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Predicting Online Search Success from Self-Reported Skills, Search Behavior, Domain Knowledge, and Task Evaluations

Implications for Teaching Information Literacy

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Abstract

Searching for information is a key activity in everyday life. Understanding how self-reported skills, search behavior and task characteristics relate to search performance can inform educational practices for teaching information literacy. This study investigates these relationships by having 102 adolescents perform search tasks and assessing their performance in relation to their self-reported information literacy, navigation behavior and task evaluations. Our findings indicate that self-reported information self-efficacy alone is not a reliable predictor of search success. Query revisions, domain knowledge and task importance positively impact search success, while reliance on superficial cues for evaluating information quality correlates with lower search success. We suggest that information literacy educators encourage learners to revise their queries, ignore superficial cues for credibility assessment, and gain an overview of a topic before searching for specific facts. Additionally, we recommend designing search tasks with potentially important consequences when solved incorrectly to increase learners' engagement.

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Vorhersagen des Erfolgs beim Suchen im Internet anhand selbstberichteter Fähigkeiten, Suchverhalten, Vorwissen und Aufgabenbewertung. Implikationen für das Vermitteln von Informationskompetenz

Zusammenfassung
Informationen im Internet suchen und beurteilen ist eine Schlüsselkompetenz. Das Verständnis dafür, wie selbsteingeschätzte Fähigkeiten, Suchverhalten und Aufgabenmerkmale mit der Suchleistung zusammenhängen, kann zu einer Verbesserung der Bildungspraktiken beim Vermitteln von Informationskompetenz beitragen. Diese Studie untersucht diese Zusammenhänge bei 102 Jugendlichen, die Suchaufgaben ausgeführt haben und deren Leistung in Bezug zu ihrer selbstberichteten Informationskompetenz, ihrem Navigationsverhalten und ihrer Aufgabenbewertung gesetzt werden. Die Ergebnisse zeigen, dass die Selbstwirksamkeitseinschätzung allein kein verlässlicher Prädiktor für den Sucherfolg ist. Das Modifizieren von Suchanfragen, das Vorwissen und die eingeschätzte Wichtigkeit der erhaltenen Aufgabe wirken sich positiv auf den Sucherfolg aus, während die Orientierung an oberflächlichen Merkmalen von Quellen bei der Bewertung der Informationsqualität mit geringerem Sucherfolg korreliert. Wir schlagen vor, dass im Rahmen der Vermittlung von Informationskompetenz Lernende ermutigt werden, ihre Suchanfragen zu modifizieren, oberflächliche Hinweise für die Glaubwürdigkeitsbewertung zu ignorieren und sich einen Überblick über ein Thema zu verschaffen, bevor sie nach spezifischen Fakten suchen. Zusätzlich empfehlen wir, Suchaufgaben mit potenziell wichtigen Konsequenzen bei falscher Lösung zu gestalten, um das Engagement der Lernenden zu erhöhen.

1. Introduction

Searching for information is a fundamental activity, essential for finding facts, facilitating decision-making, and providing enjoyment (White 2016, 1). Its importance is underscored by international declarations such as the Alexandria Proclamation (IFLA 2005), UNESCO's White Paper (Ramalho Correia 2002) and the Paris Agenda for Media and Information Literacy (UNESCO 2007; UNESCO 2011). Information literacy has been integrated into compulsory education systems and European school curricula, recognized as a key component within the broader "media and technology" domain (Guitert et al. 2017). Prominent frameworks, including the European DigComp 2.1 (Carretero et al. 2017), the British JISC model (JISC [Joint Information Systems Committee] 2014) or the American White Book on Digital Media Literacy (Hobbs 2010) highlight the centrality of information literacy.

As students transition into secondary education, they increasingly make independent decisions about their personal lives. Upon reaching adulthood at the age of 18, individuals become responsible for their actions and decisions, gain the right to vote, and are accountable to the law. Consequently, access to information about the world becomes critical, and the ability to manage information needs significantly impacts the quality of their life choices.

Adolescents prefer search engines, online encyclopedias, and news sites, with social media becoming the primary source. They want their sources to be up-to-date, verified and provide a quick overview of the most important aspects (Feierabend et al. 2018; Gebel et al. 2014; Reuters Institute 2023). Although interest shifts during adolescence (Hasebrink 2017), Feierabend et al. (2023) report that teenagers are primarily interested in socio-political topics, climate change, wars and conflicts, and diversity. Despite the importance of online information, studies have shown that adolescents struggle to assess its credibility (Masullo Chen et al. 2017; Nygren and Guath 2019; Stanford History Education Group 2016). The International Computer and Information Literacy Study (ICILS) reached similar conclusions (Fraillon et al. 2020), as did research conducted in Switzerland (Zampieri et al. 2018), where the present study was conducted.

There is little evidence on how the overall search process can be modelled to predict search success. Most data on online search are collected in artificial settings such as laboratory studies or fabricated systems (e.g., Gao et al. 2022). We lack comprehensive understanding of how web navigation, information literacy, digital skills and task characteristics collectively influence real-life search performance. While prior research has identified both individual and combined factors associated with successful search behavior (see below), to the best of our knowledge, no comprehensive model currently integrates self-reported skills, navigational behavior, domain knowledge and perceived task characteristics within a single analytical framework. Such a model allows for the estimation of the unique contribution of each factor while controlling for the others. Insights derived from this approach may inform the development of instructional courses and materials aimed at fostering information literacy.

2. Searching for Information

Searching for information on the Internet can be classified into three categories: (a) navigational tasks (reach a particular site), transactional tasks (perform a web-mediated activity), and informational tasks (acquire information present on one or more web pages) (Broder 2002). This study focuses on the latter category. The models developed to describe the information search process differ in complexity and scope (Case and Given 2016). They typically adopt a skill-based view of information

literacy, structured to facilitate the teaching of information literacy (Sample 2020) and often present a simplified view of the process, omitting external factors as well as the iterative and simultaneous nature of the steps involved (Bodemer 2017).

For this study, we adapt a model proposed by Brand-Gruwel et al. (2005), which builds on the work of Eisenberg and Berkowitz (1992). This model divides the process of solving an information problem into five steps: 1) defining the information problem, 2) selecting information sources, 3) scanning information, 4) processing information and 5) organizing and presenting information. This model allows us to define search tasks functionally, as a series of actions performed to achieve a specific goal (Vakkari 2005). Wilson (1997) emphasizes the importance of considering the context in which information tasks are solved while Byström and Järvelin (1995) highlight the influence of personal factors on various steps in the information problem-solving process, such as the cognitive abilities for analyzing the information needs or evaluating the information found. Accordingly, while we will follow the idealized step model for solving information problems, we will also account for the context in which the search takes place and the personal factors that may influence the process.

3. Factors influencing search performance

Performing an online search is successful when the information need is satisfied with accurate information, and is unsuccessful when the information need is either not satisfied or satisfied with incorrect information that is mistakenly believed to be correct. Several factors have been found to influence the information search process and search performance.

3.1 Digital Skills and Digital Literacy

Digital literacy is "the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers" (Gilster 1997, 33), particularly by using the Internet to find and evaluate information sources. While digital literacy refers to mastering concepts and ideas, the actual operations needed to use digital media are usually termed digital skills (Van Laar et al. 2017; Vuorikari, Kluzer, and Punie 2022). Research generally shows a positive relationship between digital literacy and information benefits for teenagers. For instance, digital literacy enhances teenagers' ability to evaluate the credibility of information, improve their information skills and effectively search for health information (Livingstone et al. 2023).

3.2 Information Literacy and Information Self-Efficacy

Information literacy refers to a set of skills and abilities needed for information-related tasks. These include skills and abilities to discover, access, interpret, analyse, manage, create, communicate, store, and share information (CILIP 2018). The skills often overlap with digital skills which can be considered necessary but not sufficient prerequisite for exercising information literacy in a digital context.

Self-efficacy refers to the belief in one's ability to execute behaviors necessary to achieve a desired goal (Bandura 1977). The literature provides various scales for self-assessment of information literacy or information self-efficacy (Kurbanoglu et al. 2006; Madden et al. 2018; Timmers and Glas 2010). Although these scales differ in scope and breadth, they generally involve participants providing a self-assessment of their ability to locate, find and use information according to their needs. Self-efficacy is not a direct measure of ability but rather a belief in one's capability. Self-efficacy for online searching has been explored in various studies. For example, Tsai and Tsai (2003) demonstrated that adolescents with higher Internet self-efficacy were more successful in online searches. However, the impact of self-efficacy on search success may vary depending on the task type. Hong (2006) found that self-efficacy positively influenced the quality of health-related content found online for general (broad) tasks, but not for a specific search task. In an experimental study Wood et al. (2016) observed that adults with higher generic information search skills (trained librarians) performed more efficiently.

Information literacy is often measured through self-assessment due to its cost-effectiveness. However, a more reliable approach involves measuring individuals' performance in solving information problems. This method has been employed in several studies, including those by Walraven et al. (2009), Stanford History Education Group (2016), and most notably in the large-scale ICILS testings (Fraillon et al. 2020). Previous research has reported inconclusive links between self-assessment and performance measurements, with findings ranging from no correlation to negative or positive correlations and observations (Mahmood 2016; Clark 2017; Brazier et al. 2019).

3.3 Assessment of Credibility

The utility of information hinges on its accuracy, making assessment of credibility a crucial aspect of searchers' activities. Research suggests that young people are becoming increasingly aware of sensitive topics such as fake news. They are developing new – albeit not always effective – criteria for assessing the credibility of information, such as the quality of the online video in which it is presented (Masullo Chen et al. 2017) or the number and nature of reader comments (Botturi and Negrini 2018; Franklin and Eldridge 2017; Waddell 2018). Walraven et al. (2009) demonstrated that

although students may be aware of the relevant criteria for evaluating information, they do not necessarily apply these criteria during online searches. They often rely too heavily on the design of a website to assess its credibility or only invest the cognitive effort when the topic at hand is exceptionally important (Tamboer et al. 2022). Lucassen et al. (2013) propose three categories to describe the assessment of the credibility of information: 1) semantic features of the content (e.g. accuracy, completeness, neutrality); 2) surface features of the presentation (e.g. length, images, design); and 3) source features (e.g. authority, website brand). Their research indicates that searchers who are familiar with a topic tend to rely more on semantic cues, whereas users with less knowledge are more influenced by surface features.

3.4 Online Navigation

The primary means by which individuals interact with online information retrieval systems are query statements and result selection (White 2016). Lau and Horvitz (1999) identified different user behaviors when refining search queries, including specialization, generalization, and reformulation. A study on adolescents' searches for health information found that many use a trial-and-error approach to formulate search strings (Hansen et al. 2003). When selecting results, teenagers tended to choose those appearing higher on the first search results page, assuming them to be more relevant and reliable. The difficulty of the task at hand also influences how searchers navigate online. Gwizdka and Spence (2006) found a strong correlation between students' web search task metrics and the perceived difficulty of the search task. Liu et al. (2010) observed that difficult tasks increased the number of queries and time spent on search results pages.

3.5 Domain Knowledge

Research on adults' information retrieval has demonstrated that domain knowledge and strategic knowledge are key components of search success in text searches (Downing et al. 2005). Similarly, domain knowledge and search strategy have been shown to significantly influence online search outcomes (Ford et al. 2002; Willoughby et al. 2009). Users with prior knowledge about a search task's domain are better equipped to use semantic features to evaluate the credibility of the information found online (Lucassen et al. 2013). In an educational contexts, domain knowledge can be conceptualized either as a user characteristic (available knowledge) or a task characteristic (required knowledge). The latter can be influenced through task design and by adjusting the timing of its assignment within the learning process.

3.6 Task Characteristics

The complexity of an information search task on the web can be assessed from both objective and subjective perspectives. Objectively, searching for information online is inherently complex due to the multitude of potential paths to the desired outcome and the uncertainty introduced by not knowing in advance what results search queries will return (Campbell 1988). The difficulty of non-hypertext search tasks can be categorized by the type of information being sought (Mosenthal 1998), a classification also applied in online search studies (Walraven et al. 2009). Tasks that require users to identify persons, groups, and animals are generally the simplest. More challenging are tasks that require users to provide sequences (chronologically ordered steps of events or processes), verifications or alternatives. The most difficult tasks involve explaining causes, effects, results or providing evidence for them (Mosenthal 1998). Tasks also possess a subjective complexity determined by the characteristics of the person performing the task, such as their prior knowledge and cognitive ability (Campbell 1988). Domain knowledge reduces the perceived difficulty of tasks and enhances the performance of tasks based on search findings (Willoughby et al. 2009). Finally, the perceived importance of a task is also a crucial factor. Search tasks with significant consequences if incorrectly solved, due to inaccurate information, increase users' motivation to evaluate the credibility of the information (Metzger 2007).

4. Analytical Model for Predicting Search Performance

Drawing on findings from the literature and the model proposed by Brand-Gruwel et al. (2005), we developed an analytical model that integrates self-assessed digital skills, information literacy, practices for assessing information credibility, perceived task characteristics (including importance, domain knowledge, difficulty), user navigation, and search task performance to investigate how search performance can be predicted (Figure 1). This model allows for the assessment of the unique contribution of each factor while controlling for the influence of the others.

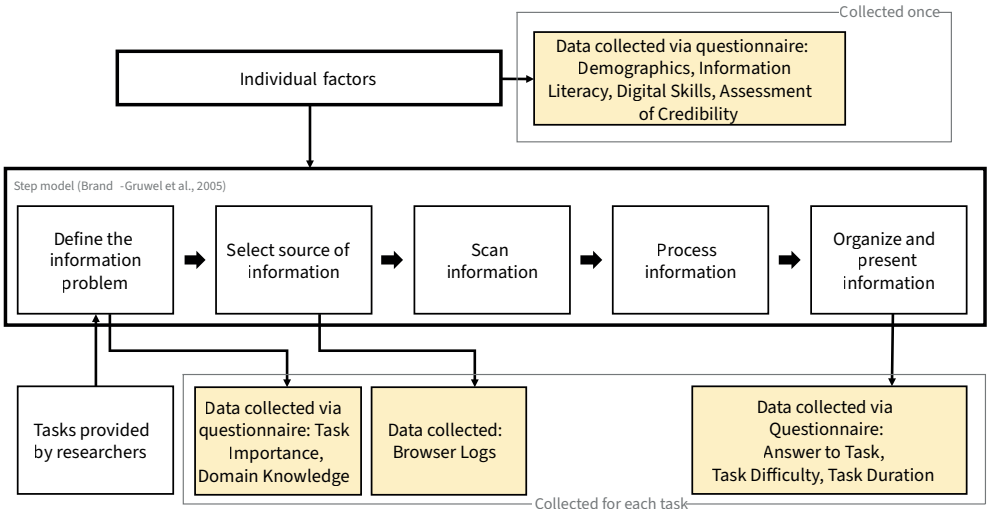

Fig. 1: Modelled Search Process and Data Collection.

The first research question (RQ1) we aim to address is: *Do self-assessed information literacy scores correlate with search performance success?* The second research question (RQ2) will examine this relationship within a broader model that also tests the effect of additional predictors: *Can the modeling of users' navigation, digital skills, information literacy, credibility assessment and task characteristics explain why some individuals are successful at solving information problems while others are not?*

5. Method

The target group of this study comprised young individuals aged between 16 and 20. Participants were recruited through schools in central and southern Switzerland. The schools were contacted via their principals who were requested to forward an invitation to their students to participate in the study. Participants were compensated with an Amazon voucher worth CHF 20.

At the beginning of the study, participants completed a questionnaire collecting data on their demographics, digital skills, information literacy self-efficacy, and their assessment of the credibility of information. The scales used were primarily adapted from existing scales in the literature (see detailed description in the results section). Participants were required to install a browser plugin which directed them to the search tasks, additional questionnaires, and recorded their browser navigation data. Participants were assigned four search tasks, three of which were closed-ended, i.e., they had a single correct solution. Each task was preceded by a brief questionnaire assessing the perceived importance of providing a correct answer and their familiarity with the topic. Participants then commenced the search process. Upon deciding that they had completed their search, participants were

directed to a questionnaire where they had to provide the answer to the task. Following this, they were presented with a short questionnaire asking them to indicate which source they used to answer the task, how difficult they perceived the task to be, their satisfaction with their solution, and whether they perceived the search to be long or short.

To ensure the searches performed by the participants were as natural as possible, we chose to use a browser plugin that allowed participants to complete the search tasks on their own devices at a time of their choosing. Incorporating realistic consequences can enhance the authenticity of tasks for performers (Kim and Soergel 2006). We accounted for this by asking participants to provide important advice to a hypothetical friend. An abbreviated version of the tasks is shown in Table 1 (https://loisresearch.org/search-tasks/).

Task	Text	Correct Answer	Source (examples)
1	Your friend wants to start eating vegan, but she is only 13 years old and has asthma. Is this a good idea?	No, in this case a vegan diet is not recommended.	The Federal Office of Public Health
2	Your friend has been invited to a home-cooked pesto dinner. But he has heard that basil can be poisonous and needs advice on whether or not to go to the dinner.	Go to the dinner, basil in this quantity is not toxic.	The University of Genoa
3	Your friend has heard that climate change will facilitate the spread of tropical diseases and wants to move further north. What would you advise her to do: stay or move to her relatives in Scandinavia?	There is no need to move further north to evade tropical diseases.	The Lancet – Regional Health

Tab. 1: Tasks provided by researchers and correct answers.

6. Results

Of the 152 participants who completed the initial questionnaire, 148 individuals also completed at least one of the search tasks. The mean age of these 148 participants was 19.13 years (SD = 2.44). Half (50%) of them were female, who were slightly but not significantly younger (M = 18.99, SD = 2.79) than the male participants (M = 19.28, SD = 2.02).

6.1 General Results for the Search Tasks

Some participants took an unusually long time to complete the tasks. To avoid possible data distortion due to participants engaging in activities other than the assigned task, four cases were excluded by using the median absolute deviation method to identify outliers (Leys et al. 2019). Of the remaining 144 participants, 102 participants (71%) completed all three tasks, 34 participants (24%) completed two tasks, and 8 participants (6%) completed only one task. Among the 102 participants who completed all three tasks, only 7% provided fully correct answers for all tasks, 26% answered two tasks correctly, 51% answered one task correctly, and 17% provided incorrect or partially correct answers for all closed-ended tasks (see Table 2).

	Vegan Diet Task (N = 121)	Pesto Task (N = 133)	Climate Task (N = 129)
Fully correct	37 (31%)	94 (71%)	30 (23%)
Partially correct	61 (50%)	21 (16%)	38 (30%)
Wrong	23 (19%)	12 (9%)	51 (40%)
Incoherent answers	0	6 (4%)	9 (7%)
Average time spent on task (minutes)	7.9	5.5	6.1
Self-reported domain knowledge pre task (1–5)	2.54	2.20	1.98
Perceived task importance (1–5)	4.7	4.2	4.0
Perceived task difficulty (1–5, post-task)	2.11	2.33	2.94

Tab. 2: Task Correctness, Time, Knowledge, Importance and Difficulty.

Due to a technical error, the tasks were not assigned in a random order to the participants as initially intended. Each participant started with the vegan diet task, then solved the basil task, and was assigned the tropical diseases task last. Consequently, some of the following results may be influenced by a fatigue effect. Most participants (71%) correctly solved the pesto task, followed by the vegan diet task (31%) and the tropical diseases task (23%). On average, participants spent the most time on the diet task (7.9 minutes).

A repeated measures t-test revealed that time spent on the vegan diet task was significantly higher than time spent on the pesto task ($t(111) = 4.35$, $p < .001$) and the climate task ($t(106) = 2.88$, $p < .01$). However, the time spent on the pesto task did not significantly differ from the time spent on the climate task ($t(119) = -1.27$, $p = .21$).

In addition to time differences, participants rated the difficulty and importance of each task. For task importance, a repeated measures t-test showed that the diet task was perceived as more important than the pesto task ($t(111) = 4.18$, $p < .001$) and more important than the climate task ($t(105) = 6.28$, $p < 0.001$). The difference

in perceived importance between the pesto task and the climate task was not significant ($t(118) = 1.33$, $p = .18$). In summary, the vegan diet task was rated as the most important, while the climate task was perceived as the least important.

For task difficulty, a repeated measures t-test showed that all tasks differed significantly from each other (Diet vs. Pesto: $t(109) = -2.17$, $p = .03$; Diet vs. Climate: $t(105) = -5.93$, $p < 0.001$; Pesto vs. Climate: $t(117) = -4.16$, $p < .001$). The climate task was rated as the most difficult, whereas the diet task was rated as the least difficult.

6.2 Navigation Data

The browser plugin recorded participants' navigation data by accessing the browser's history list and logging time-stamped URLs of: a) visits to search engine domains, search pages, or search engine results pages, b) the search queries, and c) visits to result web pages. All clicks related to search engine domains (e.g., Google.com; DuckDuckGo.com) were counted and coded into a new variable to quantify the number of search actions performed by the user per task. The search queries were compared, and if less than 60% of a previous query was changed, it was counted as a query revision. The number of query revisions was also coded as a new variable per user and task. Both values were used as predictors in the analyses.

6.3 Digital Skills

Participants' digital skills were measured using 12 items, most of which were adapted from existing scales in the literature (see Table 3). An exploratory factor analysis was conducted to examine the underlying dimensionality. All items had KMO values above 0.5, indicating their suitability for factor analysis. A parallel analysis suggested a one-factor solution. The items demonstrated good internal consistency, with a Cronbach's alpha value of 0.84.

I can …
collaborate with other people remotely
ignore messages that pop up (for example, friends' statuses) while doing something important*
solve my own technical problems, also searching online**
learn to use new technologies easily**
protect digital equipment from undesired access online***
manage and delete my digital traces***
detect when someone is trying to trick me into sharing personal information***
identify dangerous websites (for example, that can be used for fraud, viruses, etc.)***

I can …
use more digital tools in order to create digital content (presentations, videos, audios, etc.)**
choose a suitable creative commons license for material I have created***
identify when and how programming/coding can be used in different subject areas to make things better/easier***
adapt and adjust the behavior and functionality of a program or app through its settings***
(Cronbach's alpha = 0.84). All items were measured on a 5-point Likert scale ranging from strongly disagree (=1) to strongly agree (=5). The items were sourced and adapted from the following studies: * = items taken or adapted from Porat et al. (2018); ** = items taken or adapted from Ng (2012); *** = items taken or adapted from Norden et al. (2017).

Tab. 3: Digital Skills Items (N = 152).

6.4 Information Literacy Self-Efficacy

Participants' information literacy self-efficacy was measured using 9 items. The items were adapted from Kurbanoglu et al. (2006) and Madden et al. (2018), with slight modifications to fit the current technological environment. Additionally, two items were created by the authors (see Table 4). All items had KMO values above 0.64, indicating their suitability for factor analysis. A parallel analysis suggested a one-factor solution. The Cronbach's alpha for this scale was 0.74.

When searching for information of any kind I feel confident and competent to...
define what specific information I'm looking for*
select the information that answers my question best*
use different kinds of non-digital sources, like books, encyclopedias, magazines*
use different kinds of digital sources like websites, Wikipedia and social networks***
find the best words to type into a search bar (e.g. Google, library catalogue, video search, etc.)***
narrow results down (e.g. by sorting, by defining a time range etc.)***
combine information from different sources to answer my question(s)*
assess my information seeking process and its result*
determine whether the information comes from a trustworthy source**
(Cronbach's alpha = 0.74). All items were measured on a 5-point Likert scale ranging from strongly disagree (=1) to strongly agree (=5). * = items rephrased from Kurbanoglu et al. (2006); ** = items adapted from Madden et al. (2018); *** = items added by the authors.

Tab. 4: Information Literacy Self-Efficacy (N = 152).

6.5 Assessing the Credibility of Information

How participants assess the credibility of Information was measured with 12 items, primarily adapted from existing scales in the literature (see Table 5). All items had KMO values above 0.52, indicating suitability for factor analysis. Parallel analysis suggested a two-factor solution. One item had a loading below 0.3, and another item loaded equally (0.44 and 0.43) on both factors; these two items were subsequently dropped. The exclusion of these items altered the KMO values of the remaining items, necessitating the removal of one additional item due to a KMO value below 0.5.

Consistent with Lucassen et al. (2013), the first factor describes a superficial evaluation of information based primarily on visual cues and has a Cronbach's alpha value of 0.72. The second factor describes a more thorough evaluation of information. However, due to its low internal consistency (alpha = 0.49), it is excluded from subsequent analyses.

Imagine you have to make a very important decision about which you are uncertain. Consequently, you decide to search for information online and encounter numerous websites. What features can help you evaluate the credibility of the information?	**Factor loadings**	
Item	**Factor 1**	**Factor 2**
Factor 1: Superficial evaluation of information (α = 0.72)		
The text on the website is long	0.75	
The website has images and/or videos	0.71	
The website is well designed	0.70	
The website has commercial purposes	0.65	
If the page was on the top of my search results*	0.60	
Factor 2: Deep evaluation of information (α = 0.49)		
The website has references to other sources (e.g. websites, books etc.)		0.65
You have found trustworthy information on this website before		0.64
The author of the post or page has a good reputation		0.63
Info on the website fits with what you already know		0.56
All items were measured on a 5-point Likert scale ranging from not helpful at all (1) to fundamental (5). * = item taken from Timmers and Glas (2010).		

Tab. 5: Information Assessment (N = 152).

6.6 Correlation between self-assessed information literacy and search success – RQ1

To determine whether self-assessed information literacy was related to actual search success, we compared the scores on the self-assessed information literacy scale between successful and unsuccessful searchers. Successful searchers were those who provided correct answers to the tasks, while unsuccessful searchers gave incorrect answers. This analysis was initially performed for each task separately.

For the diet task, there was no significant difference in information literacy self-efficacy between the participants who provided correct answers and those who provided incorrect answers. This was also the case for the pesto task and the climate task (see Table 6). Additionally, we selected participants who completed all three tasks (N = 102) and assigned one point for each correctly completed task, resulting in a score ranging from 0 and 3 for each participant. The correlation between this score and the information literacy self-efficacy score was calculated, yielding a non-significant Spearman's $\rho = -0.01$ ($p = .91$). These results indicate that there was no significant correlation between participants' self-assessed information literacy and their search performance, either on a task-by-task basis or overall.

	Correct answer			Incorrect answer		*t*	*p*
Task	***M***	***SD***		***M***	***SD***		
Vegan Diet	36.37	4.16		37.43	5.36	(28.5) = 0.89	0.38
Pesto	36.34	4.28		36.94	5.74	(20.1) = 0.67	0.31
Climate	36.84	4.21		35.80	4.75	(116.9) = -1.30	0.20

Tab. 6: Results of the t-tests comparing differences in information literacy self-efficacy between participants who gave the correct and incorrect answers to tasks.

6.7 Can the modeling of users' navigation, digital skills, information literacy, credibility assessment and task characteristics explain why some individuals are successful at solving information problems while others are not? – RQ2

To test whether navigational behavior, digital skills, information literacy and assessment of credibility can predict search success, we performed a logistic regression analysis with the dependent variable being the correct answer (= 1). We gradually added the additional predictors to the model. As indicated above, there is considerable variability between our search tasks in terms of topic, time spent on the task, perceived difficulty, and importance. This variability implies that the outcome measures (correct answers) in our data are not independent of each other, but are influenced by attributes of the task. Consequently, the relationship between the

predictors (navigational data, task characteristics, skills, assessment of credibility) and the dependent variable may therefore differ between tasks, which we accounted for in our analysis.

For each task, we entered the navigational data (search actions and query revisions) into model 1. In model 2, we added digital skills, information literacy self-efficacy (labelled Self-Efficacy), and superficial assessment of credibility (labelled Assessment of Credibility). Model 3 included domain knowledge and task importance, and for model 4, we added interactions between digital skills and self-efficacy, as well as domain knowledge and query revisions (see Table 7).

Task 1

For task 1, no significant predictors were found when using navigation data alone (Model 1), nor when adding self-assessed measurements of digital skills, self-efficacy, and assessment of credibility (Model 2). However, when task characteristics were controlled for (Model 3), the assessment of credibility became a significant predictor for giving the correct answer. Specifically, participants who relied more on superficial cues to assess the credibility of information were less likely to give the correct answer.

	Model 1	Model 2	Model 3	Model 4
Task 1 (Diet)				
Intercept	4.82*** (2.28-10.85)	579.94 (4.91 – 145184.26)	11.56 (0.03 – 6897.92)	0.00° (0.00 – 65.82)
Search Actions	0.95 (0.87-1.05)	0.96 (0.87 – 1.06)	0.95 (0.86 – 1.06)	0.92 (0.82 – 1.04)
Query Revisions	1.42 (0.82 – 2.78)	1.49 (0.86 – 2.87)	1.55 (0.86 – 3.24)	1.34 (0.27 – 6.95)
Digital Skills		0.94 (0.87 – 1.02)	0.96 (0.88 – 1.04)	1.49° (0.93 – 2.37)
Self-Efficacy		1.00 (0.88 – 1.14)	0.98 (0.85 – 1.12)	1.68° (0.94 – 3.04)
Assessment of Credibility		0.88° (0.76 – 1.00)	0.86* (0.73 – 0.98)	0.85* (0.73 – 0.98)
Domain Knowledge			1.10 (0.71 – 1.75)	1.08 (0.61 – 1.95)
Task Importance			2.23° (0.96 – 5.20)	2.50* (1.03 – 6.23)
Task Difficulty			1.25 (0.76 – 2.18)	1.17 (0.71 – 2.05)
Digital Skills * Self Efficacy				0.99° (0.98 – 1.00)
Domain Knowledge * Query Revisions				1.08 (0.62 – 2.18)
AIC	121.86	120.5	119.79	120.16
R2 Tjur	0.012	0.081	0.114	0.156
N	121	120	119	119
Task 3 (Climate)				
Intercept	0.97 (0.55 – 1.72)	2.62 (0.07 – 102.09)	1.04 (0.02 – 61.22)	0.00 (0.00 – 53.87)
Search Actions	0.95 (0.85 – 1.06)	0.96 (0.85 – 1.08)	0.96 (0.84 – 1.09)	0.94 (0.83 – 1.06)
Query Revisions	1.61* (1.09 – 2.54)	1.56* (1.04 – 2.53)	1.57° (1.02 – 2.58)	3.64* (1.45 – 10.83)
Digital Skills		0.93* (0.87 – 0.99)	0.93* (0.87 – 0.99)	1.30 (0.85 – 2.13)
Self-Efficacy		1.14* (1.03 – 1.27)	1.11° (1.00 – 1.24)	1.67° (0.99 – 3.16)
Assessment of Credibility		0.87* (0.77 – 0.96)	0.87* (0.78 – 0.97)	0.88* (0.78 – 0.98)
Domain Knowledge			1.33 (0.91 – 1.96)	1.98* (1.19 – 3.50)
Task Importance			1.19 (0.80 – 1.79)	1.17 (0.78 – 1.78)
Task Difficulty			1.15 (0.82 – 1.62)	1.09 (0.76 – 1.57)
Digital Skills * Self Efficacy				0.99 (0.98 – 1.00)
Domain Knowledge * Query Revisions				0.66* (0.43 – 0.96)
AIC	174.26	164.29	164.89	162.37
R2 Tjur	0.048	0.145	0.157	0.200
N	127	124	121	121

Tab. 7: Binary Logistic Regression Analysis for task 1 and 3 (Odds Ratios, Confidence Intervals and Significance).

Perceived task importance emerged as a highly relevant factor. Participants who perceived it as more important to find the correct answer were more likely to do so. Although the two predictors digital skills and self-efficacy did not reach conventional levels of significance, they might indicate effects that could become significant with a larger sample size, allowing for the detection of smaller effects. In our model, these two predictors were significant at the $p < 0.1$ level, suggesting potential relevance for successfully solving online search tasks.

Task 2

For task 2, there were no significant predictors in the initial models. However, in the final model, the data suggest that assessments of credibility and self-efficacy may be potential predictors of search success, with both having p-values < 0.1.

Task 3

For task 3, the number of query revisions was a significant predictor when only navigation data was used (Model 1). This significance remained when digital skills, self-efficacy, and assessment of credibility were added (Model 2), with these additional factors also emerging as significant predictors of search success. Specifically, digital skills negatively affected the likelihood of solving the task correctly, possibly because participant who reported very high digital skills may overestimate their abilities (Kruger and Dunning 1999). Superficial assessment of credibility also negatively affected the likelihood of solving the task correctly, whereas higher self-efficacy increased the likelihood of finding the correct answer.

When controlling for task characteristics (Model 3), the data suggests query revisions and self-efficacy as significant predictors ($p < 0.1$), while task characteristics did not show predictive value. In the final mode (Model 4), which controlled for interactions, query revisions, assessment of credibility, and domain knowledge become significant predictors of search success. The interaction between domain knowledge and query revisions was also significant, indicating that the effect of query revisions on search success varied according to participants' domain knowledge.

For participants with low domain knowledge, the probability of providing the correct answer increased with additional query revisions. Conversely, for participants with high domain knowledge, the probability of providing the correct answer decreased as the number of query revisions increased (see Figure 2).

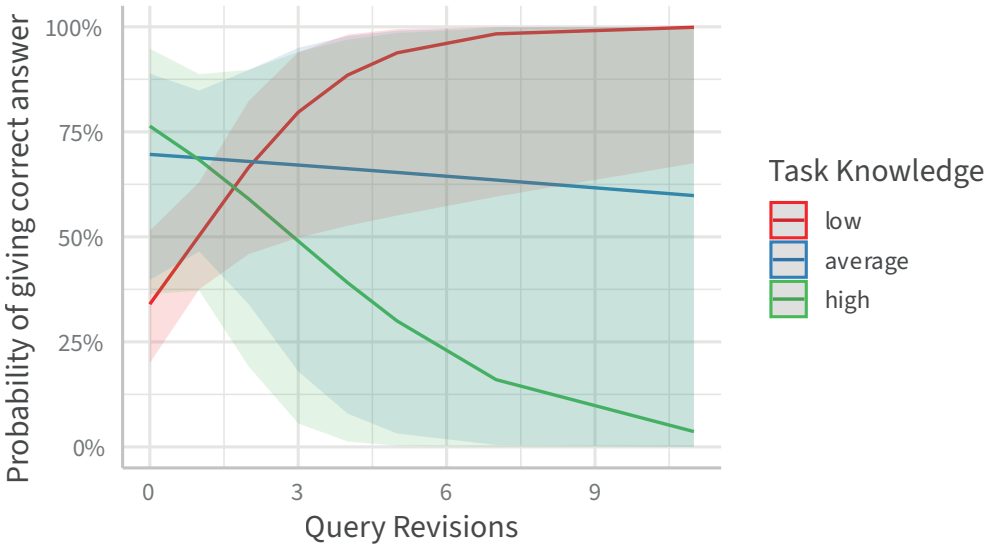

Fig. 2: Interaction of Query Revisions and Domain Knowledge.

To generalize the results across all tasks, it can be concluded that assessing credibility based on superficial cues has a significant negative effect on search success, as evidenced by the results for task 1 and 3, while task 2 shows a similar tendency. Task characteristics also predict search success, although the specific characteristics varies: for task 1, task importance had a significant effect, while for task 3, it was domain knowledge.

Interestingly, task difficulty did not significantly affect search performance in any of the models. Self-efficacy only becomes a relevant predictor when the threshold for statistical significance is lowered to <0.1. The fact that self-efficacy would be a significant predictor in the final models for all three tasks under this condition suggests that information literacy self-efficacy could be an important factor in determining search performance, particularly with a larger sample size to detect smaller effects. Although the confidence intervals include 0, the lower threshold in every model is ≥ 0.94, indicating at a possible boundary issue. Another reason for the distinct results observed in the climate task could be the better distribution of its dependent variable (correct answer), with 40% of participants providing an incorrect answer and 54% providing a correct answer. In contrast, the other tasks showed more skewed distributions (diet task: 19% incorrect vs. 81% correct; pesto task 9% incorrect and 87% correct), which can impact the predictive power of a model.

7. Discussion

In this study, we investigated various factors that influence search performance within a single model, enabling us to estimate the effect of each predictor while controlling for the influence of the others. This strengthens the explanatory power of the predictors by accounting for interdependencies. We utilized navigation data, questionnaire data on digital skills, information literacy self-efficacy, assessment of credibility, domain knowledge, importance, and difficulty as predictors of search success. To avoid creating an artificial laboratory situation that might distort the data, we allowed participants to perform the searches on their own computers. The tasks were designed to mimic real-life information problems, enhancing the ecological validity of the study.

First, we demonstrated that information literacy self-efficacy may serve as a predictor for search success. When examined in isolation (RQ1), self-efficacy did not significantly predict participants' performance. However, when controlling for additional predictors in the model (RQ2), the results indicate a possible positive effect. The fact that this effect was only marginally significant ($p < 0.1$) may be attributable to the nature of the tasks employed. As Hong (2006) shows, self-efficacy may be more relevant for broader search tasks and less relevant for narrower search tasks such as those used in this study. Compared to previous research, our results imply that the relationship between information literacy self-efficacy and search success (Clark 2017) may not be absent but more nuanced than previously assumed.

We were able to confirm that refining queries can have a measurable positive effect on search performance (Hassan et al. 2013) for some tasks (Task 3) but not others (Task 1). However, a higher number of search actions did not increase the likelihood of a successful search. We also found evidence that using superficial cues (see Table 5) to assess the credibility of information (Masullo Chen et al., 2017; Waddell and Bailey, 2017) has a measurable negative effect on search performance.

Task importance and domain knowledge significantly increased search performance. However, for task 3, we found an interaction between query revisions and domain knowledge. For those who had high domain knowledge, search performance decreased with additional query revisions. This could be due to participants overestimating their domain knowledge and becoming increasingly confused with each additional search. Alternatively, the topic of the task (climate change) might lead to encountering a mix of reliable and dubious information, increasing uncertainty with each additional search and thus lowering search performance.

Furthermore, the effects of the predictors were not consistent across all tasks. This variability may be due to the task topic, task difficulty, perceived importance, or the nature of the online information landscape. One can imagine that the

information about climate change is very different from the information about the toxicity of basil. The nature of the task may substantially affect the extent to which various factors influence search success.

Our study has several limitations. First, the scope was limited to a small number of tasks, which restricts the generalizability of our findings. Future studies should include a broader set of tasks to reveal patterns based on the task type or topic. The potential contamination of the navigation data may also limit our findings. Previous research has shown that users often search for related or unrelated topics simultaneously (Spink et al. 2002), introducing noise and obscuring the true effects of our predictors. Additionally, due to a technical issue, the tasks were not administered in random order, potentially introducing order effects such as learning or fatigue.

To deepen insights into the effects of credibility assessment, it may be beneficial to explore measuring deeper assessment of information. Although we found some evidence for such a scale, its internal consistency was too low to be useful as a predictor of search success. Our participants conducted their search on laptops or desktop computers, examining how results might differ when using mobile phones or tablet could be a direction for future research. Modelling search success across different tasks is a highly generalized approach to understanding online search. However, we propose integrating our findings into information literacy instruction, which is also typically generalized as well. Educators often focus on the basic rules of online information searching due to time and resources constraints, preventing them from exploring diverse scenarios in depth (Togia et al. 2015; Hermida 2021). Nevertheless, educators could emphasize the importance of understanding the nature and requirements of each individual search task and select examples and exercises that involve different tasks. We also suggest incorporating all the following behaviors into instruction, as they might have a positive effect on search performance. Although not every behavior may be beneficial for all search tasks, our results indicate that these behaviors either have a positive effect or no effect, and therefore no potential negative impact. To summarise our findings, we suggest the following:

- Encourage learners to revise their queries.
- Encourage learners not to use superficial cues to assess credibility. Instead, encourage them to evaluate the source. It is important to keep in mind that the less familiar learners are with a topic, the more tempted they will be to rely on superficial cues.
- Point out to learners that limited knowledge on a subject may reduce their ability to find the right information they need. Suggest that they get an overview of a topic to increase their general knowledge of it before searching for a specific fact.
- Educators should design search tasks where learners perceive it as very important to find the correct answer.

In conclusion, this study highlights the complex interplay of various factors influencing online search performance. By integrating our insights into educational practices, we can better prepare students to navigate the online information landscape successfully. Although we recently witnessed the integration of artificial intelligence (AI) into online search, we believe our insights remain valuable. AI features do not inherently assess the credibility of the information they provide and are susceptible to hallucinations (Ji et al. 2023). Therefore, for complex and important tasks, users still need to find and evaluate sources of information themselves.

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