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RESEARCH ARTICLE

How Does Students' Knowledge About Information-Seeking Improve Their Behavior in Solving Information Problems?

Marioleni Parissi Vassilis Komis Gabriel Dumouchel Konstantinos Lavidas Stamatios Papadakis

Background/purpose – This study investigates how the teaching intervention and familiarity with the search topic enhance Greek students' behavior while solving information problems.

Materials/methods – Seven university students solved three information problems on the same search topic during an academic semester. Between the first and second information problems, a didactic intervention was implemented aimed at familiarizing the participant undergraduates with the information problem-solving process based on the Big 6 model of Eisenberg & Berkowitz (1990) and the use of essential online search tools. Qualitative data were collected via observation and the think-aloud protocol.

Results – The findings indicated that following the didactic intervention and familiarity with the search topic, the participants were able to realize a greater variety of actions in order to locate the required information.

Conclusion – The study's findings deepen the comprehension of how students' information behaviors evolve, and indicate suitable interventions that could help to support students in performing more effective Internet searches.

Keywords – Information problem, search engine, higher education, Big 6 model, teaching intervention.

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1. INTRODUCTION

In contemporary education, finding sources, evaluating their credibility, and using them effectively are essential to learning (Argelagós et al., 2022). Today, students of all ages seek digital information to complete their assignments and projects and to solve information problems. The term "information problems" refers to the different situations or tasks where a person is tasked with identifying information, to locate corresponding informational sources, to extract or organize relevant information from each source, and to synthesize information from various sources (Wopereis et al., 2008).

More specifically, in terms of higher education, Deja et al. (2021) noted that it is expected that students are able to manage working with ever-increasing amounts of data available on the Internet. *Research at the University of South Australia revealed that university students depend on the Internet to find information in order to accomplish academic and non-academic tasks. Overall, students mostly use general-purpose web search engines such as Google (Salehi et al., 2018).* Many researchers have highlighted the importance of information literacy skills for undergraduate students in the 21st century (Chobjai & Sanrattana, 2022; Hassani, 2015; Naik & Paidmini, 2014). However, Argelagós et al. (2022) noted the difficulties that both undergraduate and graduate students seem to experience in finding, analyzing, and processing information in order to fulfil their academic tasks. Students of all educational levels experience problems during the information-seeking process, resulting in their being unable to locate the information being sought (Zhou & Lam, 2019). It is worth mentioning that a lack of information skills can lead to significant inequalities between skilled people in today's society (Kaarakainen et al., 2018).

Given that numerous studies have revealed that university students experience difficulties in seeking information from the Internet, the emergence of information-seeking interventions has accelerated in helping to make this procedure more comprehensible and to emphasize its importance in today's complex information age. However, it is worth mentioning that during the past two decades, information research has primarily focused on investigating the effect that different factors can have on information problem solving (Anderson et al., 2001; Korobili et al., 2011; Makinde et al., 2019; Niu & Hemminger, 2012), and less on determining the influences from didactic interventions about seeking information (Bråten et al., 2011). Among the factors that can influence users' information-seeking behavior and search performance, their subject domain knowledge is considered essential in information seeking (Allen, 1991; Karimi et al., 2011). Allen (1991) noted that subject domain knowledge is the "knowledge that users have of the topic being searched or of the general subject area from which that topic is drawn" (p. 11). However, in research conducted by Joo and Lee (2011), it was shown that domain knowledge and system familiarity do not significantly influence search outputs after query reformulation. In this context, the current study aims to highlight the role of teaching information problem solving and students' familiarity with the search topic when they solve an information problem.

2. LITERATURE REVIEW

Studying students' information behavior has been of fundamental concern to educational researchers worldwide. A significant number of studies have been published on this subject in recent decades, as the Internet has become a primary source of information for various tasks (Hinostroza et al., 2018; Ibieta et al., 2019; Kanaki & Kalogiannakis, 2022; Makinde et al.,

2019; Niu & Hemminger, 2012; Papadakis, 2022; Yadav & Kumar, 2021). *For example, numerous* studies have focused primarily on the effect that different factors can have on information behavior (e.g., Desta et al., 2019; Esfahani & Chang, 2012).

Many factors can adversely affect an individual's information-seeking behavior, such as their information needs, awareness of different sources available, as well as knowledge of different skills, etc. (Yadav & Kumar, 2021). *Desta et al. (2019) showed* how inadequate facilities can affect postgraduate students' *information-seeking behavior at the University of South Africa*. More concretely, their study showed that a lack of ICT infrastructure, frequent interruptions in electricity supply, and outdated computer hardware were the primary factors influencing postgraduate students' electronic information-seeking behaviors. Moreover, Kaarakainen et al. (2018) revealed that education level and digital technology usage affects information skills. In a study by Anderson et al. (2001), it was reported that accessibility, task characteristics, information carrier characteristics, user characteristics, and user demography were all factors affecting users' information-seeking behaviors. In their research, Prabha et al. (2007) discussed which factors can negatively affect information-seeking behavior. The factors were the feelings of information users in obtaining sufficient information, their consulting of trusted sources, lack of time, the nature of the problem to be answered or question solved, the nature of the task at hand, and their task-domain knowledge. Context, the situation in which the information user is living or working, the search system engaged, and the motivation level of the information user and their information-seeking ability were all identified as factors that can negatively impact information-seeking behavior (Prabha et al., 2007).

While many researchers have examined the effect of various factors on the information-seeking behavior of higher education students, others have focused on the influence of didactic intervention. In research by Woopereis et al. (2015, 2016), it was revealed that undergraduate students received help from information literacy instruction. Lamont et al. (2020) conducted a multi-stage reflective case study of 279 first-year engineering students' information-seeking behavior in a mandatory engineering-communications course. Their findings suggested that structuring teaching and including a library intervention as part of the course can help facilitate valuable improvements in students' attention in evaluating the credibility of sources in their work on engineering projects. Tahmasebi et al. (2019) realized a semi-experimental study using a two-group, pretest–posttest design with a study sample of 60 medical students at the Isfahan University of Medical Science. Their results showed that the training positively influenced the information behavior of the experimental group.

Other studies in the literature have demonstrated the various problems and difficulties that university students can encounter whilst searching for information on the Internet. Investigations realized by Han (2018), Walraven et al. (2008), and *Wopereis et al. (2015)* indicated that adults, young aged students, as well as undergraduate students can experience difficulties in selecting appropriate search terms in query formulation when using an Internet search engine. Furthermore, Caviglia and Delfino (2016) highlighted that students need to be more competent in finding, evaluating, and processing online information. Kaarakainen et al. (2018), having explored the information skills and technology use of 3,159 Finnish students aged 12-22 years old, concluded that students' information skills were insufficient, especially in the task of creating an effective search phrase. Finally, in a review conducted by Rieh et al. (2016), it was outlined that young web users do not adequately evaluate search engine results pages, focusing only upon the first few search results returned.

In an era where a considerable number of studies on information literacy skills and their importance in the higher education university context have dominated the international literature, very few have focused on other aspects of information behavior in the context of Greek higher education. Parissis et al. (2010) revealed that undergraduate students from the Department of Early Childhood Education (DESECE) of the University of Patras have little knowledge of how to use search engines effectively whilst seeking specific information, and tend to use multiple keyword searches in order to locate the required information and make limited use of logical operators and other logical expressions. In another study, Korobili et al. (2011) reported the need to improve graduate students' information literacy skills. Their study investigated the information-seeking behaviors of philosophy and engineering graduate students at the Aristotle University of Thessaloniki. Their results showed that most participant graduate students had a low to medium level of information-seeking behavior. In a study published by Malliari et al. (2011), it was revealed that the information-seeking behaviors of graduate students at the University of Macedonia seemed to be influenced by their search experience, computer and web experience, perceived ability, and their frequency of use of e-sources, rather than by specific personal characteristics or attendance at library instruction programs.

Moreover, the results also revealed that most students need to use sophisticated techniques in order to retrieve the relevant information sought, and outlined that information literacy programs are an essential part of the educational process but that such programs should be informed by research that examines their impact in detail. In a recent study, Parissi et al. (2019) investigated university students' perception changes towards the use of web search engines after exposure to a teaching intervention centered on the information problem-solving process. Their study reported that 138 students from the DESECE of the University of Patras were surveyed regarding their perceived ease of use and usefulness of search engines, and their search engine self-efficacy before and after the course. Their results revealed a statistically significant improvement in ease of use and search engine usefulness, and also a high level of search engine self-efficacy. Similarly, a study of Greek university students by Lavidas et al. (2020) revealed perceived ease of use and perceived usefulness were significant determinants of students' behavioral intention to use Google Scholar.

Despite the importance of information literacy skills in higher education, much still needs to be investigated about various aspects of university students' information behavior. To date, no Greek study has investigated how information behavior evolves depending on various factors. Therefore, the current study aims to investigate the role of teaching intervention about seeking information and the student's familiarity with the search topic on the information behavior of undergraduate students in solving information problems. The research process used in the current study is based on the theoretical framework of Marchionini (1995). Thus, the current study aims to investigate undergraduate students' information-seeking behaviors while solving information problems by showing four of Marchionini's processes of finding information, and to investigate how these behaviors evolve concerning certain factors. According to Marchionini (1995), people who seek information in digital environments develop distinct behaviors (patterns) and employ various strategies, tactics, and moves at each stage of the information-seeking process. "Moves" are found at the lowest level of Marchionini's first categorization of individuals' information-seeking behavior, whereas "tactics" are a set of actions used to advance the search process, and

"strategies" are approaches followed to solve information problems and consist of a set of tactics.

Deepening our understanding of undergraduate students' information-seeking behavior will help enable instruction development to better support and enhance students' information problem-solving performance. Therefore, the current study aims to provide valuable insights for those managing information literacy instructions. The study is also expected to provide a worthwhile contribution to the existing literature on information behavior in higher education, both in general and also in the context of Greek universities.

Research Questions

The two research questions of the study are:

- Does teaching about information-seeking improve the information-seeking behaviors of undergraduate students?
- Does topic familiarity improve the information-seeking behavior of undergraduate students?

3. METHODOLOGY

Research design

A qualitative research strategy was opted in order to gain a broad, yet detailed understanding of how undergraduate students' information-seeking behavior evolves (Bryman, 2016). The framework employed qualitative data collected via verbal think-aloud protocols and observation over three academic semesters. These methods were used to study information seekers' search strategies and their navigational behaviors (Nielsen et al., 2002). Our observation method was based on screen capturing the participants' ongoing activities while they solved three information problems. With thinking-aloud protocols, the participants verbalized their thoughts and explanations as they performed the solving procedure. Recording of the actions and behaviors was realized using the TechSmith Morae Recorder software[1] during the experimental procedure. All verbal expressions were recorded through a web camera. Part of the research design involved a teaching intervention designed to familiarize undergraduate students with the information problem-solving process, which was implemented following the first information problem and prior to the second and third.

Participants and setting

The research was conducted in the context of a compulsory ICT in Education course given at the University of Patras, Greece. Seven female undergraduate students at the university, aged 19-20 years old, were randomly selected from the course attendees, which is held during the second semester of the second-year for DESECE students. Prior to conducting the study, the researchers received approval from both the participants and the Research Ethics Board designated by the University of Patras (Approval code/date: 46191/June 20, 2022). In addition, the participant students were informed by their teachers prior to the data collection starting and given the opportunity to withdraw from the study at any point without penalty.

[1] https://www.spectratech.gr/en/product/48329/TechSmith_Morae?path=00

Information Problems

Three worksheets were prepared that incorporated information problems of the same difficulty level. The difficulty level was deliberately held as constant between the three problems in order to compare the effect of the didactic intervention and the students' familiarity with a specific topic on their information-seeking behaviors. The developed information problems each required that the students performed searches on the Internet for information related to basic concepts taught as part of the ICT in Education course and, more specifically, information deemed to be of relevance to how constructivism and behaviorism learning theories contribute to the design and development of educational software.

Thus, a single type of information problem was used for all three experimental conditions in order that the same characteristics would exist regarding the structure, number, and type of information sought. The interpretive task was chosen to develop the information problems of the study (Kim, 2006). Table 1 details the three problems and the laboratory lessons in which the students attempted to solve them.

Table 1. Information problems and corresponding laboratory lessons

Worksheet	Lab. Lesson	Information problem
1st worksheet	1st lesson	Information seeking on the Internet for webpages that offer free educational software downloads for use in preschool education.
2nd worksheet	6th lesson	Information seeking on the Internet for free educational software downloads. The software must be based on the behavioral theory of learning, appropriate for use in preschool education, and may concern any subject apart from mathematics.
3rd worksheet	9th lesson	Information seeking on the Internet for free educational software downloads. The software must be based on the constructivist learning theory and appropriate for use in preschool education.

Research Procedure

The research was conducted within a compulsory ICT in Education course, which aims to familiarize students with the main approaches to integrating ICT into the educational process and the main models of ICT introduction in education (Lavidas et al., 2013). The course consists of a weekly 3-hour lecture given by an instructor for 13 consecutive weeks, while two teaching assistants organize the compulsory laboratory component of the course (13 laboratory lessons of 2 hours). At the time of the study, a total of 138 undergraduates had enrolled to the course, with attendance to the laboratory sessions mandatory in order to be eligible for a pass. Seven students were randomly selected to participate in the study. The selected participants followed the same research procedure as the rest of the class whilst using the think-aloud protocol and recording their actions on their computer.

The students completed the three information problem worksheets at three appointed time points during the semester which were aimed to help them understand the basic

concepts of ICT. More concretely, the three phases of the research procedure were as follows:

a) During the first compulsory laboratory lesson of the course, the seven participants completed the first worksheet problem. This phase aimed to determine their prior information-seeking behaviors for an unfamiliar search topic.

b) A didactic intervention was implemented during the second laboratory lesson, which concerned the process of information seeking using the Internet and the use of essential Internet search tools in this process (search engines, subject directories, and typing a specific website URL into a web browser).

c) The second and third worksheet problems were completed in the sixth and ninth laboratory lessons. The goal of these two phases was to establish their future information-seeking behaviors.

Teaching Intervention

The teaching intervention was developed in order to instruct undergraduate students in how to solve information problems more efficiently. The instructional design of the intervention was based on the Big 6 model of Eisenberg and Berkowitz (1990). The intervention was divided into two parts. The first part focused on clarifying the concept of information problems, together with the six main steps and subcategories of the problem-solving (IPS) process (Eisenberg & Berkowitz, 1990). The second part described essential web search tools (directories, portals, search engines) and information-searching strategies applicable to the Internet. More specifically, during the first part of the intervention, after referring to the definition of the term "information problems," the students were tasked with thinking of information problem examples they encountered in daily life. The second part covered ways in which to approach and solve information problems involving relevant cognitive conflicts so as to help the students develop more in-depth Internet skills to solve similar problems. After a detailed presentation of the Big 6 model and its stages by the teaching assistants, the students in each laboratory group (18 to 20 students in each session) were tasked with collaboratively solving several simple to more complex everyday life information problems on a step-by-step basis.

Data Analysis

The study aimed to identify the individual moves, tactics, and strategies employed by the students to solve the three set information problems; from recognizing the need to search for information to using the retrieved information. In the study, we aimed to find invoke three of Marchionini's (1995) four process types for locating information in a digital environment in order to solve an information problem. Then, as part of the analysis, the participant undergraduate students' repetitive patterns of behavior would become evident, which constitute Marchionini's fourth behavioral type in the overall process of solving information problems. Analytically the four types of this process are as follows:

- *Moves:* Finely-grained actions that manifest as discrete behavioral actions.
- *Tactics:* Discrete intelligent choices or prompts that manifest as behavioral actions during an information-seeking session.

- *Strategies:* Sets of orders consciously selected, applied, and monitored in order to solve an information problem. Strategies are the approach that an information seeker takes to a problem.
- *Patterns:* Behaviors that can be discerned over time and across different information problems and searches.

First, video recordings of the seven participant students' solving procedures for the three information problems were observed. Specifically, it was the participants' verbal behaviors during these procedures that were recorded. Figures 1 and 2 present two snapshots captured from the Morae Manager analysis environment. Figure 1 presents one participant's attempt to locate the answer/information to the first information problem, whilst Figure 2's snapshot is of the video on a smaller screen. The lower box in Figure 2 shows the analysis details based on display criteria selected by the researcher at each set time point of the video.

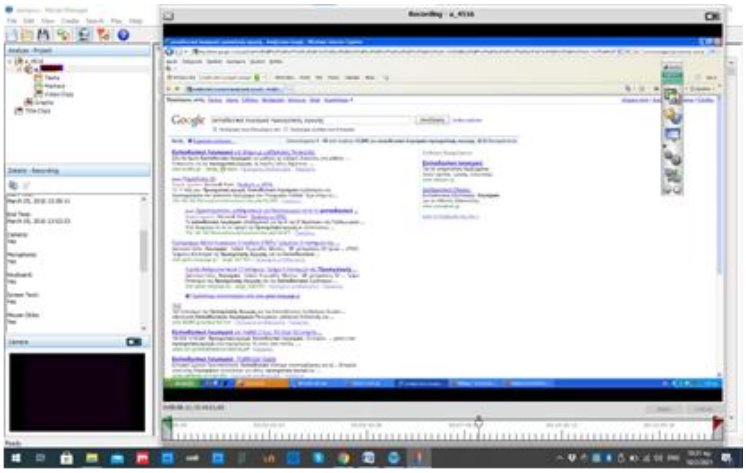


Figure 1. Snapshot 1 from the Morae Manager environment viewer

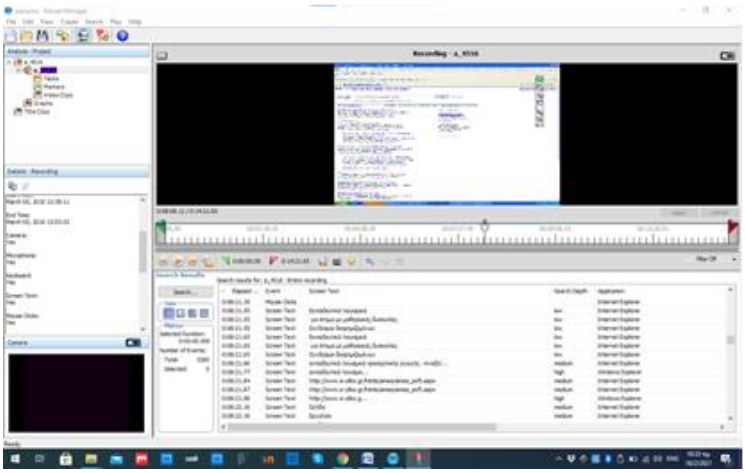


Figure 2. Snapshot 2 from the Morae Manager environment viewer

Then, using the output data from the Morae Manager analysis software for each of the seven participants, an .xls file was created for each of the three information problems, in which all the actions and verbal responses were manually recorded at the exact moment they occurred during the solving process. Content analysis and coding were then applied (Bryman, 2016) based on the theoretical constructions of Marchionini's (1995) information retrieval processes. In total, 44 codes were initially identified and grouped into three behavioral levels:

moves, tactics, and strategies. The coding of the data was conducted independently by two coders. The degree of agreement between the two coders was quantified according to Cohen's kappa, a coefficient that measures the degree of agreement when items are coded by two coders. Where the coefficient exceeds .7, the intercoder reliability is considered to be very satisfactory (Bryman, 2016), which was the case in the current study as the degree of agreement varied from .7 to .9. The results of this analysis are described in the following section according to the three levels of categorization applied to the participants' information-seeking behaviors.

4. RESULTS

Through investigation of the information behaviors developed by the seven participants while solving their three tasked information problems, it was seen that the students each had a variety of moves, tactics, and strategies, which they applied whilst searching and locating the information they needed to answer the three information problems. The results of the analysis added new categories of moves, tactics, and strategies to Marchionini's existing classes (Marchionini, 1995). The emergence of new examples in the first categorization of information-seeking behaviors may be partly due to the nature of the information problems applied in the current study.

Moves

For practical reasons, all seven of the participants were asked to use only the Internet Explorer browser in the study. Video analysis revealed that all ~~seven~~ participants searched for the information they needed using the Google search engine, whilst one participant used the default Internet Explorer search engine instead (having opened the specific browser and started typing a query in the search field, assuming they were using the Google search engine).

The rest of the participants visited Google's homepage by opening the Internet Explorer browser, typing the URL address of the search engine in the address bar, and then pressing "Enter". There were several cases where the Google URL address was displayed in the browser's history when the participants started typing the URL in the Internet Explorer address bar. They then automatically selected the Google URL (http://google.com/) with the mouse pointer from the history drop-down menu. As the video analysis continued, it was revealed that the drop-down list of related words provided when beginning to type in Google's search box was also frequently used to formulate the search queries. The participants started typing the queries in the search box they wanted to track and then either clicked on the Google Search button to execute the search or, when typing in the search box, they clicked on one of the suggestions that appeared in the drop-down list.

Moreover, after executing their searches using Google, several of the participants typed the URL of a specific website (e.g., an educational website URL) into the browser, which was seen among the search results. The participants then used the scroll bar to move the window contents up and down so as to examine the search results. During their examination of the website content, it was seen that the students used the mouse pointer to scan and read the information and to select hyperlinks.

The participants often pressed the "Back" button in order to find the information they needed from the previously viewed page. Furthermore, they used the right mouse click option to copy and paste content from the viewed webpage to their response worksheet.

Regarding the query submission in the Google search engine, the use of the feature "Did you mean" or the option "Results for....without quotes" was observed being used, which provides alternative suggestions when misspelt words appear or when users perform a Google search using the feature results without quotes.

Additionally, other Windows support tools were employed by the participants to download and evaluate software or another file during the information retrievals process, e.g., using the "Zoom", "Close", "Stop", "Download," and "Save" buttons. The various moves realized by the participants while solving their three information problems are presented in Table 2.

Tactics

The use of tactics helped the participants to locate the information they sought. Examination of the material and information (T1: Review material) available on websites enabled the university students to assess whether the specific information was appropriate to solve the problem they had been tasked with. The participants reviewed the content of webpages by selecting hyperlinks, which led them to view specific information that they could then evaluate. The participants then opted to reformulate the query (T2: Modify query) by changing or adding keywords to their search.

When the reformulated queries did not return the desired search results, the participants opted to change the information source (T3: Switching Resources) and consult the course material posted on Moodle, which is a reference system used for the information search problems in the current study. The information source was changed to help select new search terms for the query reformulation.

The cases were limited where the participants chose to use specific information based on the information they obtained from the search engine results. After examining the displayed search results, some of the students decided to visit a specific webpage by typing its URL into the browser address bar in order to access a website previously identified from their Google search results. The tactics used by the participants while solving the three information problems are presented in Table 3.

Strategies

The participants employed multiple strategies to solve their three tasked information problems. At the beginning of the problem-solving process, after having read the problem statement and devoting (or not) time to understanding it, the students made one of the following choices: (a) answer the problem directly as they considered the need to perform an Internet search unnecessary; (b) open the Internet Explorer browser and then either use the Google search engine website or the browser's default search engine; (c) type the URL of a specific website to the browser's address bar; or, (d) visit the lesson material posted on Moodle, either to obtain a prepared answer to the problem or to receive support for selecting appropriate keywords for the query formulation.

Answers given without first analyzing the information retrieved from the Internet were only provided when the students were attempting to solve the first information problem. After reading the problem statement, the students responded that they would seek help/advice from a human resource (i.e., colleague with related abilities and experience or an electronics store) to supply the required educational software. More particularly, the participants used a browser to visit a specific website which they believed would provide

them with the information they needed or used a search tool to provide links to webpages and information. For example, regarding the strategy of selecting an information source (S1: Choosing information resources), subject two typed http://www.ypepth.gr/ in the address bar of Internet Explorer in order *to be transferred to the* official website of the Greek Ministry of Education, and thereby attempting to locate the correct answer to solve the second information problem.

The strategy of using previously acquired information (S2: Use of previously acquired webpage information to promote search progress) meant that the participants had used information on a webpage that they had found on another webpage or an alternative search tool. During the information search using the Google search engine, one of the website visited was an educational portal (http://e-yliko.gr). After having failed twice at search attempts using the search engine, one of the participant students had returned to the Internet Explorer browser and had typed "e-yliko" to the address bar.

The participants employed different strategies to locate information using search engines, which included the use of keywords with or without logical operators. The analysis showed that use of a query formulation with provided keywords was a strategy (S5: Keyword search, initial – provided keywords) applied at the beginning of the search engine process. If the subject was unable to find the information they sought, they submitted a more specific or general query without logical operators. Moreover, the video analysis revealed that the participants tended to switch search strategies during their search sessions.

Other strategies applied during the participants' searches involved making decisions or choices concerning the information that they were currently processing; a strategy (S13: Specialization of a decision) which guided their search sessions. In addition, it was observed that the participants verified the information they found or had perceived after reading the problem statement so as to confirm their correct understanding of the problem. The strategies employed by the study participants in solving the three information problems are presented in Table 4.

Patterns

Specific patterns emerged through investigating the strategies, tactics, and moves used by the participant university students during their search processes employed to solve the three information problems they were assigned. As follows, the results concerning the patterns of information behaviors identified from the three experimental procedures are presented in which the subjects each participated.

Regarding the first information problem, the analysis showed that all seven of the participants read the problem statement and thus recognized the need to find information. None of the subjects devoted time to the definition of the problem. More specifically, after reading the first problem statement, almost all the study subjects, and without seemingly a second thought, were able to directly answer the problem in terms of the type of sources that they would use, other than the Internet, to find the information needed (e.g., electronic shops, colleagues) or conducted searches using simple terms through an Internet search engine. Moreover, it is worth noting that all seven students used the Google search engine to find the requested information while solving all three information problems. Participants who needed help understanding the type of information they were required to locate and retrieve used keywords provided in the problem statement to formulate their search query. More specifically, the video analysis showed that after having read the first problem statement, the

subjects did not understand the meaning of the word "software" and the kind of information they needed to find. For example, some of the first queries they entered in the search engine were "educational software," "educational software for computers," and "educational software supply." In these cases, where the searches were performed without having really understood what they were looking for, they opted to conduct one search after another, but were unable to evaluate the information returned. For example, during examination of the search results, one participant chose to open and examine a website which contained free software for preschool-aged children. After noticing it, he notably said: "Should I close it? This is not the one!" As a result, some of the students who had not readily understood the problem, and at the same time had some familiarity with the search topic, experienced some difficulties during the query formulation. Therefore, most participants were unable to provide a fully correct answer to the first information problem, or to even provide an answer at all.

Regarding the procedures realized to solve the second and third problems, most of the participants devoted more time or less time to their understanding after reading the problem statements. They then executed a search engine search using more general terms or exact words/phrases of those contained in the problem statement to formulate the query. After checking some of the returned search results, they rephrased the search query by changing or adding a term. Some of the participants needed more attempts to refine their queries until they located the information required to answer the problem. However, several of the participants referred to the course material in Moodle whilst working on the first page of the search engine in order to help them select the proper keywords. Some of the subjects answered the second and third problems correctly after using more specific search terms or through evaluating the returned information.

It is worth noting that by observing the solving processes applied during the second and third problems, it emerged that some of the participants switched between informational sources (search engine and typing specific website URL, e.g., http://www.ypepth.gr/). During the searches, some of the participants returned to the problem statement to check their comprehension.

Finally, during the search sessions, the participants exhibited the expected behaviors whilst solving the information problems. Several of the students initially found a selection of information sources they could use, and scrolled up and down to decide on the suitability of the information. Verifying the information led them to realize one of the following actions: a) click on a hyperlink; b) return to the information source; or, c) change the information source to find another webpage to locate the required information. The behavior presented here was realized recurringly until the respective activity was considered completed.

Moves, tactics, and strategies used while solving each information problem

As previously mentioned, the primary purpose of the research was to investigate a) the impact of a didactic intervention on an the information search using the Internet and the use of essential online tools, and b) how the students' familiarity with the search topic affected the behavior they developed when trying to solve an information problem.

In order to examine this, a comparison was performed of the analysis results based on the moves, tactics, and strategies employed whilst solving each problem. Therefore, it was deemed of interest to investigate whether the information behavior of the subjects changed in solving the second and third problems compared to the first, which preceded the didactic

intervention and during which the subjects had no knowledge or familiarity with the search object.

The following tables present the results related to the participants' solving of the three problems according to the moves (see Table 2), tactics (see Table 3), and strategies (see Table 4) employed.

Table 2. Problem-solving moves employed by participants

Move		Pre-intervention Problem 1	Post-intervention Problem 2	Post-intervention Problem 3
M1.	Use of scroll bar	✔	✔	✔
M2.	Click "Return"	✔	✔	✔
M3.	Click "Minimize/Maximize"	✔	✔	✔
M4.	Type a website URL in a browser	✔	✔	✔
M5.	Use of the mouse pointer	✔	✔	✔
M6.	Click on a hyperlink	✔	✔	✔
M7.	Use of drop-down menus	✔	✔	✔
M8.	Use of right mouse click		✔	✔
M9.	Click the [x]/ "Close" button	✔	✔	✔
M10.	Click "Cancel"		✔	✔
M11.	click "Open" to open a file	✔	✔	✔
M12.	Click "+" button to display more options		✔	✔
M13.	Click "Run/Execute"	✔	✔	✔
M14.	Click "Ok" when confirmation message displayed.		✔	
M15.	Click "Download" to download a file or software or click the download link	✔	✔	✔
M16.	Click "Save" to save a program	✔	✔	
M17.	Click "Exit" button on a program window		✔	✔
M18.	Click "Enter" to run browser application or execute a search	✔	✔	✔
M19.	Click "Google search" to display Google search results	✔		✔
M20.	Click on "Search pages in Greece."	✔		
M21.	Click on "Did you mean Google feature?"	✔	✔	✔

Table 3. Problem-solving tactics employed by participants

Tactic		Pre-intervention Problem 1	Post-intervention Problem 2	Post-intervention Problem 3
T1.	Review material	✔	✔	✔
T2.	Modify query	✔	✔	✔
T3.	Switch resource		✔	✔
T4.	Copy information from one source and paste to another		✔	✔

Table 4. Problem-solving strategies employed by participants

	Strategy	Pre-intervention Problem 1	Post-intervention Problem 2	Problem 3
S1.	Choosing information resources	✔	✔	✔
S2.	Use of previously acquired webpage information to promote search progress	✔	✔	✔
S3.	Keyword search, initial – broad/ simple terms	✔	✔	✔
S4.	Keyword search, initial – specific keywords	✔		✔
S5.	Keyword search, initial – provided keywords	✔		
S6.	Boolean search, initial – broad query		✔	
S7.	Boolean search, initial – specific query		✔	✔
S8.	Keyword search, subsequent –broad/simple terms		✔	✔
S9.	Keyword search, subsequent – specific keywords	✔	✔	✔
S10.	Boolean / keyword search, subsequent – broad terms		✔	✔
S11.	Boolean / keyword search, subsequent – specific terms		✔	✔
S12.	Keyword search – similar terms		✔	
S13.	Specialization of a decision	✔	✔	✔
S14.	Verification of information	✔	✔	✔
S15.	Keyword search, initial – irrelevant keywords	✔		

According to the results presented in Tables 2-4, the subjects used a more significant number of moves, tactics, and strategies during the second and third problem-solving processes than for the first problem. At this point, the analysis reveals that the participants performed several different actions in order to locate the information sought following the didactic intervention and their familiarization with the search object.

More specifically, Table 2 shows that the students used move 8 (M8: Use of right mouse click) to copy/paste information to solve the second and third problems, but not whilst solving the first problem, as all seven subjects answered the latter problems more generally than in their first worksheet. Their answers referred to hypothetical solutions, such as communicating with a colleague, visiting a technology store, searching the Internet and, more specifically, using the Google search engine to find the answer. For this reason, whilst two of the seven subjects correctly found free software when solving the first problem, they did not record them on their worksheet. However, answers that included webpage URLs with educational software were recorded on all worksheets of the second and third information problems, bar one. After several failed attempts, the subjects noted that they were unable to find the information they were tasked with locating. All of the subjects used the copy-paste function to record the webpage URLs needed to solve the problem. The use of move M8 in solving the second and third problems was the main difference seen in the moves employed between the solving process before and after the didactical intervention. The other moves used concerned examining the information and downloading and testing software, a prerequisite to realizing the correct answer. As the participants mentioned, when solving the

last two information problems, the realization of more and different alternatives was due to having been taught about information problem solving. They stated feeling more capable and confident in finding the information needed, and were sure they could locate it using the Internet through several actions similar to as they had solved information problem examples during the intervention. This underlines the impact of the intervention on the participants' information behavior, having developed the means to solve information problems using the Internet. The conclusion is that the students' familiarity with the search topic contributed to their successful solving of the problem, or at least their capability of writing down an answer (containing a software website URL), which is supported by their having sufficiently understood what was needed for the solution.

Regarding the tactics used before and after the didactic intervention and the students' acquisition of some familiarity with the search object, they were notable in the solving of the second and third problems, with two new tactics used in contrast to the first problem. For example, in order to find the information required to solve the second and third problems, the participants used tactic 3 (T3: Switch resource), referring to their switching of information resources when unable to locate the necessary information from one source, and tactic 4 (T4: Copy information from one source and paste to another) in order to locate the answer. The subjects would switch from one information source to another (T3: Switch resource) when unable to locate the required information, and also copied information from one source to use in another (T4: Copy information from one source and paste to another) to solve the problem. It is worth noting that some of the subjects used information found from one information source to use in another when solving the second and third problems. Observation of all three problem-solving procedures revealed that during the last two experimental procedures, which followed the didactic intervention and during which they were now familiar with the search object, the participants demonstrated their ease with using different information sources according to the information returned from each search.

Regarding the answer to the first information problem, only two of the seven subjects were able to find the information requested. All of the subjects noted being able to turn to alternative information sources other than the Internet. To achieve the goal of the first problem, the two subjects used only one search engine, but to answer the second and third problems, the participants used a search engine, typed a URL of a specific website in the address bar of a web browser, visited the course material to get direction for their subsequent actions, and reviewed their initial strategies which had not seemed very effective. Analysis of the last two information problem-solving procedures showed that some of the subjects gathered information from the content course on the Moodle website, and then refocused their information searches. In addition, analysis of the procedures developed by the participants during the last two experimental procedures showed that where they chose to visit a specific website and not use a search engine, they mainly turned to educational portals or websites of well-known, reputable organizations.

From this, the influence of two factors contributed to the subjects' proficiency in using different tactics during their Internet searches. It was observed that the students switched sources depending on the information accessibility and whether they were satisfied with the information they found. Also, they could exploit information found in one source for use in another.

Finally, on the strategies used to solve the three information problems, verbal protocol analysis indicated that the students' familiarity with the search object affected the strategies

they used in formulating and reformulating queries to solve the second and third problems. Table 4 shows that while solving the first problem, strategy 5 (S5: Keyword search, initial – provided keywords) was used to formulate queries containing words and terms found in the problem statement. According to Table 4, the participants may have used this strategy to solve the second and third problems. The analysis results, on the other hand, proved that strategy 4 (S4: Keyword search, initial – specific keywords) was used, which concerns the submission of an initial search engine query containing more specific keywords than those mentioned in the problem statement. The participants then tried to recall the names of specific software they had learned during their course, which they used in formulating and reformulating suitable search queries. Analysis of the observation and verbal protocols showed that the subjects preferred to use words provided in the problem statement or found it challenging to think of alternative keywords that could yield accurate and relevant search results. During the solving of the second and third problems, the use of strategy 10 (S10: Boolean / keyword search, subsequent – broad terms) and strategy 11 (S11: Boolean / keyword search, subsequent – specific terms) were observed in addition to others which involved keywords used along with logic operators or symbols, and which had not been used during attempts to solve the first problem. The didactic intervention that followed the first experimental process improved the participants' search engine use. Also, the subjects acquired knowledge from the didactic intervention which allowed them to make better use of the Google search engine functions since, as the video analysis showed, Google search was used in all except one case.

To conclude the presentation of the study's results, it is notable that strategy 15 (S15: Keyword search, initial – irrelevant keywords) was observed, which concerns the submission of an inappropriate search query for the first problem solution. This strategy was used due to the participants' need to better understand the problem, and their unfamiliarity with the search object as the first Google search included terms inappropriate to the search topic. However, the didactic intervention that followed the first experimental process improved the students' use of the Internet search engine functions. Following the didactic intervention, the subjects had gained the knowledge and skills which allowed them to make better use of the functions provided by the Google search engine.

5. DISCUSSION

The analysis showed that the participants used a more significant number of moves, tactics, and strategies when solving the second and third information problems compared to the first. Analysis of the observational data and the think-aloud protocol showed that following the didactic intervention and the participants' improved familiarity with the search topic, they were able to realize a greater variety of actions to locate the required information. This finding was as expected and not surprising since the participants needed to follow courses in information literacy and to gain familiarity with the search object (Lamont et al., 2020; Wen et al., 2006).

From analysis of the research results, the didactic intervention on information problem solving impacted how the last two information problems were approached by the students. The in-depth analysis revealed that all seven participants attempted to apply the stages of the Big 6 model to retrieve the information needed to solve the problems following the intervention. This conclusion is supported by the fact that during the first problem-solving experiment, the students tended to start their searches immediately after identifying the

information needed, without first trying to fully understand the information required and to organize their searches accordingly; a pattern also identified by Thompson (2013) and also Walraven et al. (2008). In addition, regarding the extraction and use of the information, the results showed that the students searched and located some information regardless of its reliability and used the copy-and-paste function (M8: Use of right mouse click) to incorporate the information into their answers. These results also aligned with those of Walraven et al. (2013).

In contrast, based on the research results obtained from the data analysis, it was revealed that during solving of the second and third problems, some of the participants tended to evaluate the information they found for decision-making. This conclusion is based on the students having used strategy 13 (S13: Specialization of a decision) and strategy 14 (S14: Verification of information) prior to recording their answers on the worksheet. The participants spent time processing the required information in order to successfully solve the last two problems. A more precise understanding of the relevant concepts related to the information search led to more accurate and more relevant search results. The research findings revealed that the participants performed fast searches during the first problem-solving procedure without adequate time spent on determining and finding what information was actually required.

In contrast, during the second and third problem-solving procedures, a more organized and methodical search process was seen after the participants had devoted time to rereading the problem statement and more appropriately processing the given problem. Finally, analysis of the verbal protocols showed that attempts were made by the participants to utilize logical operators during the formulation of search queries in order to solve the second and third problems. The students tried to recall how to use Boolean operators correctly in formulating their search queries, as they were shown during the intervention.

From the verbal statements recorded in the study, the participant students' familiarity with the search topic had a notably positive affect on their behavior in solving the given information problems. The study's results showed that while trying to solve the last two problems, the participants were seen to clarify concepts related to the statement of the problem or related to the search object prior to their executing a web search. In this way, the participants aimed to fill gaps in their prior knowledge specific to the search domain, which eventually enabled them to perform a more effective search. According to Jonassen (2000), familiarity with the search object and the activation of prior content schemata are key to an effective information problem-solving process. This was also confirmed in the current research, with the participants' recalling prior knowledge, memories, experiences and, in some cases, other valuable information sources. In addition, the students' familiarity with the search object enabled them to also use and evaluate other information sources. This conclusion may be said to be in line with the study of Brand-Gruwel et al. (2017), who concluded that domain ability impacts individuals' evaluation behavior during web searches, and the use of more sophisticated evaluation criteria to judge the reliability of sources, the information retrieved, and to select more reliable information when compared to domain novices.

Moreover, the use of more specific queries during the solving of the two last problems was attributed to the participants' increased familiarity with the search object. This conclusion agrees with results reported by Wildemuth (2004), who found that the most common pattern shown in students' search tactics was the specification of a concept,

followed by the addition of one or more concepts, gradually narrowing the retrieved set prior to its display. The participants in the current research also employed different strategies to formulate their search engine queries. The current study's findings revealed that most queries developed to solve the first problem were derived from words/terms to be found in the problem statement. In several cases, it was a conscious choice of the subjects to use the exact wording and phrases of the instructions due to their unfamiliarity with the search object. They seemed unable to reformulate the queries and refine the retrieval after displaying search results containing inappropriate content. This finding was reinforced by the subjects having formulated only one search engine query to answer the problem, even though they then realized that it was not helpful in solving the problem. During the second and third problem-solving process, the participants used broader terms and, in some cases, more specific terms that referred to the wording/terms of the problem statement compared to when formulating their first search query. Furthermore, analysis of the data showed that the students analyzed and consciously changed the search terms based on the returned results. Their ability to adapt to the information received back from each query and to alternate different strategies, i.e., the use of more specific or general terms, was confirmed by the participants having attempted up to seven query searches to answer the second problem and up to 10 submissions to answer the third problem.

In particular, understanding how search engines work and familiarity with the search object led the participants to formulate many different search queries containing various keywords and terms, and various combinations of these both with and without logical operators.

6. CONCLUSION

Based on the results reported in the current study, it is safe to conclude that university students' familiarity with the use of online search tools and the information problem-solving process, as well as their familiarity with the search object, seems to provide a sense of confidence and certainty that the requested answer can be retrieved.

From the research results, the teaching intervention based on the Big 6 model of Eisenberg and Berkowitz (1990) applied in the current study was shown to have positively affected the information behaviors that the participant students developed to solve the given information problems. The intervention was designed and organized for which the information problem-solving process required the Internet to be used effectively as a means to changing the information behaviors of students to solve information problems. It was also aimed at subjects who were unable of retrieving positive results when attempting to solve their first information problem. Hence, due to the confirmed improvement that the students showed in their use of search engines during the second and third information problem solving, as well as improvement in their overall information behavior, the benefits of the intervention are considered to be clear and effective.

However, it should be noted that the study's results cannot be generalized due to the small number of participants in the current research. Also, the disadvantages associated with "convenience sampling" mean that the sample's representativeness is questionable, and the generalizability of the results is not indicated due to the potential for bias in the study sample selection. Another limitation is that the current study used self-reporting, which runs the risk of socially desired responses and measurement bias (Lavidas et al., 2022). The findings of the current study should therefore be confirmed by more extensive sample surveys using both

quantitative and qualitative data. Hence, the current research should be repeated in various Greek universities and with a more representative sample. Another interesting question to be addressed by future research would be which information literacy skills do university students employ when collaborating in solving information problems.

7. SUGGESTIONS

The current study is considered to be one of only very few that have examined how information behavior evolves just two factors. In addition, the study can be said to be one of the few empirical studies undertaken in Greece. The study can be seen as a first step in better understanding information behavior in higher education students, and a worthy contribution to the existing literature, with more research needed specific to the field in Greece. However, Greek universities are attempting to develop instruction for information literacy skills and practices, and to integrate information skills into different formats (Kanakis, 2015). Recent research has concluded that university students should be taught information literacy skills and how to apply information problem-solving processes and to correctly use Internet search tools (Chobjai & Sanrattana, 2022; Hassani, 2015). In this sense, information literacy programs are considered essential to the educational process, but that the impact of such programs should also be informed by research that investigates their impact to an appropriate level of detail.

DECLARATIONS

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