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Using the Internet: Skill related problems in users' online behavior

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ABSTRACT

This study extends the conventional and superficial notion of measuring digital skills by proposing definitions for operational, formal, information and strategic skills. The main purpose was to identify individual skill related problems that users experience when navigating the Internet. In particular, lower levels of education and aging seem to contribute to the amount of experienced operational and formal skill related problems. With respect to information skills, higher levels of education seem to perform best. Age did not seem to contribute to information skill related problems. Results did reveal that age had a negative effect on selecting irrelevant search results. Individual strategic Internet skill related problems occurred often, with the exception of subjects with higher levels of education. Younger subjects experienced far less operational and formal skill related problems, but there was no difference regarding information and strategic skill related problems.

1. Introduction

The rapid diffusion of the Internet into daily life presents citizens with situations that require diverse digital skills. In the explanation of Internet usage differences, the level of digital skills appears to be one of the most important factors. It has a strong effect on the Internet use of individuals after they have reached physical access to the Internet according to digital divide research since 2000 (Norris, 2001; Hargittai, 2003; Solomon et al., 2003; Mossberger et al., 2003; Warschauer, 2003; van Dijk, 2005). More and more it is recognized that digital skills are not equally spread in society. Despite the importance of this topic, very few measurements of skills are available. Studies that attempt to measure digital skills are often limited in their definitions, small sample sizes and methods of data collection. They mainly use surveys that measure skills indirectly (e.g., measuring the amount of use of specific applications), use self evaluations that provide a flattering picture (e.g., Merritt et al., 2005) or use conceptually superficial definitions of Internet skills. Very little scientific research has been done on the actual level of digital skills mastered by populations at large. Disciplines that have more profoundly investigated digital literacy or skills are library research, computer science and educational science.

In the study reported here, performance tests are administered on a representative sample of the Dutch population. Four skill definitions help to identify how often individual skill related problems occur when the Internet is used. The definitions emerge from research directions discussed in Section 2 and are the methodological contribution of this article. The practical contribution is an investigation of individual skill related problems that users have when they navigate the Internet.

2. Internet skill definitions and research questions

The few Internet skill studies conducted (e.g., de Haan, 2003; Hargittai, 2003) show large variations in digital skills among different social segments, but they fail to explain what these skills mean. This is caused by the fact that many interpretations are given to a wide range of digital skill related terms. There is a lack of theoretical justification, resulting in different operational definitions that ignore the full range of skills concerned.

Three sources propose a succession of general types of skill categories that are applicable to both online and offline computer use (Eshet-Alkalai and Amichai-Hamburger, 2004; Steyaert, 2002; van Dijk, 2005). These frameworks integrate aspects from multiple research directions. Research literature in each direction helps to provide operational definitions. The first direction copes with the operation of digital media, so-called 'button knowledge'. This direction attracted the most attention in digital divide discussions and statistics (e.g., Bunz, 2004; de Haan, 2003). The second direction relates to the specific medium used and covers the formal structures on which this medium is built (e.g., Dias et al., 1999; Kim and Hirtle, 1995; Nielsen, 1990). For example, the Internet offers hyperlinks, a formal structure that enables users to choose their own non-linear paths instead of the fixed formal structures

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of print media (chapters, paragraphs, references, etc.). The third direction covers the content provided by digital media and focuses on information search behavior (e.g., Hölscher and Strube, 2000; Marchionini, 1995; Spink and Jansen, 2004). More and more studies are conducted in this direction due to the incredible amount of available information on the Internet for the public. Finally, the fourth direction considers the personal goals and benefits for using digital media. Research that actually considers the goals and benefits of the individual Internet user is scarce; most studies take a macro level approach that consider the economic, cultural or social benefits for the society at large (e.g., Bonfadelli, 2002; DiMaggio et al., 2004; van Dijk, 2005; Mossberger et al., 2003).

Considering each of the four research directions separately would not help us in better understanding the skills individual users require when using the Internet. To better understand the specific individual Internet skill related problems that users experience, definitions that emerge from all four research directions are proposed.

2.1. Operational Internet skills

Operational skills are often studied and captured in many terms, e.g., instrumental skills (Steyaert, 2000, 2002), operational skills (van Dijk, 2005), technical competence (Mossberger et al., 2003), technical proficiency (Søby, 2003), computer literacy, IT literacy and IT fluency (see Bawden, 2001). All of these terms indicate a set of basic skills in using computer technology. Mossberger et al. (2003), for example, identify technical competence as the ability to operate a computerised or electronic device and Søby (2003) describes technical proficiency as the basic component of digital literacy, including a foundational knowledge of hardware, software, applications, networks, and elements of digital technology. Van Dijk (2005) defines operational skills as the skills used to operate computers and network hard and software.

When focusing on the Internet, both Steyeart and van Dijk refer to the operationalisation of the European Computer Driving License (ECDL) that defines a number of modules for the attainment of operational skills. Scientific operational definitions are presented by Bunz (2004). Furthermore, Larsson (2002) created a Digital Literacy Checklist following Gilster's (1997) definition of the concept 'digital literacy'. Combing these sources, the following definition can be used to measure operational Internet skills:

- Operating an Internet browser:
  - opening websites by entering the URL in the browser's location bar;
  - navigating forward and backward between pages using the browser buttons;
  - saving files on the Hard Disk;
  - opening various common file formats (e.g., PDF);
  - bookmarking websites; and
  - changing the browser's preferences.

- Operating Internet-based search engines:
  - entering keywords in the proper field;
  - executing the search operation; and
  - opening search results in the search result lists.

- Operating Internet-based forms:
  - using the different types of fields and buttons and
  - submitting a form.

2.2. Formal Internet skills

Operational Internet skills need to be complemented by formal skills that allow the use of hypermedia. Most traditional media are linear, giving the user little control over the flow of information. Hypermedia allow users to choose their own non-linear paths. Users can move not only forward but also backward and to unknown locations, referred to as cross-referencing (Kwan, 2001). Cross-referencing characterises a difficult problem for users of the Internet (Kwan, 2001). Without a sense of location, distance, and necessary direction, it is not surprising that users often have a strong sense of disorientation (Kwan, 2001), the most frequently cited problem in hypermedia use (Lee, 2005). Users might become disoriented and lost in the non-linear structure of the Internet (Nielsen, 1990). Loss of a sense of orientation can involve not knowing where one is, where to go next, how to get back to a previous site, what path one has followed or where to look for information (Edwards and Hardman, 1989; Park and Kim, 2000). Eshet-Alkalai and Amichai-Hamburger, 2004 integrate the hypermedia aspect in her framework with the concept of branching literacy, which she defines as the ability to avoid losing orientation when navigating through a labyrinth of lanes. Empirical research of hypermedia has suggested that disorientation often restricts the effectiveness and efficiency of its usage (Lee, 2005). Users often get lost, even with sufficient content domain expertise. Disorientation can be framed in terms of site structure, web-links and web-design, independent of the information topics being navigated (Danielson, 2002). We propose the following definition for measuring formal skills:

- Navigating on the Internet, by:
  - being able to recognise and click links that are embedded in different formats such as text, images, menus and website lay-outs.

- Maintaining a sense of location while navigating on the Internet, meaning:
  - not becoming disoriented when navigating within a website;
  - not becoming disoriented when navigating between websites; and
  - not becoming disoriented when browsing through, and opening search results.

2.3. Information Internet skills

There are several terms that strongly relate to information skills, for example information competence (Mossberger et al., 2003) and information literacy (see Bawden, 2001). Standards and statements regarding these terms are produced by information professional bodies, all derived from the widely accepted definition of the American Library Association (ALA) (Correia and Teixeira, 2003). According to the ALA, an information literate person is "*able to recognize when information is needed and has the ability to locate, evaluate and use the needed information effectively.*" Literature relevant to skills in online information searching is spread across different areas that tend to stay separate, and, as a result, the information is often not well integrated (Jenkins et al., 2003). Information searching is mostly seen as an action by which users try to fulfil their information needs. For our goal of defining information skills, studies that consider successive steps to explain the process of information searching behavior are most interesting. These studies are often based on the information searching models of Ellis (1989) and Marchionini (1995). Although the successive steps they define are originally developed in the context of traditional information retrieval, they can also be extended to online search engines. The model of Marchionini (1995) is most appropriate for digital environments.

The first measurable step is choosing a specific system, which depends on the information seeker's previous experience with the task domain, the scope of his/her personal information

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infrastructure, and the expectations about the answer that may have been formed (Marchionini, 1995).

After choosing a search system, a user must formulate search queries whose quality directly affects the quality of the generated search results. When using search queries, advanced search operators such as quotation marks can improve the precision of search results, but this must be learned (Marchionini and White, 2007).

Selecting the most relevant results is the next step and often a difficult one. Results are often presented in lists that can be simple lists, hierarchical lists, visualizations, snippets or metadata records (Greene et al., 2000). When the lists only contain few search results, they can be inspected comprehensively. However, often a vast number of often unsuitable results are generated (Livingstone, 2005).

Finally, the evaluation of information sources is considered. Information is not always of the same quality. This calls upon specific skills that enable users to check the actual correctness of data and the reliability of the sources ('the art of critical thinking' – Gilster, 1997).

The process described is recursive and not limited solely to the information seeking process in search engines. During the process, people will reflect on whether the process relates to the information problem, the effort is as expected, and whether the extracted information maps well onto the task (Marchionini, 1995). The following operational definition is used for measuring the level of information skills:

- Being able to locate required information, by:
  - choosing a website or a search system to seek information;
  - defining search options or queries;
  - selecting information (on websites or in search results); and
  - evaluating information sources.

2.4. Strategic Internet skills

While the skill dimensions discussed so far all relate to an effective use of the Internet, strategic skills are more related to the purpose of this use. Van Dijk (2005) defines strategic skills as the capacity to use computer and network sources as the means for particular goals and for the general goal of improving one's position in society. Strategic skills relate to the usage gap, as described by Bonfadelli (2002) and van Dijk (2005), between those who primarily use Information Communication Technologies for professional and educational development and those who mainly use it for entertainment. Pruulmann-Vengerfeldt (2006) relates strategic skills to the discussion of how economic, educational and cultural capitals influence everyday lives and activities. These capitals increase the value of Internet use and will be higher for people with better strategic skills.

Strategic skills appear to be the most complex of all the types of digital skills distinguished and have never been measured at all. Taking advantage of the Internet is a process that entails four analytically distinct steps.

The first step is goal orientation. This means being aware of the opportunities that the web offers and taking advantage of these opportunities for a particular personal or professional goal. Keeping an eye on this goal and acting towards it are difficult and hard to learn skills, especially in a digital media landscape that offers an enormous number of distracting stimuli for other goals.

The second step is taking the right actions on the Internet. This means combining the various possible information sources to achieve the best means for the goal desired. After the right actions are taken, it is time to make decisions to reach the original goal by using the (often excessive amount of) information retrieved selectively.

Making decisions – e.g., what product am I going to buy, what political party am I going to vote for or am I going to file an appeal? – is the third step and should be done by consulting the right information sources, relevant for work, study or personal life.

The final step is gaining the actual benefit. When the right decisions are made, they can be turned into benefits of a personal, social, professional or educational nature.

Taking these four steps into consideration, we consider the following subsequent indicators for measuring strategic skills:

- Taking advantage of the Internet, by:
  - an orientation towards a particular goal;
  - taking the right action to reach this goal;
  - making the right decision to reach this goal; and
  - gaining the benefits belonging to this goal.

2.5. Research questions

The study reported here addresses the skill definitions from the former sections to identify individual skill related problems that users experience when they use the Internet. This study accounts for the type and number of problems that users experience, but will also reveal differences between users. Besides gender, education and age – the three most important factors in digital divide research (Norris, 2001; Mossberger et al., 2003; Warschauer, 2003; van Dijk, 2005) – other factors that are accounted for and come forward as important contributors in digital divide discussions are Internet experience, amount of time spent on the Internet, using social support, the primary location of Internet use and socio-economic status (Norris, 2001; Mossberger et al., 2003; Warschauer, 2003; van Dijk, 2005). There are two research questions:

1. What individual skill related problems do users experience when using the Internet, and how often do these problems occur?
2. Are there differences in the individual skill related problems experienced, between users with different gender, age, educational attainment, Internet experience, amount of time spent on the Internet, social support, primary location of Internet use and social position?

3. Method

To answer the research questions, a large-scale study was conducted in which subjects performed assignments on the Internet. During the assignment completion, several problems are tested for. This section describes the subjects that participated, the method of data collection, the assignments, the coding scheme used to identify individual skill related problems and the technical specifications of the study.

3.1. Subjects

Subjects were recruited in July 2007 by randomly dialling telephone numbers in cities and villages nearby the University of Twente. The cities and villages were specifically chosen to reflect the urban, rural and countryside distribution of the Netherlands. A condition of invitation was that the participant used the Internet at least once every month and for more than just e-mail. This ensured that low-frequency users who are nonetheless familiar with the Internet are included. Subjects were promised 20 euro for their participation in a one-and-a-half hour research session about their Internet use.

109 Subjects performed the tests, following a sample procedure with a two-step approach. First, a sample was randomly selected

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from a telephone book. Subsequently, a selective quota sample was drawn for the strata and quota of gender, age (for recruitment divided over four categories, 18–29; 39–39; 40–54 and 55–80) and educational attainment (primary school equivalent, high school equivalent, college and university equivalent), the three variables on which the subjects were recruited. Table 1 provides an overview of the subjects' characteristics. The average age was 43.3 (SD = 15.5), the average years of Internet experience was 8.1 (SD = 3.0) and the average number of hours spent online every week was 9.7 (SD = 9.7).

3.2. Methods of data collection

Two methods of data collection were used. Prior to the study, a 10-min questionnaire was administered to gather information about gender, age (year of birth), education (low–middle–high), frequency of Internet use (hours a week), Internet experience (years), participation in an Internet course, location of respondents' regular Internet use, their social support networks and socio-economic status.

After the subjects completed the questionnaire, they were given a sequence of nine assignments (discussed in Section 3.3), one at a time. Morae Recorder (TechSmith, Version 2.2) was used to record the screen actions that are analysed in this study. Detailed log files of the recordings were created with Morae Manager (TechSmith, Version 2.2) to enable in-depth analysis. In total, 109 sets of data were generated by the screen recordings analysed here.

3.3. Performance test assignments

The subjects performed specific assignments to identify individual operational, formal, information and strategic skill related problems. The topic area chosen for this study was online public service delivery, and all the assignments consisted of actions the government assumed all citizens are able to complete. For the assignments that directed subjects to a specific website, websites in the usability top 10 of the Dutch public benchmark (Overheid.nl) were selected. All assignments were pilot-tested with twelve participants to ensure comprehensibility and applicability.

The assignments were fact-based and had a specific correct action or answer. We avoided open-ended tasks because of the ambiguity of interpretation of the many potential answers. Subjects themselves decided when they were finished or wanted to give up on an assignment. After a specific, ample time period, a deadline appeared when the test leader gently asked the subjects to pass on to the next assignment. All subjects completed the assignments in the same order. Appendix A contains the list of assignments charged and the maximum allowed time.

Table 1
Number of subjects over gender, education, age, primary location of use, gaining help from peers, socio-economic status and participation in an Internet course ($N = 109$).

	n	%
Gender		
Male	51	47
Female	58	53
Education		
Primary school equivalents	32	29
High school equivalents	37	34
College and university equivalents	40	37
Age		
18–29	25	23
30–39	27	25
40–54	27	25
55–80	30	28
Primary location of Internet use		
At home	95	87
Elsewhere	14	13
Need help from peers when using the Internet		
No	51	47
Yes	58	53
Socio-economic status		
Active (employee, employer, student)	75	68
Inactive (retired, disabled, unemployed, housemen-wife)	34	32
Participation in an Internet course		
No	84	77
Yes	25	23

3.4. Coding scheme

The richness of the video data required a systematic approach for coding. A coding scheme was developed based upon the Internet skill definitions as discussed in Section 2 and upon trends observed in the data. As additional skill related problems were identified, the coding scheme was extended. In total, 38 problems were identified, described at a general level of abstraction (instead of a concrete level such as mouse clicks or keystrokes). Appendix B contains the final coding scheme.

Most of the operational and formal skill related problems in the coding scheme emerged from the matching skill definitions in Sections 2.1 and 2.2. A specific task was created to reveal whether subjects would experience them. During the completion of the information and strategic skill assignments, the occurrences of specific experienced information and strategic skill related problems were counted. Most of the problems emerged from the skill definitions in Sections 2.3 and 2.4. However, these definitions not always appeared sufficient. Take for example the following part of the information Internet skill definition: *selecting information.* Analysis of the data revealed that there are more problems regarding this part alone; for example choosing only the first few search results, choosing sponsored search results or choosing irrelevant search results. The same accounts for the strategic skill definition explained in Section 2.4. For example, analysis of the data revealed that *taking actions towards a final goal* contained the problems of being misled, using information from only one source (while more were needed), working in an unstructured manner and using websites that support decisions incorrectly. In short, problems that emerged from the data and were not directly mentioned in the Internet skill definitions were added to the coding scheme.

To test the reliability of the empirical work, the coding of the data was replicated by a second observer. This observer independently coded the recordings of ten subjects, which was compared to the coding of the primary observer. The comparison revealed no disagreements on the coded operational and formal skill related problems (with the binary outcome experienced/not experienced in the specific task). The number of the individual information skill related problems that were counted during the completion of the information skill related assignments did not reveal any points for discussion. However, some disagreement on three strategic skill problems occurred, which was solved after discussion. One of the points of discussion for example was whether filling out an (to the assignment) irrelevant form itself also could be coded as taking an incorrect decision. Each session of video recording took about 2–3 h to code and analyse.

3.5. Technical specifications

The experimenter and the subject were present in an office of the University of Twente where the setting was equally new for all subjects. They used a keyboard, a mouse and a 17-in. monitor connected to a laptop. During the study, subjects were allowed to use their choice of browser (Internet Explorer 6, 7 or Mozilla

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Firefox 3), so that they could replicate their usual Internet use. No default page was set on the browsers, and all the assignments started out with an empty page. To ensure that subjects were not influenced by previous users' actions, the browser was totally reset after each session. The laptop connected to the Internet on a high-speed university network.

4. Results

The next sections discuss the individual skill related problems that emerged from the Internet skill definitions and the completion of the assignments. Both the operational and formal skill problems are recorded during specific tasks designed to these corresponding skills and during the performance of the information skill assignments. To measure the experienced information and strategic skill problems, the total numbers of occurrences of every problem are counted in all 109 screen recordings so as to make statistical analysis possible. To answer the first research question, Section 4 overviews the skill related problems and the number of subjects that experienced these problems. To address research question two, the same section provides details about problems that different users experience when completing the assignments.

4.1. Operational Internet skill related problems

For 5% of the subjects the *use of the address bar* appeared to be problematic. Three seniors did not recognize the address bar at all. Without the immediate appearance of Google, they were unable to recognize the Internet browser and had no clue on how to start the session. One 55-year-old middle-educated man did not remove the 'about:blank' part in the address bar. A 44-year-old low-educated woman was convinced that she could only open a website using the 'Open' option in the File-menu of Internet Explorer.

Saving a file to the hard disk (in this case the online tax declaration program) was problematic for 37% of the subjects. The largest percentage of the subjects who failed this test saved the whole web page (12%) or had absolutely no clue on how to proceed (11%). Other mistakes included assuming that the file was automatically saved after opening the save dialog, making website shortcuts to the desktop or adding a website to the favourites.

In one task, subjects were asked to open an online *PDF file* and save it in an existing folder on the desktop. Forty-nine percent of the subjects experienced problems and did not succeed. Twenty-five percent had absolutely no idea, and 15% were only able to save the PDF in the automatically opened 'My documents' folder. Others added the file to the favourites, closed the save dialog instead of saving the file, clicked right on the opened PDF file or saved the whole website before opening the PDF.

Ninety percent of the subjects were able to add a website to the *Favourites* (or *Bookmarks* in Mozilla Firefox).

For only four subjects, filling out a *web-based form* appeared to be a problem. They forgot to complete the whole form, which resulted in a warning message that caused confusion. During the information assignments, five subjects experienced this problem.

Problems with respect to the use of *search engines* were rare. Four subjects overlooked the search engine on a website (while obviously present), and 11 subjects (10%) experienced search term-related problems. These were typed without spaces or preceded by 'www'. Ten senior subjects (33% of all seniors), entered search queries into the address bar.

Finally, three subjects in the oldest age group (10% of all seniors) only used the *scrollbar*'s tiny arrow buttons for traversing long distances on a page. They were not aware of the easier-to-use middle part of the scrollbar. Using the *mouse* resulted in some surmountable problems for 14 seniors (47% of all seniors), causing minor delays. These subjects clicked multiple times on search buttons or used the right button instead of the left.

Failing to save a file to the hard disk, to open and save an online PDF file in an existing folder on the desktop, to add a website to the Favourites and operational problems with respect to the use of search engines appeared the most and are accounted for in regression analyses summarized in Table 2. The regression analysis is conducted to provide details about the different users that experience these problems when completing the assignments. The specific factors mentioned in research question two are added to the analysis. Since the experienced problems are measured in a specific task with a binary outcome (not succeeded/succeeded), logistic regression analyses are performed to identify what factors appear significant in the regression model. In the models for saving a file and opening and saving a PDF, age is predictive. So was education for saving a PDF, adding a website to the favourites and using a search engine. Other factors did not appear significant, interesting enough Internet experience and amount of use included.

4.2. Formal Internet skill related problems

To identify individual *lay-out and website design* related problems, subjects were asked to find the street address (simple information) of three government agencies in the Dutch city Nijmegen. Twenty-one percent did not succeed. Some subjects simply overlooked the 'contact' button in the main menu, while others did not recognise this menu at all. There was one subject who altered the URL by adding '/Nijmegen', believing that this would bring him directly to the contact details. During the information tasks, 40% of the subjects experienced problems while using (roll-over) menus.

Keeping *orientation within a website* was difficult for 28% of the subjects. In a specific task, subjects were asked to return to the homepage of the Dutch Tax and Customs administration from a deep-link. One of them tried to find the homepage using the Internet browser's help function and another attempted to call his brother asking him for help finding the homepage. During completion of the information assignments, subjects often believed that they were on the homepage of a website while this was not the case, clicked 'Up' while they were already at the top of a page or clicked on a link to the current page.

To measure problems related to *orientation between websites*, subjects were instructed to click an external link on the website

Table 2
Logistic regression analysis of operational skill related problems.

	Exp(*B*)			
	Saving file	Opening and saving a PDF	Adding site to the Favourites	Using search engines
Gender (male/female)	1.21	.33	.81	1.05
Age (years)	.95*	.91***	.95	.95
Education (low–high)	1.72	5.59***	3.17*	3.67*
Internet experience (years)	1.23	1.33	.97	1.48
Time online (hours per week)	1.00	1.01	1.04	1.09
Followed an Internet course (no/yes)	1.15	.76	.69	.34
Using peers for help (no/yes)	.54	.94	.30	.68
Primary location of use (at home/elsewhere)	4.44	1.29	1.62	3.08
Socio-economic status (inactive/active)	3.12	1.03	1.55	2.16
Nagelkerke R^2	.47	.61	.48	.64
Chi-square	45.84***	65.64***	41.58***	66.66***

* $p < .05$.
*** $p < .001$.

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of the Government Information Service (Central Office of Information). Twenty-one percent of the subjects lost their orientation when a new browser window was opened. They did not understand why the back-button was deactivated and overlooked the Government Information Service's website in the original window, even when it was still visible in the background. Some of the participants closed all windows and started again. During the completion of the information assignments, 29% of the subjects experienced similar problems. They were relocated without noticing and did not see the original window anymore after opening a new one.

Keeping an *orientation when navigating search results* was measured by asking subjects to open the first and fourth search result after performing a search operation. One-third of subjects experienced problems. The main one being that after opening the first search result, subjects chose the fourth option in another nearby menu that had nothing to do with the generated search results. They were convinced that they opened the fourth search result, indicating that the website's structure caused confusion. Two subjects opened the fourth page with search results instead of the fourth search result. During completion of the information assignments, ten subjects never returned to the original search result list. They retyped the same search queries in a new Google window.

According to Table 3 (in which the binary outcome is not succeeded/succeeded), in the regression models for using different website designs, keeping an orientation within a website and getting confused when a new browser window is opened, age is predictive. Like the younger subjects, the higher educated are less likely to experience the problem of getting confused when a new browser windows are opened. Furthermore, the more experienced Internet users are, the more likely they are able to open more than one search result. Finally, subjects that need help from peers when using the Internet experience more problems with using different website designs.

4.3. Information Internet skill related problems

Three assignments were prepared to identify information Internet skill related problems. The first assignment used a closed environment (one specific website). In the second and third assignment, subjects could choose their own *starting point*. All subjects, with the exception of two, chose Google.

Defining search queries is a step that revealed large differences between the subjects. Fifty-six percent of the subjects performed search operations using *search queries that did not fit the information problem or were too general* (e.g., keyword 'salary' when searching for 'minimum wages in a specific year'). In a few cases, the full assignment was entered into the search bar, resulting in unusable search results.

Ninety-five percent of the subjects did not limit the number of search results by using *Booleans*. In only four cases quotation marks were used and in two cases the '+' symbol. Nobody used advanced search methods (e.g., exact word combinations or entering dates).

Since search engines return a vast number of unsuitable search results, intensive *selection* is required before the results become useful. Two subjects selected the Google option "I'm feeling lucky". Opening sponsored or commercial results was done by 56%. This percentage is probably higher than in other contexts since the Dutch government usually appears at the top of the search result lists in Google with sponsored links. Thirty-six percent of the participants did not go *beyond the first three search results* (12% went beyond the first three results in all information assignments). Ninety-one percent did *not go further than the first page with search results* in all the assignments. Fifty-five percent of the participants selected one or more *irrelevant search results*, 20% selected *irrelevant information pages within websites and* 4% filled out *irrelevant forms* for finding the information needed (e.g., filling in forms that generate average wages for specific jobs instead of searching for the minimum wages as assigned).

Using information from a less reliable website was done by 6% of the subjects. A striking observation was that nobody seemed to pay attention to the source of the information found. Finding the answer seems to be the primary objective; it does not seem to matter where the information comes from. For example, government information was taken from a website with classroom talks of primary school pupils. Nobody *evaluated* the date of the information. Only four subjects checked information on another website.

During the completion of the information skill assignments, the total number of the problem's occurrences was counted. Linear regression analyses over this number that revealed significant *F*-values are reported in Table 4. In the model for selecting irrelevant search results, age is predictive. Surprisingly, the older the subjects are, the less likely they select irrelevant search results. Education is predictive for using broad search queries, not going beyond the first three search results and selecting irrelevant information, where the higher educated experience these problems less than the lower. Other factors do not appear predictive to the regression models.

4.4. Strategic Internet skill related problems

Keeping an orientation towards the final goal was hard for some subjects. Strategic skill related problems that emerged in this step are being distracted by irrelevant stimuli (e.g., banners) (4%), not

Table 3
Logistic regression analysis for formal skill related problems.

	Exp(*B*)			
	Using different website designs	Orientation within a website	New browser window	Browsing more search results
Gender (male/female)	1.06	1.02	1.64	.90
Age (young–old)	.93*	.95*	.97*	.97
Education (low–high)	1.71	1.11	2.72***	1.47
Internet experience (years)	1.03	1.02	.95	1.48*
Time online (hours per week)	.98	.88	1.01	1.00
Followed an Internet course (no/yes)	.82	.56	.56	1.00
Using peers for help (no/yes)	.06*	.06	.49	.37
Primary location of use (at home/elsewhere)	2.57	1.54	2.5	6.73
Socio-economic status (inactive/active)	.98	.92	2.20	.97
Nagelkerke R^2	.87	.59	.39	.44
Chi-square	40.18***	41.64***	37.33***	40.73***

* $p < .05$.
*** $p < .001$.

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Table 4
Linear regression analysis for individual formal skill related problems.

	Using too broad search queries		Limited use of search results		Irrelevant search results		Using irrelevant information	
	t	Beta	*t*	Beta	*t*	Beta	*t*	Beta
Gender (male/female)	.57	.05	.534	.121	−.14	−.01	−.10	−1.06
Age (young–old)	−.38	−.05	−.43	−.12	−2.30	−.32*	−.08	−.62
Education (low–high)	−2.48	−.27**	−1.81	−.31*	−1.41	−.17	−.26	−2.25*
Internet experience (years)	−1.37	−.14	−1.70	−.45	−.86	−.10	−.02	−.19
Time online (hours per week)	−.92	−.10	−.76	−.01	−.65	−.07	.07	.65
Followed an Internet course (no/yes)	.85	.08	..76	.03	−.41	−.04	−.06	−.58
Using peers for help (no/yes)	.79	.08	.79	.05	.52	.06	.16	1.45
Primary location of use (at home/elsewhere)	.14	.01	.13	.03	.63	.07	−.07	−.67
Socio-economic status (inactive/active)	−1.73	.20	−.98	.48	−.73	−.09	−.08	−.63
R^2	.26		.21		.22		.15	
F	3.85***		2.76***		2.84***		1.97*	

* $p < .05$.
** $p < .01$.
*** $p < .001$.

having *a clue on how to start* at least one of the two strategic assignments (49%) and being misled during the completion of the assignments without noticing (20%).

A few strategic skill related problems emerged from the second step in the definitions, taking action toward the final goal. Thirty-six percent of the subjects used *websites that support users* in making informed decisions (e.g., choosing a political party). Unfortunately, these websites were only used in the simplest way, and the generated outcomes were too easily taken for granted. Of the subjects that used these websites, 92% were not able to generate useful outcomes. Twenty-five percent of the subjects did not *combine multiple information sources* and used information from only one website, not enough to resolve the strategic assignment (e.g., in making decisions based on different political views). The problem of working in an *unstructured* way (determined by checking whether information is not gathered piece by piece but by randomly surfing) was done by 71% in any of the two strategic assignments.

In the final stage of the strategic skill definition, an important problem appeared to be taking *wrong decisions* based on the information found, done by 46%. Sixty-three percent based their decisions on *incomplete information tenure*.

Linear regression analyses over the total occurrences of specific problems that revealed significant *F*-values are reported in Table 5. In the models for not knowing how or where to start, using only one website to make decisions, working in an unstructured manner and making incorrect decisions based on the information found, education is predictive. Subjects with more Internet experience have fewer problems with not knowing how to start an assignment. Surprisingly, subjects that followed an Internet course are less likely to know how to start a strategic skill assignment. They do however make less incorrect decisions based on the information found.

5. Discussion

5.1. Relevance of results

As outlined in the first section, few empirical investigations are available regarding digital skills and studies that attempt to measure these skills are often limited in the definitions used, the small sample sizes and the survey method for data collection in which skills are measured indirectly or by self evaluations. Most of the survey studies only address operational skills and to some extent formal skills and generate an excessively positive overall picture. So, the main benefits of our taxonomy are: (1) a definition and measurements of problems relating to the four types of Internet skills separately distinguished by others in the literature and (2) the cumulative nature of these four types in a taxonomy representing a full range of Internet skills. However, as discussed, below limitations in the range of skills to be distinguished still apply.

Results of this study reveal that age is mainly related to operational and formal problems. Though the number of operational and formal individual Internet skill related problems is highest for the oldest age group, surprisingly, they do *not* experience more individual information and strategic skill related problems. As for selection in search results, they scored even better than the youngest group. This underlines the importance of accounting for skill

Table 5
Linear regression analysis of strategic skill related problems.

	Not knowing where to start		Using only one website		Working unstructured		Taking incorrect decisions	
	t	Beta	*t*	Beta	*t*	Beta	*t*	Beta
Gender (male/female)	.83	.07	.49	.05	−.15	−.01	−1.18	−.11
Age (young–old)	.34	.04	−.94	−.12	.91	.11	.69	.09
Education (low–high)	−2.48	−.26**	2.45	.27*	−3.10	−.34**	−2.81	−.32**
Internet experience (years)	−2.84	−.29**	−.41	−.04	.29	.03	.17	.02
Time online (hours per week)	−.27	−.03	−1.40	−.15	−.15	−.02	−.32	−.04
Followed an Internet course (no/yes)	2.19	.19*	1.35	.12	.26	.02	−2.07	−.19*
Using peers for help (no/yes)	.09	.01	−2.49	−.27*	.13	.01	−.64	−.07
Primary location of use (at home/elsewhere)	−.10	−.01	2.22	.21	−1.87	−.18	2.37	.23
Socio-economic status (inactive/active)	−.64	−.07	−.76	−.09	−1.10	−.13	.74	.09
R^2	.31		.23		.25		.18	
F	4.84***		3.37***		3.62***		2.44*	

* $p < .05$.
** $p < .01$.
*** $p < .001$.

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related problems in the detailed way we have attempted here, and it shows the importance of paying attention to information and strategic skills in addition to operational and formal skills in educational and occupational settings.

5.2. Future work

The proposed definitions in Section 2 proved to be powerful contributors for understanding the complexity of Internet skills and for a better understanding of the individual skill related problems that users experience when using the Internet. The results of this study suggest that follow-up Internet skill studies should account for the four levels of skills measured.

Future work might also investigate how differences in Internet skills can be reduced. Improving Internet skills means reducing the individual skill related problems. On the one hand, new media developers can implement websites that consider the problems of seniors and the low-educated. On the other hand, there is a strong need for educational intervention. While operational and formal skills can be learned in practice using the social network and from computer books and courses, the higher order information and strategic skills will require special educational intervention (Solomon et al., 2003) to teach information selection, processing, evaluation and use on the Internet. These latter skills will gain a more central position in digital inequality research in the future. The technological innovations that provide the foundations for the information society make strategic skills increasingly important. We expect that a lack of operational and formal skills will be a temporary problem (until a really new technology appears), while the lack of information and strategic skills will appear to be structural problem. Therefore, information and strategic skills will have to gain a more central position in future research.

5.3. Limitations

The four definitions of Internet skills mainly focus on the Internet as information and service provider. Communication skills on the Internet required for computer-mediated communication in, for example emailing, chatting, social networking, online discussion and online dating are not a part of these definitions. Adding these skills would require the adoption of a particular theory of communication and it would multiply the problems of creating operational definition. However, measuring communication skills certainly is one of the next steps required in the investigation of digital skills.

Regarding the effects of age, we would like to emphasize that these results account for the current era and current generations. We do not know whether the same differences will persevere in the future. Although operational and formal skill related problems are easiest to account for, they might persist since technology changes and with these changes new specific operational and formal skill related problems will come into existence. Also, other factors that accompany aging, like cognitive decline, motor skills or arthritis, might cause seniors to experience these digital skill problems. Taking a closer look at the problems related to information and strategic related skills, we observed that no differences in age appeared significant. When current educational programs are going to account for both operational and formal skills and these 'higher' Internet skills generational differences might disappear.

6. Conclusions

Lower levels of educational attainment and higher age contribute to a large extent to the individual operational and formal skill related problem, limiting basic Internet use. The major operational problems are saving files or PDF documents. This is problematic since many agencies offer their brochures and information by PDF. More support on how to open and save files is needed. The use of search engines as instruments of support is also not a natural task for everyone (e.g., entering keywords in the address bar or typing keywords attached to each other). The mouse, scrollbar and web-based forms caused only some problems for lower-educated and seniors.

Regarding individual formal skill problems, one can notice that while websites may seem to be easy to navigate for designers, users may find them disorientating and confusing. The most frequently experienced problem was the lack of orientation when navigating between websites, but also within websites and between search results. Also, websites' menus – especially roll-over – were sources of confusion. Mostly seniors and low-educated participants experienced these problems. The design and implementation of websites should offer better support for these groups.

A major information skill related problem seems to be the formulation of unsuitable or overly general search queries. Educational attainment is a strong contributor to this problem. Another problem is the lack of knowledge about employing Booleans. The use of Booleans is not publicized, and the interface to compose queries with them is hidden from initial view (Marchionini and White, 2007). A problem that almost all subjects experienced is the limited use of search results; typically, the first three results attracted attention, and the second page with results was only opened sporadically. This is in accordance with other information-seeking studies (e.g., Aula and Nordhausen, 2006; Birru et al., 2004; Hargittai, 2003). The results also revealed that the older the subject the less irrelevant search results were selected. This illustrates that information skills are not necessarily more easily mastered by the digital generation. An important problem that users experienced is the fact that almost none of them tended to evaluate the information found. The individual information skill related problems identified in this study should gain more attention in educational programs, both on primary levels and programs for the elderly.

Regarding strategic skill related problems it was revealed that the use of websites that support users in making informed decisions (e.g., voting) only caused more new problems. These websites, though often found, are employed in the wrong way. Lower levels of educational attainment contributed to working in an unstructured manner. Another important problem was the fact that subjects had trouble keeping their focus on the original goal of the assignment. Although the number of distracted subjects was low (we expect this number to be higher in real life since the test environment more or less forced the participants to focus on the assignment), many of them did lose track of their personal goals. Like information skill related problems, strategic skill problems should gain more attention in educational programs (also emphasized by Schrum and Bracey, 2003). However, it will be hard to address these problems as they may turn up in a large and unpredictable diversity.

Appendix A. The assignments

A.1. Operational skill assignments

A.1.1. Assignment 1. (max. 12 min)

- Task 1.1. Go to the website of the Dutch Tax and Custom Administration (www.belastingdienst.nl).
- Task 1.2. Click on the link 'Download and order' in the menu on the right.
  - Click on the subject 'Marriage', placed in the column 'private'.

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- Click on the link to the brochure 'When you are getting married'.

- Task 1.3. Open the brochure 'When you are getting married'.
  - Save the brochure in the folder 'Marriage' on the desktop of the computer.

- Task 1.4. Use the back-button to go back to the 'Download and order' page.
  - Click on the link 'Declaration 2006' placed in column 'private'.
  - Click on 'Declaration software 2006 (Windows)'.

- Task 1.5. Save the file 'Electronic declaration IB 2006 for Windows' on the desktop.
- Task 1.6. Go back to the homepage of the Dutch Tax Administration.
  - Add the homepage to the favourites (or bookmarker).

- Task 1.7. Use the search engine on top of the website using the keyword 'save-as-you-earn deduction'.
  - Open the third search result of the search assignment.

A.1.2. Assignment 2. (max. 8 min)

- Task 2.1. Go to the Child care allowance website of the Dutch Tax and Custom administration: www.toeslagen.nl/reken/kinderopvangtoeslag/.
  - Complete the fields using the information given.

A.2. Formal skill assignments

A.2.1. Assignment 3. (max. 10 min)

- Task 3.1. Go to the website of the Central Office of Information, postbus51.nl.
  - Follow the options accommodation/rent/rental price/rent subsidy.
  - Choose the option: 'What is rent subsidy and how do I apply for it?'

- Task 3.2. Click on the link 'Applying for rent subsidy'.
  - Go to the homepage of the allowance website in the new window.
  - Go back to the homepage of Postbus51 in the old window.

- Task 3.3. Perform a search on the Postbus51 website with keyword 'rental price'.
  - Open the first search result.
  - Open the second search result.

A.2.2. Assignment 4. (max. 10 min)

- Task 4.1. Imagine that you just moved to Nijmegen. You would like to look up the physical office addresses of the following organisations: IB-Groep, UWV and CWI.

A.3. Information skill assignments

A.3.1. Assignment 5. Parking (max. 12 min)

- Task 5.1. Imagine that you just moved to Rotterdam. Because it is hard to find a parking spot, you decide to buy a subscription to a parking lot. Find out how much a subscription to the car park named 'Spaanse Kade' costs. Use the homepage of the municipality of Rotterdam (www.rotterdam.nl).

A.3.2. Assignment 6. Theft (max. 12 min)

- Task 6.1. Imagine that, during a day at the shopping mall, your passport is stolen. Use a search engine (e.g., www.google.nl or the one you use at home) to find out what type of document you need to apply for a new passport after the old one is stolen.

A.3.3. Assignment 7. Salary (max. 12 min)

- Task 7.1. Imagine that you are 25 years old. In between September 1st and December 30th you had a full-time job in a factory (40 h/week). Your wage was 1275 euro gross every month. This was not much. Use a search engine (e.g., www.google.nl or the one you use at home) to find out whether you were entitled to a higher salary during this period. (Yes, because the salary was lower than__euro./No, because the salary was higher than__euro).

A.4. Strategic skill assignments

A.4.1. Assignment 8. Salary (max. 12 min)

- Task 8.1. When your employer paid you too little, what financial recourse do you have can you then personally obtain? Sort this out using the Internet.

A.4.2. Assignment 9. Elections (max. 30 min)

- Task 9.1. Image that there are national elections soon. You are in doubt whether to vote for the PvdA, the CDA or the VVD. You have the following opinions:
  - you are in favour of using nuclear energy;
  - you are in favour of a high child care allowance; and
  - you are against having two nationalities.

- Using the Internet, find out which of these three political parties have your first, second and third preference.

Appendix B. The coding scheme

Individual operational Internet skill problems	
Address bar[a,b]	Using the address bar incorrect (e.g., entering keywords)
Save[a]	Not being able to save a file to the hard disk
PDF[a]	Not being able to save a PDF-file
Favourites[a]	Not being able to add a website to the Favourites (or bookmarks)
Form[a,b]	Using a web form incorrectly (e.g., buttons or pull down menus)
Search engine[a,b]	Not recognizing the search engine or input field
Search queries[a,b]	Using search queries incorrectly (not spelling)
Mouse[b]	Using the mouse incorrectly (e.g., double click or right click)
Scrollbar[b]	Experiencing scroll bar related problems
Individual formal Internet skill problems	
Design_Website[a]	Experiencing problems with different website designs
Design_Menu[a,b]	Using website menus incorrectly (e.g., not being able to use scroll over menu's)
Orientation_Within[a,b]	Not knowing where one is located within a website
Orientation_Between[a,b]	Entering a browser window that opens automatically and not realizing this

(*continued on next page*)

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Appendix B (*continued*)

Orientation_Search[a,b]	Not being able to open more than one search result
Individual information Internet skill problems	
System_Proper	Not choosing a proper search system or way of searching
Queries_Wrong	Using too broad search queries not emergent from the search task
Queries_Specific	*Using search queries specific to the task*
Queries_Booleans	Not using booleans to limit search results (e.g., parenthesis)
Search_Advanced	Not using advanced search methods (e.g., date or excluding keywords)
Search_Limit	Not searching within search results
Search_Luck	Using the Google option "I'm feeling lucky"
Select_Sponsor	Choosing sponsored or commercial results
Select_First three	Not checking more than the first three search results
Select_First page	Not checking more than the first page of search results
Select_Irrelevant	Choosing irrelevant search results
Information_Form	Filling out a form that does not lead to the necessary information
Information_Wrong	Using information that is not applicable to the situation
Information_Source	Using information from a less reliable website
Information_Date	Using information that is outdated
Information_Check	Not checking information on another website
Individual strategic Internet skill problems	
Orientation_Stimuli	Being distracted by irrelevant stimuli (e.g., banners)
Orientation_Start	Not knowing how or where to start with the assignment
Action_Misled	Being misled (e.g., working towards a goal that does not deliver personal benefits)
Action_Source_Single	Using information from only one website (source)
Action_No_structure	Working in a unstructured way (randomly) towards the final answer
Action_Support_Wrong	Using websites incorrectly that support the decision-making process
Decision_Wrong	Making an incorrect decision based on the information acquired
Decision_No	Not making a decision at all
Decision_Incomplete	Making a decision based on incomplete information

[a] Measured in a specific task.
[b] Measured during information assignments (free surfing).

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