate their skills higher than older generations. Differences between educational groups are also as predicted by the literature. Those with higher educational levels are significantly more confident for all skills, including Information Navigation skills. The descriptive analysis of occupational groups mostly confirms the literature around inequalities in skill levels. For all skills, the full time employed and students indicate having the highest skill levels, with the exception of Information Navigation skills where differences are 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. Overall, the analyses indicate that the scales show consistency with previous general research and theoretical thinking around how Internet skills relate to inequalities and differences between socio-cultural groups.

4.4 Convergent and Discriminant Validity

To understand whether 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). Tables 10 and 11 show that the proposed factor structure is valid in the sense that both the convergent and discriminate validity are high (see Hair, Black, Babin, & Anderson, 2010).

Table 10

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 11

Convergent and discriminant validity indicators skills scales

	CR	AVE	MSV	ASV
Operational	0.82	0.50	0.45	0.28
Information Navigation	0.89	0.63	0.08	0.04
Social	0.86	0.55	0.45	0.31
Creative	0.86	0.56	0.44	0.27
Mobile	0.94	0.84	0.44	0.28

4.5 Scale Characteristics and Consistency

To understand whether the factor solution was stable, a Bollen-Stine (1992) test was conducted for the full factor model. In all 2000 bootstrap samples the fit was better than in the original model ($P<.001$ - but this is to be expected with a large dataset and a complex model). We can be confident that the model shows a good fit and is a stable solution for the full population.

Reliability comparison between socio-demographic groups. When constructing our scales, it is important to explore the extent to which they are reliable across different groups. Overall the scales are similar in their reliability across different socio-demographic groups. However, students have a low reliability for Mobile Skills. 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 for this group.

Table 12 shows the correlations between the scale constructs. We also examined correlations between factors within different socio-demographic groups using Fisher's r-to-z transformation tests. None of the differences between the men and women's correlations were significant. 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. 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.

Table 12

Correlations between short scales in population survey of Dutch Internet Users (N=1,337)

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

5. DISCUSSION

5.1 Main Findings

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, and an important aspect of this are digital skills. However, there is a need for more theoretically informed, reliable, and valid instruments that are able to measure developments in this area. In the current contribution, we propose a thoroughly tested instrument for measuring Internet skills, a concept that is considered a key component in digital inclusion debates. The development of the instrument began with a critical look at the existing literature. Two main theoretical approaches were used to build the proposed skill framework and test measures (Helsper & Eynon, 2013; Van Deursen & Van Dijk, 2010; Van Dijk & Van Deursen, 2014). We ensured that all proposed items reflected typical Internet uses that are well established in previous research. 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 in the instrument 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. 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. The result is a theoretical, empirically and cross nationally consistent framework consisting of five types of digital skills listed in Table 13. Importantly, this instrument can be linked theoretically with both uses of the Internet and outcomes of using the Internet (Helsper, Van Deursen, & Eynon, 2015).

Table 13

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. Italic items are added to create longer scales; depending on the aim of the research project these can be used to replace those on the short scale.
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.

5.2 Limitations and Future Studies

A first limitation is that this study compares cohorts from only the UK and the Netherlands. Although these countries are different in, for example, levels of Internet diffusion, other cultures should be included in future investigations in order to truly test the cross-cultural validity of the developed instrument, that we have called the Internet Skills Scale (ISS). The survey is currently being applied in other countries to test more broadly for validity.

A second issue is that we have developed this instrument using online surveys. This was a deliberate methodological choice as in our wider study of which this instrument forms part we wished to connect Internet skills with uses of the Internet and outcomes of Internet use – which would not be appropriate for non- or ex-users of the Internet. Future research should include current non-users when the aim is to measure skills distributions across the population. Nevertheless, due to the careful use of online panels we have a representative sample that contains a wide spectrum of individuals with a range of Internet skills, which is entirely in line with the goals and objectives of this research.

With regards to the developed instrument (the ISS) of the five highest loading items of the information navigation dimension, four relate to navigation. From a statistical point of view, the construct focusses on navigation more than information. This means that if the 5-item scale is used the results especially focus on navigation. From an academic point of view, we cannot ignore information seeking skills. Therefore, we suggest adding additional items that load on the information navigation factor. In particular, the evaluation aspect of information skills is now missing. These items did not load on one factor because they were shown to be context dependent for each individual and was not easy to measure in general population survey research. We suggest that future cross-national studies might add additional information seeking

items to address this issue. Future work is required to determine a new set of measures that can (if at all possible) explore evaluation skills that can be measured independent of context.

Secondly, the full study examined consistency of the five Internet skill scales and their characteristics when measured in a representative sample survey of Dutch Internet users. The reliability and validity of the scales as well as indicators of convergent and discriminant characteristics were good which made us to recommend the use of the Operational, Information Navigation, Social, Creative and Mobile skills scales in general population research. Nevertheless, the 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 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.

Finally, future studies might propose additional items for the mobile skills construct to ensure all components of mobile skills are covered – as the creation of a mobile skills construct was not the original intention of this research.

Despite these limitations, we propose that our framework of five types of digital skills - Operational, Information Navigation, Social, Creative and Mobile - is a valuable contribution to survey research in the field of digital inclusion and will provide a useful set of items that can be used across countries.

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Appendix A

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 B

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

Footnotes

1. This phrasing was based on external validity testing through performance tests in the Netherlands which explored whether answers to the survey questions corresponded to actual ability to perform these skills in a laboratory setting (Van Deursen, Van Dijk & Peters, 2011).