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Can digital information literacy among undergraduates be improved? Evidence from an experimental study

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ABSTRACT

The Internet has become a pivotal source of information among university students. However, studies routinely show that many students lack digital information literacy skills (i.e. skills needed to find and evaluate information online). In this paper, we report results from an experimental study testing the effect of a workshop for third-year students of a German university. The workshop was designed to teach relevant information literacy skills in a computer lab. Afterwards, students were given academic search tasks and their search behavior was recorded with a tracking device. We find that, compared with the control group, workshop participants significantly increased their use of academic databases and cited more articles from scholarly journals. On the other hand, we find no effect on the relevance of the content students found online. Teaching digital information literacy is essential and feasible, but it is no panacea for increasing the academic quality of students' work.

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Information literacy; digital literacy; information-seeking behavior; internet; instruction; experiment

Introduction

The Internet is now ubiquitous in university life: Students as well as faculty members use it as the first source when looking for information related to academic tasks (Hemminger et al. 2007; Biddix, Chung, and Park 2011; Catalano 2013). Accordingly, the skills needed to find and retrieve information online as well as the ability to discern reliable from unreliable sources have become ever more important. However, many studies show that these skills are often poorly developed among college students entering university (e.g. Gross and Latham 2012; Catalano 2013). While most students use general-purpose search engines such as *Google*, many are not aware of academic databases such as *Web of Science* or academic search engines such as *Google Scholar* (Callinan 2005; Mittermeyer 2005). When performing an online search, students often use one-word search queries and rarely select 'advanced search' options (Timmers and Glas 2010). Moreover, research has shown that while today's students spend a large amount of time online each day, only a small share of online activities are usually related to learning or academic work (Madge et al. 2009; Margaryan, Littlejohn, and Vojt 2011).

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The importance of digital media skills for academic life and beyond has often been discussed (Cox and Marshall 2007; Tien and Fu 2008). Many universities have for quite some time integrated methods for teaching digital information literacy into subject curricula or offered specialized courses (Corral 2008), and empirical studies have evaluated the effectiveness of such courses (e.g. Long and Shrikhande 2007; Cullen, Clark, and Esson 2011; Fain 2011; Ferrer-Vinent et al. 2015). A shortcoming of previous research has been the fact that most studies have relied on self-reported behavior from, e.g. online surveys, but have rarely observed in detail the way students search for information on the Internet. The scarcity of in-depth evidence on actual behavior points to the more general question as to whether (and how) teaching information literacy skills can in fact change students' behavior in this regard.

This paper seeks to address this question, reporting findings from an experimental study where students' online search behavior was recorded with a browser plug-in to test the effectiveness of a workshop on information-seeking strategies. Students were randomly assigned to the experimental group or a control group which did not attend the treatment workshop until after the main tests. Pre- and post-treatment tests required the participants to perform online literature research on specific topics and cite three academic sources that they deemed most relevant for the respective research question. The search process was tracked with the browser plug-in and the references were evaluated in terms of reliability and relevance of the content. This setup provides us with detailed insight into students' online search behavior and allows us to figure out where our teaching was successful at changing behavior and where not.

In the following, we first outline theoretical arguments concerning how digital information literacy skills affect the outcomes of online search processes. We then describe the workshop's formal learning objectives and pedagogic approach as well as the experimental study's design and the tests used to measure information behavior. Our results first look at the workshop's impact on search strategies. Using browser data, we are interested in knowing whether workshop participants changed their online search behavior after attending the course. Finally, we analyze the references that students cited after they performed their search with regard to reliability and thematic relevance.

Theory and state of research

Research on students' ability to find, retrieve, and evaluate content via the Internet does not use a uniform terminology. Popular terms in this strand of research are information literacy, digital literacy, information and communication technology (ICT) skills, or media competence, to name only a few popular concepts (for an overview, see Wilson 1999). In this paper, we use the term 'digital information literacy' to highlight the overlap of information literacy and information technology skills. This overlap focuses on the skills needed to find and evaluate information online. More specifically, since our target group is students in higher education, we analyze the ability to find academic literature that is relevant to a specific research question and to evaluate its scientific value.

Digital information literacy is usually conceived as a multidimensional concept. For instance, Timmers and Glas (2010) define six components of information-seeking behavior based on the Association of College and Research Libraries' (ACRL) framework from the year 2000 (which has since been revised, see ACRL 2016). A large number of other

conceptualizations exist, among them the 'Seven Faces' model by Bruce (1997) or the UNESCO's 'Information Literacy Life Cycle' (UNESCO 2008). In this paper, we limit the scope of the analysis to the search process and hence to two dimensions that are present in most of the commonly used models: the sources students consult for their search ('using sources' in Timmers and Glas' (2010) classification) and the degree of sophistication of search queries ('applying search strategies').

In the context of online research for academic literature, usage of general-purpose search engines such as *Google* can be distinguished from specialized academic search engines and databases. Many studies find that students typically use *Google* as a starting point for doing research (Du and Evans 2011; Catalano 2013). However, more advanced users often use more than one website, e.g. combining *Google* with *Google Scholar* or a library database (Du and Evans 2011). Similarly, research shows that academics as well as students often use *Wikipedia*, but typically only in an early stage of research, since many regard it as not reliable and therefore consult additional sources (Knight and Pryke 2012). We thus hold that basic online sources such as *Google* or *Wikipedia* are not in competition with specialized sites, but the more advanced students use the latter in addition to the former. Using academic databases that are less known to undergraduate students has been shown to lead to better search results in terms of academic content and reliability (Helms-Park, Radia, and Stapleton 2007). Therefore, we expect students to find more academically relevant literature when using databases designed to find scientific content as opposed to standard search engines.

With regard to how students perform online searches, most studies conclude that the degree of sophistication of search strategies is rather low among university students. Catalano (2013) finds that even among graduate students, knowledge and usage of advanced search strategies is limited. Boolean operators to refine search queries, for instance, are only used by a minority. Likewise, Cullen, Clark, and Esson (2011) find that junior doctors entering the workforce lack search skills. In the study by Du and Evans (2011), PhD students reported confidence in their ability to use advanced search options, but hardly actually used it. In general, it can be expected that a standard one-word or two-word search is likely to return a list of search results that is too broad in its scope. By contrast, a more sophisticated search that reformulates search terms several times, makes use of advanced search options such as Boolean operators, puts keywords in quotes, or limits the timespan for the date of publication, arguably leads to more relevant search results (see, e.g. Timmers and Glas 2010).

Following these previous findings, we argue that, given a limited amount of time available for online research, knowledge of academic databases and skills to adequately use search engines are crucial factors to arrive at search results that can be considered reliable and thematically relevant to the question at hand. Therefore, we expect that the quality of search results for a specific research task is a function of academic search tools usage and sophistication of search strategy (see Figure 1). Individual characteristics such as background knowledge on a topic or cognitive abilities can also be expected to affect the search process. Moreover, discipline-specific conventions can play a role, e.g. differences regarding where the most important findings are published can affect which sources students primarily use (Engels, Ossenblok, and Spruyt 2012; Whitmire 2002). Finally, students need to evaluate information found online based on criteria such as quality, reliability, and relevance to the topic at hand. Using adequate search strategies arguably

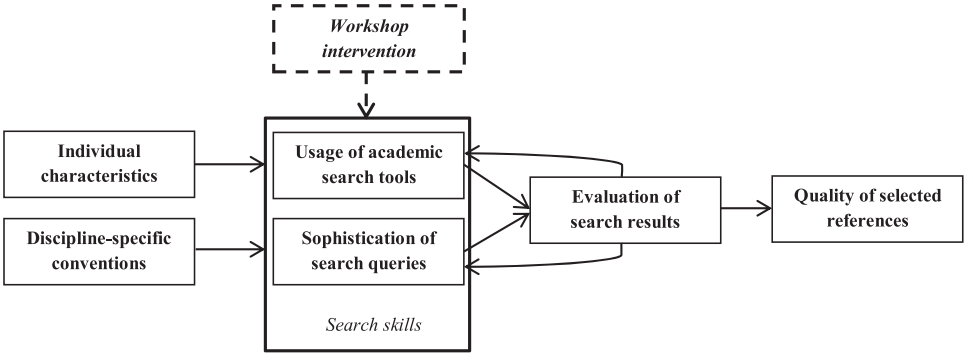

Figure 1. Theoretical model.

provides students with a list of more relevant search results, which is why we expect to find a positive effect on the quality of the resources that are actually selected for later use. However, we assume that the skills to critically evaluate and select resources are much more difficult to be enhanced by teaching compared with the skills to perform the search. For instance, knowing how to judge the thematic relevance of a source is arguably a skill that develops with years of experience in an academic field and that cannot easily be influenced by a single pedagogic intervention. We look at this aspect in the final part of the paper.

Design and contents of the workshop

The target group for our workshop were third-year students of sociology or educational science who were about to write their final bachelor's thesis. Participants were recruited via an e-mail announcement as well as posters put up at various locations on campus. 47 students signed up to participate, among them 24 students of educational science and 23 students of sociology. The workshop was held one week before the semester started, such that it did not interfere with regular lectures. Students were told that the workshop was combined with a scientific study which they could voluntarily take part in. As an incentive, each workshop attendant who also participated in the study was rewarded with a 10 Euro voucher from an online shopping site.

All students that registered to participate in the workshop were randomly assigned to either the experimental or the control group. Of the 47 registrations, 39 students showed up on the day of the workshop and all agreed to participate in the study. One student left during the day, having completed only the first task. The remaining 38 were equally represented in the experimental ($N = 19$) and the control group ($N = 19$). Both groups attended the workshop on information literacy and a thematically unrelated lecture on formatting scientific papers and graphics. The experimental group attended the workshop in the morning and the alternative lecture in the afternoon while the reverse was true for the control group. Classes were held in different rooms and the groups did not meet during the day. Before agreements were obtained, the study and the tracking device were explained to both groups (i.e. students knew their browser history was logged during the experimental phase). Students were told the study was on Internet search

behavior. However, the experimental setting (the idea of systematic grouping and which of the two groups they were in) was not explained to them. They were also not aware of the fact that the tests were used to evaluate the workshop's effectiveness. All students were handed an information sheet listing data protection and privacy regulations.

As noted above, empirical studies have repeatedly shown deficits among students' digital information literacy in two dimensions: knowledge and usage of academic search engines and databases, and usage of advanced search options. Our workshop responded to these well-known deficits and accordingly directed its didactic goals to these two central dimensions (see Table 1). For the first dimension, one learning objective was to impart knowledge on scholarly journals, the peer-review system, and journal impact factors. Previous studies found that students were often not aware of the importance of peer-reviewed publications in academia. Therefore, before turning to the actual search process, we intended to raise awareness of the differences between certain publication types (e.g. academic journals, books, newspapers, blogs, etc.) and publishers and the limits of the peer-review system. The second learning objective in this dimension referred to the skills that are necessary to find and access scholarly publications. Several websites were introduced and their features were discussed, namely *Google Scholar*, *JSTOR*, *Web of Science*, and the local library catalog. In comparing the results of identical search queries to these websites, and in discussing the possibilities to narrow down the list of search results, we intended to draw attention on advantages and limitations of different sites.

Regarding the second dimension, one objective was to teach skills to use the advanced search options that various search engines and databases offer. This included using Boolean operators and limiting timespan or publication type of search results. Another important point was to use different search terms, e.g. by searching in titles and abstracts of initial search results for other keywords that might also be relevant for the question at hand. Since the search algorithms used by different databases vary, we also wanted to stress that students should not limit their search to one website. Finally, we intended to highlight the importance of going beyond students' native German language and using

Table 1. Dimensions of information behavior, didactic goals, and empirical indicators.

Dimension	Didactic goals	Empirical indicators
Sources used in online search	• Imparting knowledge of scholarly journals and their relevance in academia. • Teaching skills to use academic databases and search engines to find and retrieve journal articles. • Imparting knowledge on advantages and limitations of different sites.	Academic search engine usage, factor composed of three items: • Usage of *Google Scholar*. • Usage of *JSTOR*. • Usage of *Web of Science*. Academic reputation of three cited references, factor composed of three raters' evaluations.
Sophistication of search queries	• Teaching skills to use the advanced search option of different search engines with, e.g. Boolean operators, confinement to publication date, etc. • Teaching skills to adapt search queries and use different search engines. • Stressing importance of English-language search terms for finding relevant sources.	Sophistication of search queries, factor composed of four items: • Usage of advanced search options. • Number of different search queries. • Number of different search engines consulted. • Share of English-language search queries.

international (i.e. English or another language relevant for the topic at hand) search queries.

We thus set formal learning objectives as goals for the workshop. As is long known in educational science, however, prescriptive guidelines alone can encourage surface learning with unsustainable outcomes (Johnston and Webber 2003). Several pedagogic approaches instead emphasize the role of active learning techniques which relate to learners' previous experiences and information needs. For instance, the core adult learning principles according to Knowles, Holton, and Swanson (2007) state that learners must have a need to learn in order to motivate them to actively increase their knowledge. Moreover, learning should be problem-centered and based on active practice. Contents have to relate to previous learning experiences and be of relevance to students' every-day work. The 'informed learning' approach (Bruce 2008; Hughes and Bruce 2012) stresses that information literacy education should promote simultaneous learning about disciplinary content and the information using process. For instance, learning how to use a new journal database should be combined with actively researching and communicating about an authentic topic meaningful to the students (Hughes and Bruce 2012). This can probably be better realized within discipline-focused curricula as compared with teaching information literacy outside the context in which using information occurs to students of mixed disciplinary backgrounds (Maybee 2015).

Hence, several principles guiding our pedagogic strategy were derived: First, learning was to be problem-centered and based on active practice. We therefore held the workshop in a computer laboratory where each participant had their own computer to use. Lectures using presentation slides alternated with practical exercises, partly in groups. Second, our workshop intended to build on students' previous experiences and their information needs. Therefore, at the beginning of the workshop, the teacher surveyed the level of knowledge on, e.g. journal databases, and partly adjusted the teaching accordingly by selecting from a set of presentation slides and skipping content that the students already knew. Moreover, practical exercises were framed in a way that they related to past experiences and information needs. For instance, after learning about techniques for constructing search queries, students were told to think of the latest written assignment they worked on and to try to find citations previously unknown to them using the new methods individually. Finally, learning about the information using process was to be paired to learning about substantial disciplinary content. We therefore limited workshop participation to students of two related disciplines (sociology and educational science) and worked with topics which are relevant to both disciplines throughout the workshop. For instance, the group discussed school dropout rates in Europe and possible influencing factors, and the teacher then explained how to find sources and reflected on their reliability.

The workshop consisted of two 120-minute classes with a lunch break in between. At the end, an optional one-hour round of questions concluded the day which the students could take part in if they had individual questions related to the workshop contents, e.g. concerning research for their bachelor's thesis. Asking questions was also possible during the courses. Teaching took place in a computer laboratory assisted by *Powerpoint* presentation slides. Those slides were already copied to each of the students' computers in advance, so that students could revisit previous content if needed or click on links to, e.g. databases which were displayed on the slides.

The workshop was conducted and completed without significant problems. A paper-and-pen survey among participants at the end of the workshop (i.e. after both groups had attended all classes) showed that satisfaction with the course on information literacy was overall high, with more than 80% rating it good or very good and none as poor or very poor. More than 90% indicated they would apply the skills learned in their future work, and only around 40% said they already knew much of what was taught. We thus have no reason to believe that problems with workshop organization or the lecturer interfered with teaching. We also can rule out finding a null-effect due to the possibility that most students already knew most of the contents beforehand.

Measurement and study design

One approach to measuring information literacy is measuring students' knowledge on specific aspects of information seeking behavior (e.g. questions such as 'What does a journal impact factor indicate?', see Leichner et al. 2013). The most common method, used in most large-scale surveys, is asking students about their usual strategies when searching for information online and using this self-reported behavior to construct information literacy scales (e.g. Timmers and Glas 2010; Perruso 2016). In Helms-Park, Radia, and Stapleton (2007), participants submitted a bibliography for a research assignment and indicated how these sources were found (e.g. via *Google,* the university's library catalog, or *Google Scholar*). Leichner et al. (2014) also evaluate search results as well as search procedure by asking students ex post how they found the sources they cited.

Contrary to most previous work, we did not ask participants to report on their behavior but observed the whole search process with a browser plug-in which we developed for this purpose. Only rarely have actual search logs been analyzed instead of survey data (e.g. Du and Evans 2011). Our plug-in records the browser history while students perform a search task and also categorizes actions such as, e.g. clicking on a link or submitting a form. Using this tool, we extracted the search queries students submitted to various sites and categorized them according to the following factors: number of different search queries, number of different search engines or databases consulted, proportion of queries using advanced search options (e.g. Boolean operators, quotation marks, setting timespan of publication date), and proportion of non-German-language queries. These indicators correspond to the concept of 'sophistication of search strategy' (see Table 1). We also coded whether the participants had used specialist sites designed to find academic content such as *Google Scholar*, *JSTOR*, or *Web of Science* (factor 'academic search engine usage').

Our tasks were created in the fashion of Leichner et al.'s (2014) tasks with difficulty level three. This means that students were required to search for scientific publications on a topic which is described in non-scientific terms (i.e. not mentioning a scientific theory or model in the task description). The assignment for the first task reads (originally presented to students in German): 'Imagine you were to write a Bachelor's thesis on the following topic: reasons for the currently high level of youth unemployment in Spain. Please use the Internet to search for sources on this topic and name three sources that you would cite in your thesis.' For two subsequent tasks, topics changed to 'educational success among children of Indian origin in the United Kingdom' and 'difference in working hours between fathers and mothers in the United States', respectively. The criteria for choosing these topics were that they mean something to both sociologists as well as

educational scientists; they should be specific enough such that one can reasonably assume that most students do not know relevant citations beforehand and must use combinations of search terms to arrive at appropriate search results; and they should refer to international issues where German-language search terms are less likely to succeed in finding the most relevant literature. Time limit for each search task was ten minutes.[1]

Our approach is similar to Long and Shrikhande (2007) who evaluate the quality of resources students used for a paper after attending a workshop. Like Helms-Park, Radia, and Stapleton (2007), we had three independent raters evaluate the bibliography that students reported after their search tasks. Our raters had backgrounds in sociology (two) and educational science (one) and gave scores for each citation with regard to two dimensions: academic reputation and relevance of the content. Scores each ranged from 1 (lowest) to 5 (highest). Raters were given a sheet with guidelines about what is meant by these two dimensions, but the scores were subjective. First, they evaluated the (subjective) academic reputation of the outlet the cited work appeared in (e.g. a scientific journal or a blog post). For relevance, raters were told to evaluate how well the topics dealt with in the respective article corresponded to the assignment. All citations were presented to the raters without reference to students' identities or search strategies used to arrive at these sources. The three raters differed somewhat in their judgments: Rater 1 gave on average (2.66) lower scorings compared with rater 3 (mean = 3.7), with rater 2 ranging in between (mean = 3.26). However, inter-rater-reliability was nonetheless high. Cronbach's alpha as a measure of how well the raters agreed on the rank order of their scores ranged between .76 and .8 for the different dimensions and tasks. Factor scores from the three raters' grades were extracted from a confirmatory factor analysis and the mean value for all three citations was taken to denote an individual's score for the respective task.

In order to assess the impact of attending the workshop on these outcomes, we embedded the workshop in an experimental study. The experimental design is illustrated in Figure 2. As noted above, the experimental group first attended the course on information literacy and later heard an unrelated lecture, while the reverse was the case for the control group. Both groups completed the first task before hearing anything on the workshop, while the second task was completed immediately after the experimental group attended the workshop. After this second test, the control group attended the workshop on information literacy as well, since for practical and ethical reasons, we did not want to deprive them of the contents they signed up for. The participants were unaware of this experimental setting and were told that we had to split up the group since it was too large for the computer lab in which the tests were held.

Several previous studies also use a pretest-posttest design, but mostly without a control group (e.g. Fain 2011; Ferrer-Vinent et al. 2015). In these studies, it is not clear whether

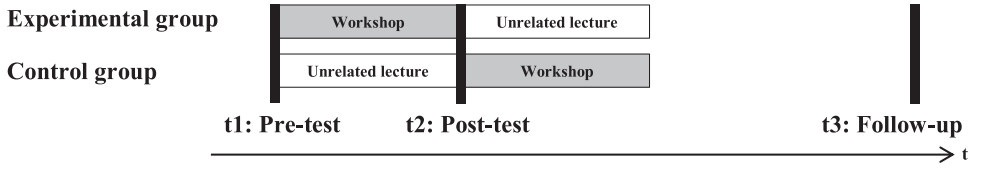

Figure 2. Design of the study.

changes between t1 and t2 were due to workshop attendance or other factors. By contrast, our setup which varies the treatment randomly in a controlled environment allows us to identify the effect the workshop has on short-term changes in information-seeking behavior. In order to assess the sustainability of the teaching, a follow-up study was conducted two weeks after the workshop. Similar to Leichner et al. (2014), our third measurement takes place at a time when both the experimental as well as the control group have received the instruction.

We collected and merged data from three different sources: Search-event data from the search tasks, the raters' evaluations of the citations, and data from a post-hoc online survey on socio-demographic characteristics. At the beginning of the study, each participant was handed a sheet containing instructions and a randomly created personal identification number (PIN) which was used to activate both the browser plug-in as well as access the online survey. We used the PINs to merge data from these different sources without participants' personal information. We use simple pretest-posttest comparisons as well as multilevel regression models (random-effects models) to assess the effect of the workshop on the different outcomes. A few missing data points are present in our sample (see Appendix for descriptive statistics on all variables used in the study). We used mice software (Van Buuren and Groothuis-Oudshoorn 2011) for R (R Core Team 2015), ran all models in ten multiply imputed datasets and averaged the results using Rubin's (1987) rules.

Results (I): impact of the workshop on search strategies

We are first interested in knowing whether workshop participants differ in their information-seeking behavior after the workshop. Figure 3 plots average factor scores for academic database usage among workshop participants and the control group before the workshop (t1), after the workshop (t2), and at the follow-up study two weeks later (t3).

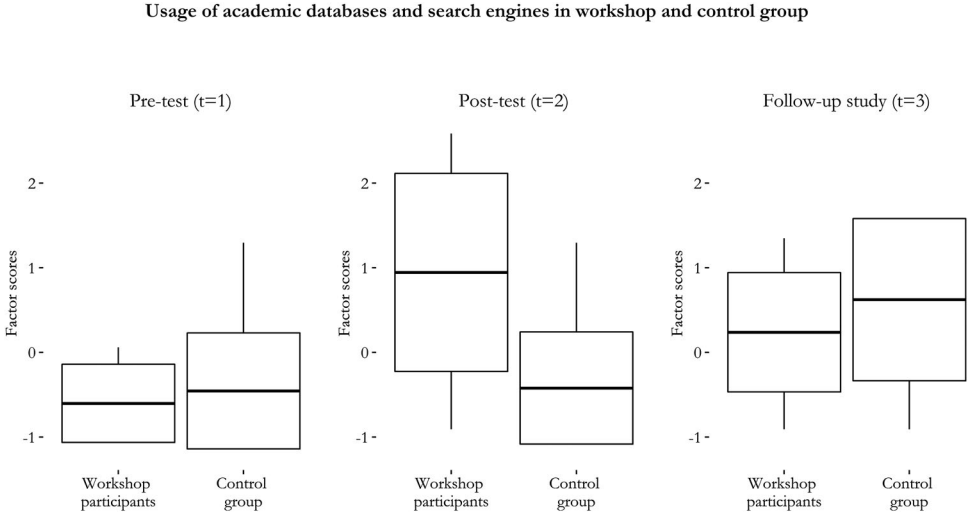

Figure 3. Impact of workshop participation on usage of academic databases.

Thick horizontal lines denote median values, box limits are 25% and 75% percentiles, respectively, and thin vertical lines denote the total range. The left panel of Figure 3 shows that experimental and control group did not differ significantly in the first search task. Academic database usage was generally low before the workshop. While almost all students used *Google*, only 27% used *Google Scholar*, 6% *JSTOR* and 3% *Web of Science* to find literature for the first assignment. The university's library catalog, on the other hand, was already consulted by 70% of the students. At the second assignment, the control group remains constant while the workshop participants significantly increase their usage of academic databases. 95% of workshop participants used *Google Scholar*, 47% used *JSTOR* and 26% used *Web of Science*.

At the time of the follow-up study ($t = 3$), the groups did not differ significantly. This result was expected, since both groups had completed the workshop at this point. Note, however, that some of the initial workshop participants reverted to their previous habits two weeks after the study. One in four students did not consult *JSTOR* or *Web of Science* again although having previously done so. On the other hand, usage of *Google Scholar* (89%) and the share of English-language search terms (42%) remained constant in this group. Thus, we have mixed evidence regarding the long-term impact of the teaching.

Figure 4 shows the development of sophistication of search strategies, which is rather low at the first assignment. On average, students of both groups used three different search queries sent to two different search engines or databases. Only one student used advanced search options, and only 9% of all search terms were in a language other than German.

When researching for the second assignment, the level of sophistication of students' search strategies generally increased to a small degree. However, this cannot be attributed to workshop participation since the control group improved as well. The increase is somewhat stronger among the experimental group, but the difference is not statistically significant. A possible explanation for the fact that both the workshop participants as well as the control group increased might be that finding adequate literature for the second assignment was harder compared with the first. Also, the setting of the question in the

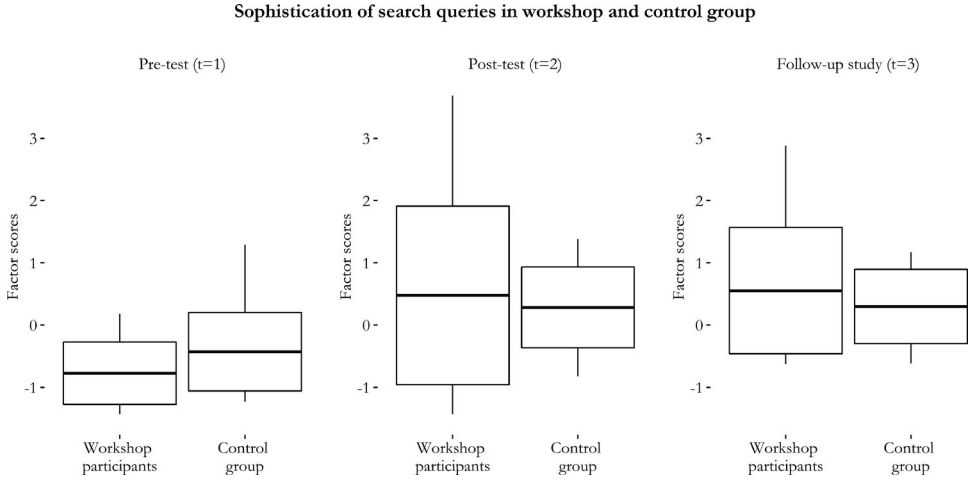

Figure 4. Impact of workshop participation on sophistication of search strategies.

United Kingdom might have prompted more students to use English search terms, regardless of group membership. Still, almost all students used simple search strategies and only 6% of workshop participants made use of advanced search options.

We validate these descriptive findings using panel regressions, as shown in Table 2. The first two columns report determinants of usage of academic databases, while in models 3 and 4 the dependent variable is the degree of sophistication of search strategies. As predictors, we include dummy variables for group membership and task number as well as interactions between group and task number. Models 2 and 4 also include three individual-level control variables. Workshop participants (here labeled the 'treatment group') do not differ significantly from the control group in all models, which shows that the randomization was effective in creating equal groups with regard to search behavior. The important coefficient is the interaction between treatment group and $t = 2$. The significant effect for this interaction in the first two models confirms that after the workshop, participants used academic databases more frequently compared with the control group. This difference vanishes at the follow-up study ($t = 3$), after the control group had also participated in the workshop. Interestingly, we find that current grade point average is negatively associated with academic search engine usage. This could indicate that higher-achieving students are more reluctant to change their search habits, but this finding needs further investigation. For the degree of sophistication of search queries, no significant effect from workshop participation becomes evident.

An interim conclusion can thus be that the workshop effectively raised awareness of scholarly journal articles and workshop participants significantly more often used academic databases. On the other hand, most students did not change their habits regarding

Table 2. Predictors of students' search strategies: panel regressions.

	Dependent variable:			
	Usage of academic databases		Sophistication of search queries	
	(1)	(2)	(3)	(4)
Intercept	−.749*	.262	−1.119**	−.648
	(.419)	(.784)	(.454)	(.799)
Treatment group	−.147	−.058	−.346	−.217
	(.270)	(.296)	(.292)	(.324)
Study part: t2	3.059***	3.059***	1.790***	1.790***
	(.405)	(.414)	(.563)	(.579)
Study part: t3	.366	.461	1.747**	1.928***
	(.526)	(.535)	(.713)	(.731)
Treatment group*t2	1.512***	1.512***	.539	.539
	(.260)	(.266)	(.362)	(.372)
Treatment group*t3	−.371	−.308	.520	.619
	(.330)	(.336)	(.448)	(.460)
Major: Sociology		.512**		−.110
		(.231)		(.226)
Semesters studied		.054		.103
		(.115)		(.112)
Current grade point average		−.655**		−.417
		(.261)		(.255)
Observations	91	91	91	91
Adjusted R^2	.516	.515	.291	.301

Notes: Multi-level (random intercept) models. Dependent variable is measured as factor scores with mean = 0 and standard deviation = 1. Cells show unstandardized coefficients with standard errors in parentheses.
*$p < .1$, **$p < .05$, ***$p < .01$.

how they searched within these databases. Most notably, advanced search options were only rarely selected, and only a minority used a language other than their native German in their search terms.

Results (II): impact on quality of cited references

A common assumption in research on information literacy is that more sophisticated search queries result in more relevant search results. Indeed, one might argue that the whole point of teaching information literacy is that we hope this improves the outcomes of information-seeking exercises. To test this, we analyze the impact of the workshop on the academic reputation of the references cited by the participants and their thematic relevance to the research question, as evaluated by our three raters.

Figure 5 shows the impact of the workshop on the ratings received for academic reputation of cited references. As the graph shows, after the workshop, an improvement can be noted for the experimental participants over the control group. In the follow-up study, both groups scored equally again. The workshop thus appears to have caused an increase in the citation of sources which are regarded as reliable in the scientific community, and this effect lasted at least until the follow-up study.

Finally, we are interested in knowing whether workshop participants find and cite sources that are thematically more relevant to the respective research question as compared with the control group. It should be noted that the workshop itself had no pedagogic component dealing with how to evaluate and select literature based on substantial relevance of its content. Teaching these skills is arguably not feasible within a single-day workshop since they are probably part of a general ability to judge relevant from irrelevant content which develops over the years in higher education. However, we are nevertheless interested if there exists a 'spill-over effect' such that those who have learned how to properly search for information also arrive at more substantially relevant sources.

Figure 6 shows the average ratings for the thematic relevance of the citations our participants submitted. As the graphs show, no significant differences between experimental

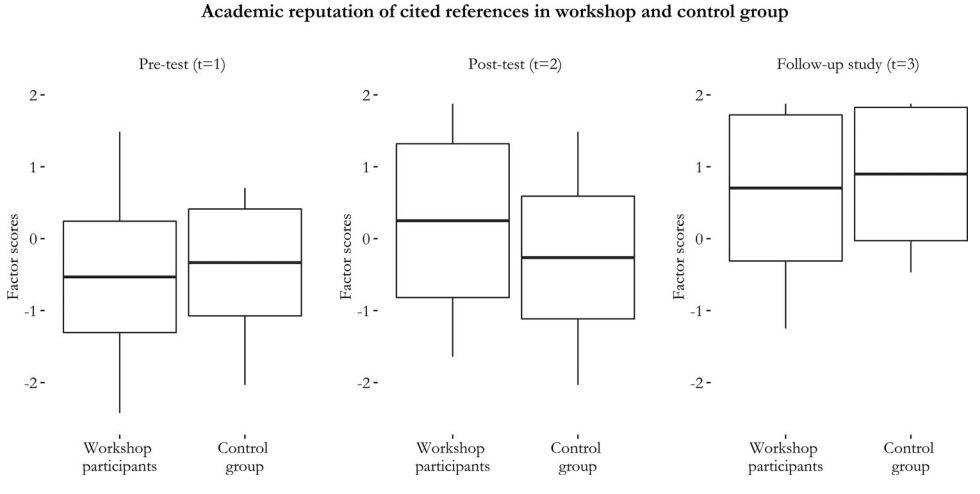

Figure 5. Impact of workshop participation on academic reputation of cited references.

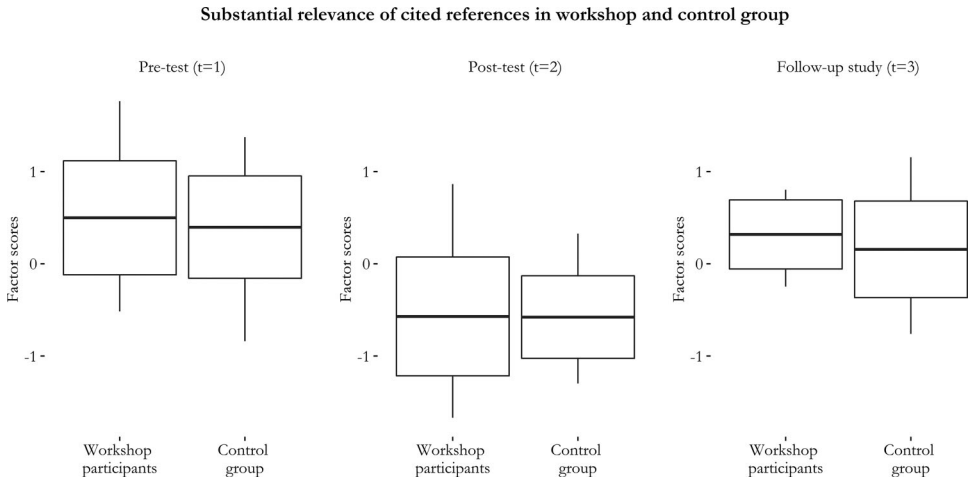

Figure 6. Impact of workshop participation on substantial relevance of cited references.

group and control group can be noted for all three search tasks. This means that after having participated in the workshop, students do not cite more substantially relevant sources compared with the control group.

We also noticed that students of both groups had severe problems finding appropriate sources for the second assignment (educational success of ethnic Indians in the United Kingdom). Many articles were cited which dealt only with a fraction of the key words

Table 3. Predictors of academic reputation and substantial relevance of cited references from the literature research: panel regressions.

	Dependent variable:			
	Reputation of sources		Relevance of sources	
	(1)	(2)	(3)	(4)
Intercept	−.730	.551	.600**	1.126**
	(.464)	(.748)	(.288)	(.505)
Treatment group	−.200	−.431	.102	.030
	(.298)	(.312)	(.185)	(.207)
Study part: t2	1.495**	1.495**	−1.163***	−1.163***
	(.587)	(.590)	(.376)	(.379)
Study part: t3	1.267*	1.250*	−.086	−.071
	(.742)	(.738)	(.472)	(.477)
Treatment group*t2	.713*	.713*	−.094	−.094
	(.378)	(.380)	(.242)	(.244)
Treatment group*t3	.038	.057	.086	.106
	(.466)	(.465)	(.296)	(.300)
Major: Sociology		.650***		.202
		(.208)		(.142)
Semesters studied		−.191*		−.059
		(.103)		(.070)
Current grade point average		−.283		−.148
		(.234)		(.160)
Observations	91	91	91	91
Adjusted R^2	.256	.323	.445	.443

Notes: Multi-level (random intercept) models. Dependent variable is measured as factor scores with mean = 0 and standard deviation = 1. Cells show unstandardized coefficients with standard errors in parentheses.
*$p < .1$, **$p < .05$, ***$p < .01$.

from the assignment, e.g. a report on Indian migration to Germany. It might be that the reluctance to use advanced search options and English search terms among both groups is responsible for the low thematic relevance, but this assumption cannot be validated with the data at hand. Note that since both experimental and control group were given the same set of questions, the level differences in scores between the tasks should not affect the differences between experimental and control group which we are mainly interested in.

Again, we validate the findings from the descriptive analysis with panel regressions, shown in Table 3. We find a significant effect from workshop participation on the academic reputation of sources cited after the search assignment (see coefficient for treatment group * t2), but no effect on the relevance of sources. Students of sociology cited more articles from scientific journals compared with students of educational science, but again no effect was found on the substantial relevance of the content these papers dealt with.

Conclusions

There is a long-standing debate on the role of information literacy among university students in the digital age. A recurring finding in empirical studies is that undergraduate students make extensive use of the Internet to search for study-related information, but also that their search strategies are usually rather crude and do not include academic databases and advanced search options. In response to these deficits, we designed a workshop to improve digital information literacy among third-year students and combined it with an experimental study to test the workshop's effectiveness. We found that workshop participants significantly increased their usage of scholarly databases and, on the basis of their search, cited more articles published in academic journals. However, the level of sophistication of students' search queries remained rather low. Only a small minority made use of advanced search options, and only around one in three students followed the instruction to use international (e.g. English-language) search terms.

A possible interpretation of these findings is that students get along well with using simple searches in everyday life and therefore are reluctant to change these habits in college, even when explicitly told to do so. However, they are more open to replacing *Google* with a scholarly database or search engine as the primary tool to find literature online. This is also accompanied by an increasing attention to scientific journal articles and a decline in references to Internet resources of doubtful reliability.

A number of lessons for the practice of teaching can be derived from our findings. First, already a non-recurring one-day instruction can apparently be effective in influencing students' online information-seeking behavior, albeit not every aspect of it. This is an important insight because financial constraints as well as crammed curricula often do not allow for regular periodic instruction on information literacy. In particular, teaching students on the role of scholarly journals in academia and on how to locate journal articles using tools such as *Google Scholar*, *Web of Science*, and library catalogs appears to be fruitful. This is where we find our instructions to be most effective. By contrast, the degree of sophistication as well as the language used to construct search queries may be more difficult to influence in a short period of time and thus probably need more extensive treatment. Integrating more English- or other foreign-language readings into curricula early on might increase the usage of international search terms and hence the scope of students' information searches.

Regarding the timing of a one-off course, it presumably helped that our students were about to start writing their final bachelor's thesis, so that their intrinsic motivation was likely to be higher than before. Obviously, introductory courses in information literacy are usually held during the first year of a study course, but a refresher course in such a critical stage, when the demand for these skills is particularly high, can be helpful. Information literacy skills taught to first-year students might rarely be put soon into practice since many students rely on textbooks and materials supplied by the lecturers in early stages of their studies. This means that many students may revert to their common habits of simple *Google* searches after initial instructions. Once the need for more sophisticated approaches is recognized, courses on information literacy should include practical exercises with search tasks on real-world topics which students can relate to their academic subject. Therefore, mixing students from different disciplines might interfere with learning progress. Although we taught to students from two related disciplines in our study (sociology and educational science), framing the tasks in a way that they appeal to both groups proved to be a challenge.

Finally, some lessons can be drawn from our finding that workshop participants used more academic databases but apparently still failed to select more relevant resources at the end of their search process. First, this finding suggests that we should not assume that increasing information literacy will quasi automatically improve academic performance. Expertise on the topic at hand is required to evaluate sources and to distinguish between relevant and irrelevant content. This expertise can hardly be taught in a one-day course as it typically evolves over the years when studying a subject. Note also that out of several dimensions of information literacy that are usually distinguished, we limited the scope of our experiment to two central dimensions; therefore, other aspects (such as organizing or disseminating information) could not be examined within this setup. Second, looking at the participants' search logs, it appears that students use the library's database or *Google Scholar* the same way they use *Google*: They send short search queries and rarely go beyond the first page of search results or modify their queries. Many students might expect that an algorithm has already ranked search results by relevance so there is probably no need to review them themselves or apply advanced options. This reasoning might be adequate in everyday usage but obviously not when searching for scientific literature. We therefore suggest that future research pay more attention to the process of individual information selection and how it can be influenced by teaching.

Note

1. While such a short time limit may not be present in real-world applications, the experimental setting required a time constraint for practical reasons and to make the results comparable. We argue that the skills we intend to capture regarding search strategies – usage of academic databases and sophistication of search queries (e.g. using Boolean operators and foreign-language terms) – can already be detected in short assignments.

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Appendix

Table A1. Descriptive statistics.

Variable	N	Mean	Std. Dev.	Min	Max
Group	91	1.484	0.502	1	2
Part	91	1.813	0.759	1	3
Semesters studied	91	6.549	1.157	5	10
Current grade point average	91	2.186	0.447	1.400	3.700
Number of search engines consulted	87	2.563	1.097	1	5
Number of different search queries	87	4.816	2.931	1	14
Usage of advanced search options	84	0.020	0.081	0.000	0.500
Share of English-language queries	71	0.222	0.372	0.000	1.000
Usage of Google Scholar	91	0.549	0.500	0	1
Usage of JSTOR	91	0.176	0.383	0	1
Usage of library catalogs	91	0.571	0.498	0	1
Usage of Web of Science	91	0.121	0.328	0	1
Factor: Reputation of references	91	0.000	1.000	−2.424	1.878
Factor: Relevance of references	91	0.000	0.718	−1.668	1.762
Factor: Usage of academic databases	91	0.000	1.000	−0.907	2.586
Factor: Sophistication of search queries	91	0.000	1.000	−1.430	3.687