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# A Longitudinal Perspective on Digital Skills for Everyday Life: Measurement and Empirical Evidence

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## Abstract

Our everyday lives are increasingly digital: We meet with friends, search for information, watch films, and buy goods online. This generates data that is automatically collected and analyzed. The ability to deal with the resulting algorithmically selected and personalized content is essential to benefit from digital technologies, and for this, digital skills are crucial. Studies focusing on digital skills, their antecedents, and consequences have mostly relied on self-reported, one-time measurements. A deeper understanding of the measures of digital skills and the role such digital skills play in everyday life and over time is needed. To address these gaps, this article compares self-reported measures of digital skills and knowledge of datafication and algorithmization in everyday internet use and maps the evolution of their relevance for digital everyday life. To do so, this articles analyzes data from multiple cross-sectional surveys conducted from 2011 to 2023 with representative samples of Swiss internet users. First, the findings indicate that self-reported skills reflect internet users' knowledge of algorithmization and datafication in everyday internet use. This renders the measure a decent tool for empirical studies. Second, the findings show that digital skills are associated with socioeconomic background, cyber-optimistic attitudes, usage time, use of social media, health trackers, voice assistants, ChatGPT, and feeling included in the information society. These relationships varied over time. This article provides longitudinal empirical evidence on the relevance of digital skills in a highly digitized country. The findings highlight that promoting digital skills can contribute to fostering more inclusive digital societies.

## Keywords

algorithmization; datafication; digital inclusion; digital inequality; digital skills; online survey; skills measurement

## 1. Introduction

Our everyday life is marked by internet use. Ninety-six percent of the Swiss population is currently using the internet (Latzer et al., 2021). On average, Swiss internet users spend 5.6 hours per day online and this amount has vastly increased in the past years (Latzer et al., 2023). Since the Covid-19-pandemic, people have spent more time online than before, for instance working from home, shopping online, and spending their free time using digital technologies (Latzer et al., 2023). The current trends of digitalization can be viewed as marked by datafication, platformization, and algorithmization (Latzer, 2022). To be able to use the internet in a beneficial way, internet users need a certain level of digital skills (Hargittai & Micheli, 2019). The effective use of new innovative services, like for instance voice assistants, requires specific digital skills (Gruber et al., 2021). Moreover, they are needed for protecting one's privacy online (Büchi et al., 2017) or for coping with algorithmic risks (Kappeler et al., 2023). In addition, theoretical approaches have suggested that digital skills are an important factor that is associated with the inclusion in the information society (see e.g., Hargittai & Micheli, 2019; Ragnedda, 2020; van Dijk, 2020). Indeed, recent empirical studies have indicated that differences in skills can lead to the reproduction of existing social inequalities (Blank & Lutz, 2018; Festic et al., 2021; Gruber & Hargittai, 2023; Ragnedda, 2020; Sharp, 2023). Theoretical approaches like the digital divide framework or the digital inequalities perspective have argued that a person's digital skills are impacted by their social position (van Dijk, 2020), which has been evidenced empirically as well (see e.g., Bonfadelli, 2002; Büchi et al., 2016; Ragnedda, 2020). Differences in digital skills can lead to a variety of internet uses and also to various consequences such as different levels of inclusion in the information society (Correa et al., 2022). This makes the study of digital skills highly relevant, especially in societies where the digital is increasingly becoming the norm and both private corporations, and governments employ a digital-first strategy (Allmann & Blank, 2021). The rapid development of digital technologies requires matching digital skills to use them. Therefore, this article asks: How can digital skills be measured and how has their association with socioeconomic background, cyber-optimistic attitudes, internet use, and the feeling of inclusion in the information society changed over time?

To answer this overarching research question, first, this article compares survey-based self-reports of digital skills with internet users' knowledge of datafication and algorithmization related to everyday internet use. Second, this article aims to illustrate the role that digital skills play in everyday internet use and how they have developed over time. To do so, this article tests the association of digital skills with socioeconomic background, cyber-optimistic attitudes, internet usage, and the feeling of inclusion in the information society. It compares data from multiple cross-sectional surveys that were conducted in Switzerland, each with a representative sample of Swiss internet users. This study contributes to current research on digital skills on two levels. Firstly, it compares a self-reported digital skills measure with an evaluation-based knowledge measure. Secondly, it adds a longitudinal perspective on the role that digital skills play in the literature. In a fast-evolving digital world, it substantiates theoretical claims on the relevance of digital skills with comparisons of empirical data from a highly digitized country over time. The findings presented in this article highlight the importance of digital skills for everyday life in today's digitized society.

## 2. Theoretical Background and Previous Research

### *2.1. Defining Digital Skills*

The idea that the use of information and communication technologies, digital media, or the internet requires a specific form of literacy, competency, or skills has evolved with the advent of these technologies. According to van Dijk (2020), the term "literacy" originates from the larger field of media, and the term "competency" can be viewed as more general than the term "skills." The terms "computer" and "digital literacy" were used in conceptual research from the early 2000s on and are still used lately (see Bawden, 2001; Livingstone & van der Graaf, 2010; Tinmaz et al., 2022; Warschauer, 2003). The term "competency" is predominantly used in policy-related settings, like the DigComp digital competence framework by the European Union (see Carretero et al., 2017). The terms "online" and "internet skills" were promoted by Hargittai (2002) who referred to abilities that are necessary for navigating the internet and completing online tasks. In a similar vein, van Deursen and van Dijk (2014) referred to "internet" or "digital skills" to highlight the digital characteristics of the concept. This term has been adopted by recent policy reports as well (Helsper et al., 2021). Recently, the term "algorithm" has been added to the concepts of "literacy" and "skills" to denote a specific focus on the role that algorithms play in today's online environment (see Dogruel et al., 2022; Hargittai et al., 2020). Alongside this, the term "digital skills" is used to denote a more general, overarching concept (see Allmann & Blank, 2021; van Dijk, 2020).

### *2.2. Measuring Digital Skills*

The ways in which digital skills are measured differ greatly between studies (see Dogruel et al., 2022; Grošelj et al., 2020; Hargittai, 2005; Litt, 2013; Livingstone et al., 2023; Oh et al., 2021; Orero-Blat et al., 2022; van Deursen et al., 2016; van Deursen & van Dijk, 2010). Self-report questions that ask survey respondents to evaluate their own digital skills are widely used. A benefit of this measurement is its easy administration and efficiency. However, the validity of self-reported measures remains unclear (van Dijk, 2020) and researchers have found systematic gender biases in self-evaluations (Hargittai & Shafer, 2006). One strategy to avoid the subjective evaluation of one's own skills involves the administration of experimental tasks (see Eshet-Alkali & Amichai-Hamburger, 2004). However, while this approach improves external validity, it also increases costs, thereby reducing feasible sample sizes (van Dijk, 2020). Another way to measure skills is through the understanding of terms that can be viewed as proxies for skills (see Hargittai, 2005). However, this measure still relies on self-reports. Besides quantitative studies, observations and interviews have tried to measure skills qualitatively (Allmann & Blank, 2021; Hargittai et al., 2020). While such approaches allow for an in-depth study of skills, they require a lot of resources and are only applicable to specific groups and not to population-based investigations. The vast variety of measurements of digital skills and related concepts renders the comparison of results across studies difficult (Sharp, 2023). Therefore, a comparison of different modes of measurement is desirable. As self-reports are the most common approach and these measurements have the advantage of being timeless as they reflect individuals' subjective perceptions, I ask in my first research question:

> RQ1: How do self-reported digital skills compare to knowledge of datafication and algorithmization in everyday internet use?

To answer this research question, I compare a self-reported evaluation of digital skills with the correct evaluation of statements related to everyday internet use.

### *2.3. Associations With Digital Skills*

The relevance of digital skills originates from the role they play in beneficial internet use (Hargittai & Micheli, 2019). The digital divide framework sets out to explain three levels of differences related to internet use. The first level is concerned with differences in access to and mere use of the internet. The second level focuses on differences in the types of internet use and digital skills. Finally, the third level centers around differences in the consequences of internet use (Ragnedda, 2020; van Dijk, 2020). As the view of such digital divides has become more nuanced, differences in internet use have been referred to as "digital inequalities" to denote their non-binary nature (Hargittai, 2018; Helsper, 2021). With the spread of the internet, such divides or inequalities were expected to diminish and vanish over time. However, it soon became apparent that this was not the case and that existing social inequalities were perpetuated rather than eliminated through internet use (van Dijk, 2005). Recent research shows that digital inequalities are still relevant today, even in highly connected societies. Research on the first level suggests that internet use remains stratified along socioeconomic background variables and that more privileged groups are more likely to use the internet (Kappeler et al., 2021). Similarly, research on the second level reveals that digital inequalities in how the internet is used still persist (Festic et al., 2021). A person's social position is associated with their level of digital skills. The more privileged groups—i.e., young, highly educated, well-earning individuals and men—have reported a higher level of digital skills (Bonfadelli, 2002; Büchi et al., 2016; Festic et al., 2021; Grünangerl & Prandner, 2022; Hargittai, 2002; Helsper, 2021; Ragnedda, 2020; Scheerder et al., 2017; van Dijk, 2020). This leads to the first hypothesis:

> H1: A person's age, level of education, income, and gender are associated with their level of digital skills.

According to van Dijk (2020), a person's attitude is related to their internet usage and skills. In addition, individual digital skills facilitate varied and beneficial internet use, which in turn relates to more favorable attitudes towards such technologies (Hargittai & Micheli, 2019). Recent research has shown that attitudes are indeed related to digital practices and skills (Blažič & Blažič, 2020; Cabellos et al., 2024; Ma et al., 2017). From this, a second hypothesis can be deduced:

> H2: Cyber-optimistic attitudes are associated with a higher level of digital skills.

According to van Deursen et al. (2011), a person's digital skills relate to the time they spend online. This relationship has been supported by empirical studies (Cantú-Ballesteros et al., 2017). Moreover, according to the digital divide framework, a higher level of digital skills allows for more active and more innovative internet use (van Dijk, 2020). Indeed, skills have been shown to relate to the active use of social media (Correa, 2016) and the use of emerging technologies like voice assistants (Gruber et al., 2021). The relationship between digital skills and the use of digital technologies is recursive; hence, use can lead to a higher level of skills (van Dijk, 2020). Therefore, I hypothesize the following:

> H3: The level of digital skills is associated with internet usage time and the active use of social media, health trackers, voice assistants, and ChatGPT.

Within the digital divide, second-level differences have an impact on the third level. This is exemplified by research on older adults, a group among which first- and second-level digital divides are still apparent. For them, digital skills are important for strategies to bridge these divides and hence lead to more equal outcomes of internet use (Blažič & Blažič, 2020). Research on younger groups, and specifically students, has shown that digital skills relate to individuals' academic performance (Ben Youssef et al., 2022). In addition, studies focusing on adolescents reveal an association between a higher level of digital skills and online opportunities (Livingstone et al., 2023). Also, more generally, a person's skill level is relevant for the application of privacy protection strategies (Büchi et al., 2017) and for coping with algorithmic risks (Kappeler et al., 2023), both of which may lead to fewer negative consequences of internet use. Still, the differences in outcomes of internet use and the role that digital skills play remain understudied (Scheerder et al., 2017). Conceptualizations of digital skills have established their relevance for usage, as well as for social inclusion as a consequence of usage (Hargittai & Micheli, 2019; Helsper, 2021; Reisdorf & Groselj, 2018; van Dijk, 2020). This claim has been empirically supported by a recent panel study on internet use and digital skills (Correa et al., 2022). The relationship between digital skills, internet usage, and the feeling of inclusion in the information society is especially relevant in a society where the digital is the norm (Allmann & Blank, 2021). Therefore, I propose the following:

> H4: The levels of digital skills and internet usage are associated with the feeling of inclusion in the information society.

Finally, research on digital skills predominantly relies on cross-sectional surveys at one specific point in time. Comparative studies mapping the evolution of digital skills over time are rare. Therefore, I want to address this with my second research question:

> RQ2: How have the relationships of associated factors with digital skills evolved over time?

To do so, I analyze data from seven cross-sectional surveys that were conducted between 2011 and 2023.

## 3. Method

### *3.1. Data Collection, Samples, and Analysis*

This study analyzed telephone and online survey data that is representative of Swiss internet users aged 14 years and over regarding age, gender, household size, and employment status ($n_{2023} = 1,008$; $n_{2021} = 1,069$; $n_{2019} = 1,035$; $n_{2017} = 1,013$; $n_{2015} = 981$; $n_{2013} = 949$; $n_{2011} = 851$). The data was weighted to closely match the demographics of the general internet-user population. The survey was conducted in German, French, and Italian, thus representing the three big language regions in Switzerland. For this article, the items were translated into English. In Switzerland, 96% of the population uses the internet (Latzer et al., 2021). Respondents gave informed consent to participate in the study and the scientific use of their data. No personal inferences were possible. To answer the research questions and to test the hypotheses, I applied multiple linear regressions using R. The hypotheses were analyzed for the years in which the individual items were in the field.

### 3.2. Measures

The self-report measure for digital skills was applied using one item, which was the following question: "How good are you at using the internet?" Respondents were given five possible answer options—*bad*, *sufficient*, *good*, *very good*, and *excellent*—to subjectively rate their digital skills.

To compare the self-reported digital skills measure to knowledge of current challenges of digital everyday life, i.e., datafication and algorithmization, I applied a knowledge measure consisting of five statements related to everyday online experiences. This list was based on previous qualitative and quantitative studies (see Dogruel et al., 2022; Festic, 2020; Hargittai et al., 2020). The following five statements were shown to the respondents:

- Internet services can tailor the recommendations they give a user to their personal interests.
- When using Google with the same search terms, everyone always gets the same results.
- If different users visit the same website at the same time, they will always receive the same advertising.
- How long one stays on a post on Facebook or other services can influence what content they are shown on the internet.
- The newsfeed of individual users on social media such as Instagram, Facebook, or TikTok is compiled by humans.

For each of these statements, respondents were asked to evaluate the correctness of these statements (1 = *true*, 2 = *false*, 3 = *not sure*). I then recoded these variables to capture the percentage that evaluated each statement correctly and calculated an index from these. This index is used next to reflect the knowledge of everyday internet use processes related to datafication and algorithmization.

In terms of socioeconomic background, respondents were asked about their gender (1 = *male*, 2 = *female*, 3 = *diverse*); their age (in years); their education level, which was recoded into categories (1 = *low*, 3 = *high*); and their household income, which was also recoded into categories (1 = *low*, 5 = *high*).

The active usage of the internet was operationalized in terms of the daily time spent on the internet (in minutes), actively using social media like Facebook or Instagram, and the intensity of active use of innovative technologies including health trackers, voice assistants, and ChatGPT on a six-point frequency scale (1 = *never*, 6 = *several times a day*).

Cyber-optimistic attitudes were operationalized using the following five items:

- My internet use has more positive than negative consequences for my life.
- All in all, the internet is a good thing for society.
- New digital technologies have the potential to solve almost all of society's problems.
- New technologies have the potential to develop people's physical and mental abilities in a targeted manner.
- My high level of trust in these services makes my everyday life much easier.

For each statement, respondents gave their agreement on a five-point agreement scale (1 = *do not agree at all*, 5 = *fully agree*).

The feeling of inclusion in the information society was captured with one question asking about how included individuals feel in today's information society on a five-point scale (1 = *not at all*, 5 = *completely*). Hence, this item reflects respondents' perception of their own inclusion in the information society.

## 4. Findings

This section presents the empirical findings to the three research challenges related to digital skills that I address in this article: (a) I compare self-reported digital skills to knowledge about datafication and algorithmization, (b) I test literature-based factors' association with digital skills, and (c) I show how these changed over time in a highly digitized society.

### *4.1. Measuring Digital Skills*

As pertains to RQ1, the descriptive findings show that on average, 3.15 out of 5 statements were evaluated correctly. There was some variance in the knowledge, depending on the statements: The correct evaluation per statement ranged from 44% (curation of newsfeeds) to 82% (tailored recommendations). A quarter of all internet users evaluated all statements correctly. 10% evaluated only one statement correctly and 4% none. The proportion that evaluated two, three, or four statements was each roughly 20%. The comparison of the two types of measurements shows that the self-report digital skills measure (mean = 3.27) has a significant positive correlation with the knowledge measure ($r = 0.260$, $p < 0.001$).

### *4.2. Associations of Digital Skills Over Time*

To test the hypotheses and to answer RQ2, I used the one-item self-reported digital skills measure. Table 1 depicts how the mean level of self-reported digital skills developed over time. The findings show that from 2011 to 2023, the distribution of digital skills was relatively stable.

### *4.3. Social Background and Attitudes' Association With Digital Skills*

H1 states that younger, higher educated, higher income, and male persons are more likely to report a higher level of digital skills. It was tested for 2011–2023. Table 2 depicts the results and coefficients of the multiple linear regressions per year. For the years 2011, 2013, and 2015, the overall model and the individual

**Table 1.** Mean level of digital skills, between 2011 and 2023, in Switzerland.

| Year | *M* | *SD* | *n* |
|---|---|---|---|
| 2011 | 3.21 | 1.022 | 804 |
| 2013 | 3.27 | 1.048 | 861 |
| 2015 | 3.23 | 1.004 | 904 |
| 2017 | 3.15 | 0.963 | 844 |
| 2019 | 3.14 | 0.947 | 869 |
| 2021 | 3.03 | 1.071 | 916 |
| 2023 | 3.27 | 0.915 | 1,008 |

Note: Swiss internet users aged 14 years and older.

associations were not significant. For 2017, the model was significant and so were the effects of gender and education. For 2019, the model was significant, as well as the effect of income. For 2021, the model was significant, and the effects of gender and income were significant too. For 2023, the model was significant,

**Table 2.** Association of digital skills with socioeconomic background, 2011–2023.

| Year | | *B* | *SE* | *β* |
|---|---|---|---|---|
| 2011 | Constant | 3.250 | 0.228 | – |
| | Gender | 0.061 | 0.073 | 0.029 |
| | Age | –0.003 | 0.036 | –0.003 |
| | Education | –0.024 | 0.067 | –0.014 |
| | Income | –0.026 | 0.031 | –0.031 |
| 2013 | Constant | 3.271 | 0.226 | – |
| | Gender | –0.003 | 0.075 | –0.002 |
| | Age | –0.010 | 0.037 | –0.010 |
| | Education | 0.046 | 0.066 | –0.026 |
| | Income | –0.022 | 0.034 | –0.024 |
| 2015 | Constant | 3.062 | 0.201 | – |
| | Gender | 0.052 | 0.068 | 0.026 |
| | Age | –0.029 | 0.034 | –0.031 |
| | Education | 0.046 | 0.052 | 0.032 |
| | Income | 0.023 | 0.025 | 0.034 |
| 2017 | Constant | 2.909 | 0.129 | – |
| | Gender | –0.150 | 0.069 | –0.077* |
| | Age | 0.030 | 0.034 | 0.032 |
| | Education | 0.124 | 0.058 | 0.082* |
| | Income | 0.019 | 0.023 | 0.031 |
| 2019 | Constant | 3.011 | 0.193 | – |
| | Gender | 0.16 | 0.068 | 0.008 |
| | Age | –0.045 | 0.033 | –0.050 |
| | Education | 0.032 | 0.053 | 0.022 |
| | Income | 0.057 | 0.023 | 0.090* |
| 2021 | Constant | 2.816 | 0.221 | – |
| | Gender | –0.168 | 0.077 | –0.079* |
| | Age | 0.026 | 0.038 | 0.026 |
| | Education | 0.048 | 0.064 | 0.030 |
| | Income | 0.069 | 0.027 | 0.103* |
| 2023 | Constant | 3.634 | 0.166 | – |
| | Gender | –0.206 | 0.056 | –0.115*** |
| | Age | –0.188 | –0.028 | –0.213*** |
| | Education | 0.170 | 0.056 | 0.099* |
| | Income | 0.071 | 0.020 | 0.113*** |

Notes: Swiss internet users aged 14 years and older; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

and age, education, income, and gender were significantly associated with the level of digital skills a person reported. This means that respondents who were younger, had higher education, higher household income, and were male were more likely to report a higher level of digital skills.

H2 states that more cyber-optimistic attitudes are related to a higher level of digital skills. It was tested for 2023. The model to test H2 was significant. Table 3 shows the results and coefficients of the multiple linear regression. Attributing more positive than negative consequences to the internet, thinking the internet is a good thing, believing in the potential of new technologies to solve societal problems, believing in the potential of technologies to further human abilities, and thinking that trust in these services eases everyday life have a significant positive association with the level of digital skills. This means that those with stronger cyber-optimistic attitudes have a higher level of digital skills.

### *4.4. Digital Skills' Association With Usage and Inclusion*

For H3, I looked at the relationship between different usage practices and digital skills. It was tested for the years 2011–2023. The included independent variables vary across years as not all of them were included in the survey every year. Table 4 shows the results and coefficients for the multiple linear regressions. For the years 2011, 2013, 2015, 2017, and 2019, the overall models and associations were not significant. For 2021, the overall model was significant and using social media had a significant negative association with digital skills, while using voice assistants had a significant positive association. For 2023, the model tested as significant. It shows that overall daily usage time, using social media, using health trackers, and using services like ChatGPT had a significant positive association with the reported level of digital skills.

Finally, to test H4, I looked at the relationship between usage time, digital skills, and inclusion. This hypothesis was tested for the years 2015–2023. Table 5 shows the results and coefficients of the multiple linear regressions. For the years 2015, 2017, and 2021, the overall model was significant and daily usage time had a significant positive association with the feeling of inclusion in the information society. For 2019 and 2023, the model tested as significant, and it showed that usage time and digital skills both had a significant positive association with the feeling of inclusion in the information society.

**Table 3.** Association of digital skills with cyber-optimistic attitudes, 2023.

| | *B* | *SE* | *β* |
|---|---|---|---|
| Constant | 1.773 | 0.124 | — |
| More positive than negative | 0.083 | 0.032 | 0.091** |
| Good thing | 0.175 | 0.036 | 0.176*** |
| Solve societal problems | 0.083 | 0.030 | 0.099* |
| Develop human abilities | 0.085 | 0.030 | 0.102* |
| Easier everyday life | 0.053 | 0.025 | 0.068* |

Notes: Swiss internet users aged 14 years and older; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

**Table 4.** Association of digital skills with internet usage, 2011–2023.

| Year | | *B* | *SE* | *β* |
|---|---|---|---|---|
| 2011 | Constant | 3.295 | 0.065 | – |
| | Usage time | 0.000 | 0.000 | –0.034 |
| | Social media | –0.022 | –0.036 | –0.036 |
| 2013 | Constant | 3.241 | 0.068 | – |
| | Usage time | 0.001 | 0.000 | 0.011 |
| | Social media | 0.007 | 0.019 | 0.377 |
| 2015 | Constant | 3.243 | 0.063 | – |
| | Usage time | –0.001 | 0.000 | –0.006 |
| | Social media | –0.004 | 0.017 | –0.009 |
| 2017 | Constant | 3.219 | 0.070 | – |
| | Usage time | 0.000 | 0.000 | –0.081 |
| | Social media | 0.011 | 0.018 | 0.024 |
| | Health trackers | –0.015 | 0.022 | –0.023 |
| 2019 | Constant | 3.045 | 0.075 | – |
| | Usage time | 0.000 | 0.000 | 0.048 |
| | Social media | 0.027 | 0.017 | 0.058 |
| | Health trackers | –0.023 | 0.021 | –0.040 |
| 2021 | Constant | 2.950 | 0.086 | – |
| | Usage time | 0.000 | 0.000 | –0.040 |
| | Social media | –0.047 | 0.018 | –0.090 ** |
| | Health trackers | 0.027 | 0.021 | 0.043 |
| | Voice assistants | 0.153 | 0.030 | 0.171*** |
| 2023 | Constant | 2.244 | 0.078 | – |
| | Usage time | 0.049 | 0.007 | 0.202*** |
| | Social media | 0.070 | 0.015 | 0.142*** |
| | Health trackers | 0.039 | 0.017 | 0.072* |
| | Voice assistants | 0.021 | 0.022 | 0.030 |
| | ChatGPT | 0.210 | 0.030 | 0.215*** |

Notes: Swiss internet users aged 14 years and older; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

**Table 5.** Association of digital skills and usage time with digital inclusion, 2015–2023.

| Year | | *B* | *SE* | *β* |
|---|---|---|---|---|
| 2015 | Constant | 3.233 | 0.122 | — |
| | Usage time | 0.001 | 0.000 | 0.241*** |
| | Digital skills | 0.045 | 0.035 | 0.043 |
| 2017 | Constant | 3.064 | 0.117 | — |
| | Usage time | 0.002 | 0.000 | 0.365*** |
| | Digital skills | 0.038 | 0.034 | 0.035 |
| 2019 | Constant | 3.012 | 0.130 | — |
| | Usage time | 0.001 | 0.000 | 0.169*** |
| | Digital skills | 0.103 | 0.038 | 0.087** |
| 2021 | Constant | 3.304 | 0.104 | — |
| | Usage time | 0.002 | 0.000 | 0.368*** |
| | Digital skills | –0.040 | 0.030 | –0.040 |
| 2023 | Constant | 1.624 | 0.008 | — |
| | Usage time | 0.000 | 0.000 | 0.079** |
| | Digital skills | 0.517 | 0.027 | 0.527*** |

Notes: Swiss internet users aged 14 years and older; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

## 5. Discussion

This article explored longitudinal findings to expand our understanding of different measurements of digital skills (self-reported versus knowledge-based through correct evaluation of statements related to everyday internet use) and the change in their association with socioeconomic background, cyber-optimistic attitudes, internet use, and the feeling of inclusion against the backdrop of existing literature.

With regard to the comparison of self-reported levels of digital skills with knowledge of datafication and algorithmization in everyday life examples, the findings demonstrated that they correlate positively, albeit weakly. In terms of research economics, this is a positive finding since it allows studying digital skills with a resource-saving instrument (Parry et al., 2021). The self-reported digital skills were relatively stable between 2011 and 2023. This relative stability can be explained by the changing nature of the online context. While skills are expected to increase over time, so are the challenges that internet users face (Hargittai et al., 2020). The online environment is known for its quick developments and new technologies can emerge quickly. One such example is the generative AI service ChatGPT, which is based on a large language model that allows for interaction with a chatbot using natural language. The use of such a service requires a new level of skills, like knowing how to formulate prompts to receive useful answers and being able to judge the quality and truthfulness of the answers received (Kasneci et al., 2023). These skills differ vastly from, for instance, being able to upload a picture on Facebook, which was a new digital skill in the 2010s. Hence, measuring skills requires trying to get hold of a moving target: With new technologies, new affordances arise, which necessitate new digital skills. Therefore, instruments measuring skills should be constantly adapted and include affordances that are relevant at a specific moment in time, e.g., understanding artificial intelligence (see Dogruel et al., 2022) or prompting for services like ChatGPT.

Regarding the associations of digital skills with socioeconomic background, cyber-optimistic attitudes, internet usage, and the feeling of inclusion in the information society, the findings showed that they changed over time. Before 2017, socioeconomic background was not associated with digital skills. However, in 2023, gender, age, education, and income were related to a person's level of digital skills. This illustrates that in the latest survey, socioeconomic background played a bigger role in digital skills than it did in previous ones.

In 2023, digital skills were associated with cyber-optimistic attitudes. Moreover, since 2021, digital skills related to the extent and ways the internet is used. This means that what people do online has become more important for digital skills over time. Furthermore, while internet usage time played a role in feeling included in the information society, digital skills increasingly became more important. Taken together, these findings highlight that the relevance of digital skills has grown over time.

However, it should be noted that the identified associations should not be understood as unidirectional, but rather as intertwined relationships. For cyber-optimistic attitudes, internet usage, and the feeling of inclusion in the information society, the relationship with digital skills should be considered as a recursive one (Gillespie, 2014; van Dijk, 2020). While socioeconomic background can enable a higher level of digital skills, the relationship between skills and internet use can be viewed as recursive (van Dijk, 2020). Hence the two are mutually shaping each other and a higher level of digital skills can lead to more sophisticated uses which again can further a person's skills.

In a similar vein, the level of digital skills and the feeling of inclusion in the information society can be viewed as closely intertwined. On the one hand, when a person reports that they can cope with digital technologies well, this can lead them to feel more included in the information society. On the other hand, when a person feels included in the information society, this can motivate them to use the internet in different and more advanced ways, which in turn can entail an increase in the perceived level of digital skills. Hence, the empirical evidence presented in this article should be understood against the backdrop of the entanglement of social and digital inequalities (Chen & Li, 2021; van Dijk, 2020).

The findings presented here shed light on an important aspect of digital inequality research: Inequalities do not automatically disappear with the wider spread of the internet. Rather, existing social inequalities can be reproduced in the digital sphere and in addition, new ones can emerge (Schradie, 2020). As the digital becomes the norm, being able to use it becomes a requirement (Gruber & Hargittai, 2023). People who do not possess the needed digital skills will encounter real-life disadvantages, ranging from spending more time or paying higher prices to even completely missing out on opportunities.

## 6. Limitations and Future Research

This study has some limitations which should be reflected on critically. The nature of these limitations and potential avenues for future research are discussed here. First, it should be noted that the correlation between self-reported digital skills and knowledge about datafication and algorithmization was characterized by a small effect size. This could be related to the five-item measure that was used for measuring knowledge about datafication and algorithmization. Measuring knowledge with only five items is problematic as such a scale only covers a limited number of relevant aspects. For this study, the choice of items was a compromise between including aspects that would apply to many people (e.g., types of social

media mentioned) and at the same time allowing for variation in the complexity of statements to be able to depict potentially varying digital skill levels adequately. Future studies should extend this measure and include additional statements to reflect the breadth of everyday internet use and to depict its evolving nature. Especially, the inclusion of current technological developments specific to the population under scrutiny will be valuable to paint an adequate picture of a population's digital skills. Furthermore, to test the association of digital skills with other variables, this study used the self-report measure. While this study has shown that it correlates with the knowledge-based measure, self-reports have another shortcoming. Research has shown that they can be biased in terms of social desirability and gender patterns. In terms of skills related to internet use, this has been demonstrated by Hargittai and Shafer (2006): Men were more likely to self-report a higher level of digital skills than women, even when experimental evidence showed their skill level was the same. Moreover, this study viewed the feeling of inclusion in the information society as a potential consequence of internet use. Here, the feeling of inclusion was used as a proxy for social inclusion (see, e.g., Hargittai & Micheli, 2019; Ragnedda, 2020; van Dijk, 2020). This entails shortcomings. For instance, the feeling, which is in itself subjective and perceived, was measured using a self-report measure. This entails the potential of social desirability and hence, can be biased (Parry et al., 2021). To measure digital inclusion, future studies should include more tangible consequences of digital practices and investigate their relationship with digital skills (see Helsper et al., 2015). In addition, this study was conducted in Switzerland, a highly digitized society, with high levels of internet penetration and use. Therefore, the findings cannot be automatically transferred to other countries and cultural contexts. While this study included a comparative component by describing the evolution of digital skills across cross-sectional samples at different points of time within a country, future studies should use panel data to illustrate the evolution of these phenomena and include cross-country-comparisons as well to further substantiate the claims here and to take cultural differences into account. Moreover, while this study focused on potential barriers to digital skills, future studies should look more closely at interventions that are aimed at tearing down these barriers and evaluating their efficacy. In line with this, future research should derive concrete policy measures to promote digital skills to contribute to a more inclusive digital society. Finally, similar studies that aim to investigate digital skills face one dilemma: On the one hand, the skills measure should reflect current internet use validly. On the other hand, the measure should be designed in a way that is not too time- or place-sensitive, so that it can be used over a longer period of time and across cultural contexts for comparative research. The problem is that knowledge-based measures that ask about concrete knowledge or understanding about specific processes are the most valid. At the same time, they need resources as they require multiple items to capture the concept adequately. Also, they need constant updating as digital technologies are constantly evolving and differ across contexts. Therefore, for now, self-reports provide a simple and easily applicable way to measure digital skills, although they come with limitations that should be considered when applying them. At this stage, a combination of different measures can be regarded as the best way to go.

## 7. Conclusion

This article set out to compare a self-reported digital skills measure with an evaluation-based knowledge measure and to investigate how the associations of digital skills with socioeconomic background, cyber-optimistic attitudes, internet use, and the feeling of inclusion in the information society changed in Switzerland in the years 2011–2023. To address these aims, it quantitatively analyzed survey data representative of Swiss internet users. In sum, the findings show that (a) self-reported digital skills correlate

with evaluation-based measures for knowledge of datafication and algorithmization, and (b) self-reported digital skills were associated with gender, age, education level, and income, as well as with cyber-optimistic attitudes, internet usage in terms of average daily hours spent online, active use of social media, health trackers, voice assistants, and ChatGPT, and that furthermore, usage time and digital skills were associated with feeling included in the information society. These associations varied over time and the relevance of digital skills grew over the past years. These findings show that there is empirical evidence for the theoretical claim that existing social inequalities can be reproduced through digital inequalities in terms of digital skills. Hence, this study contributes to research on digital skills by substantiating theoretical claims on relationships between digital skills and associated factors. It demonstrates that internet usage and digital skills relate to the feeling of inclusion in the information society. In terms of policy, this highlights that focusing on digital skills to alleviate digital inequalities can be a valuable route. Hence, it provides an empirical basis for the promotion of digital skills for greater inclusion in today's information society.

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## Conflict of Interests

The author declares no conflict of interests.

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