Journal of Education and Learning; Vol. 5, No. 4; 2016
ISSN 1927-5250 E-ISSN 1927-5269
Published by Canadian Center of Science and Education

Key Information-Problem Solving Skills to Learn in Secondary Education: A Qualitative, Multi-Case Study

Esther Argelagós[1] & Manoli Pifarré[2]

[1] Department of Psychology, Universitat de Girona, Spain

[2] Department of Pedagogy and Psychology, Universitat de Lleida, Spain

Correspondence: Esther Argelagós, Department of Psychology, Universitat de Girona, Spain. Tel: 34-972-41-8192. E-mail: esther.argelagos@udg.edu

Received: April 25, 2016 Accepted: June 15, 2016 Online Published: July 13, 2016

doi:10.5539/jel.v5n4p1 URL: http://dx.doi.org/10.5539/jel.v5n4p1

Abstract

Internet has become one of the most important information sources for students' personal and academic life. In addition, the World Wide Web is receiving increased attention in education because of its potential to support new forms of learning. However, using the information from the net for learning requires the development of a set of abilities such as searching and tackling information from the Internet to find solutions of a problem—this set of abilities is called Information-Problem Solving (IPS) skills. The main objectives of this study are the following three: first, to provide a detailed description about how secondary students solve an IPS task; second, to identify key IPS skills, sub-skills, and regulation activities that have more incidence upon students' success to solve a problem using digital information on the Web; and third, to use this information to draw educative guidelines to design web-based instructional process and foster IPS in secondary classrooms. In-depth analyses of quantitative and qualitative data of a multi-case study allowed us to identify distinctive patterns and sequences of IPS skills used by students to solve a task. Furthermore, IPS skills (defining the problem and search for information), sub-skills (specifying search terms and selecting results from a SERP), and regulation activities (orientation on the task, monitoring, and testing) were identified as key skills which have more incidence in students to solve successfully IPS tasks to learn curricular contents at school.

Keywords: Information-Problem Solving (IPS), secondary education, web search, skills, regulation, performance

1. Introduction

The World Wide Web (WWW) has become one of the most important information sources in students' lives—secondary students use Internet widely for both school assignments and leisure. In addition, the WWW is receiving increased attention in education because of their potential to support new forms of learning. However, although learning in such dynamic learning environments is much more engaging, it is also much more challenging (Kuiper, Volman, & Terwel, 2009), and a set of skills as searching and tackling information from the Internet to solve problems are needed. This set of skills has been called Information-Problem Solving (IPS). Since the Internet is an extensive source of information, IPS skills and regulation activities are necessary in order to be successful in web-based learning (Brand-Gruwel, Wopereis, & Vermetten, 2005; Brand-Gruwel, Wopereis, & Walraven, 2009). Nevertheless, contemporary cognitive and educational research has shown that most students have difficulty in performing IPS skills and regulating their learning spontaneously (Badía & Becerril, 2015; Bannert & Reimann, 2011; Lazonder & Rouet, 2008; Walraven, Brand-Gruwel, & Boshuizen, 2008; Wood, 2009).

In this context, school is the institution that has the mission to provide citizens the necessary competences to become active and critical individuals in our Information Society. Competences related to the Information and Communication Technologies (ICT)—in particular, IPS processes—are needed to be developed by students, in order to enable students to better achieve learning goals using the WWW.

The main objectives of this study are, on the one hand, to provide a detailed description about how secondary students solve an IPS task, focusing on what IPS skills are used and how; and, on the other hand, to identify key

IPS skills, sub-skills, and regulation activities that have more incidence upon students' success in solving a problem using digital information on the Web.

1.1 Information-Problem Solving

According to the influential model proposed by Brand-Gruwel et al. (2005), it is highlighted that students need to master the following constituent skills in order to successfully solve a digital problem: defining the information problem, searching information on Internet, scanning information, processing information in a deeper way, and organizing and presenting information found. Furthermore, each skill can be subdivided in several sub-skills; for instance, defining the information problem involves the sub-skills reading the assignment and activating prior knowledge, and the skill searching information requires the sub-skills specifying search terms and selecting a result from a SERP.

In addition, to be successful in IPS, a set of regulation activities is also required during executing all those skills. Regulatory aspects—such as orientation, monitoring, steering, and evaluation—play an important role for the coordination of the IPS process (Raes, Schellens, De Wever, & Vanderhoven, 2012). Orientation includes the analysis of the task, and the task performance. Steering is aimed at making decisions about what activities have to be performed. Monitoring the process means that someone keeps *a finger on the pulse* (de Jong & Simmons, 1988) during the IPS process. Finally, testing is focused on evaluating process and task performance.

Studies on IPS have found that when attempting to solve IPS tasks and regulate the learning process, students predominantly use ineffective strategies (Azevedo, Cromley, & Seibert, 2004). In reference to the constituent skill *defining the problem*, previous research shows that secondary students have difficulties in the next four subskills: formulating questions (Wallace, Kupperman, Krajcik, & Soloway, 2000), activating prior knowledge, clarifying task requirements, and determining information needed (Walraven et al., 2008). Besides, most students start searching with no much reflection about the topic and the task and without outlining the search (Fidel et al., 1999, Ladbrook & Probert, 2011; Quintana, Zhang, &Krajcik, 2005).

In relation to the constituent skill *searching information*, secondary students have problems in selecting the appropriate search terms (Quintana et al., 2005; MaKinster, Beghetto, & Plucker, 2002; Van Deursen, Görzig, Van Delzen, Perik, & Stegeman, 2014; Wallace et al., 2000). Most of the times, students do a general search when they navigate the hypermedia environment rather than having specific searching objectives (Azevedo et al., 2004). Furthermore, students do not systematically judge the search results and therefore they have difficulties to consult reliable web sources which have been chosen attending to superficial cues as the title or the web site briefing (Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011).

To *scanning information*, teenagers also have problems in choosing between reputable and questionable sources, and selecting and assessing web site information (Lorenzen, 2002; Ladbrook & Probert, 2011; Van Deursen et al., 2014). As a result, the information selected may either come from a commercial or a scientific source (Fidel et al., 1999; Mason, Junyent, & Tornatora, 2014).

Concerning the constituent skill *processing information*, expert searchers spend more time on elaborating the content than novices (Brand-Gruwel et al., 2005). In the same line, Goldman (2011) found that the amount of time spent on a site was another key difference between novice and expert searchers. The former ones spent more time on reliable sites whereas the novice did not differentiate them.

On *organizing and presenting information*, students predominantly use ineffective strategies such as copying information from the hypermedia environment to their notes (Azevedo et al., 2004) and have the tendency to copy-and-paste the web information in order to solve the scholar tasks (Probert, 2009). In addition, Raes et al. (2012) also observed that students tend to reduce the whole task to find a straightforward answer on a particular web site instead of reading critically and thoroughly the web information.

As regards regulation activities, secondary students do not feel the need to plan a search or to check whether their planning is adequate (Fidel et al., 1999). However, they check their spelling in URLs and search terms, and are aware of the fact that spelling can influence the results of a search (Fidel et al., 1999). In addition, non-strategic searchers are less successful and do not regulate their search process (MaKinster et al., 2002). Brand-Gruwel et al. (2005) stated that experts monitor and steer their process more often than novices. According to Walraven et al. (2008), the quality of the IPS process is influenced by regulation—students become better searchers when they orientate, monitor, steer, and test during their IPS process.

To sum up, there are experimental evidences that support secondary-school students face serious challenges during the IPS process which hinders potential learning outcomes by using Internet in classroom activities.

1.2 Research Objectives

Previous studies have examined how students use the WWW to solve IPS tasks and their chellenges to do that (i.e., Britt & Aglinskas, 2002; Goldman, 2011; Lorenzen, 2002; Wallace et al., 2000). Some studies, for instance, have focused on how students assess the information or sources found on the Internet (i.e., Walraven, Brand-Gruwel, & Boshuizen, 2009). Others have described searching patterns of students while using the Web in Sciences (Makinster et al., 2002). Our study extends previous work in because it focuses on in-depth descriptions and analyses on how the IPS skills can have an incidence on students' ability to successfully solve a problem using digital information.

The goals of this research are to gain a more detailed understanding of the key IPS skills *sine qua non* students are lacked of success in their learning through the WWW. The following objectives guide this study:

(1) To provide detailed and qualitatively account of how secondary students solve an IPS task: what IPS skills students use and in what sequence.

(2) To identify the IPS skills, sub-skills, and regulation activities which have more incidence in students' success to solve a digital problem.

(3) The accomplishment of these objectives will provide insight to draw pedagogical guidelines to promote the development of efficient IPS for using Web information as a tool for learning in secondary education.

2. Method

2.1 Participants

Six students participated in this multi-case study, conducted in 2008. They were 7th and 8th grade students (13-15 years old), in Spanish secondary schools.

2.2 Design

The six participants of this study were randomly selected from a larger study of forty students; the reader can find more details of this larger study in Argelagós and Pifarré (2012). The participants for this paper were three representative cases of unsuccessful IPS (Axel, Pam, and Peter), and three representative cases of successful IPS (Ashley, Miriam, and Moses). The names of the participants are fictitious.

2.3 Procedure

Participants performed an IPS task as a test, which was solved individually during 45 minutes approximately, and was performed in the real context of the classroom, as a curricular learning activity, in order to ensure ecological validity (Wopereis & Van Merriënboer, 2011), and effectiveness (Frerejean, Van Strien, Kirschner, & Brand-Gruwel, 2016).

2.4 Materials

In the IPS task, students were engaged to explain, using Internet information, the conditions a planet must fulfill to make life possible on it. This task belonged to a whole learning curricular task about the possibilities of life on Mars.

2.5 Data Analysis Procedure

The IPS task performed by each participant was logged in by screen-capture software (CamStudio 2.0) in order to record all the actions executed on the computer screen. Each IPS task was carefully analyzed considering the four set of variables: task performance, constituent skills, sub-skills, and regulation activities.

Task performance referred the way in which the question was answered by each student. A correct answer must have minimum three conditions required for a planet to make life possible on it, and these three conditions had to be found on the Internet. Thus, the answers could be correct or incorrect.

The second set of variables (constituent skills) were the following: (1) *defining the problem*, when the student was analysing the problem at the task webpage, without typing anything on it, (2) *searching information*, when the student was accessing a search engine, typing search terms on it, or selecting results from a SERP, (3) *scanning and processing information*, when the computer screen showed a webpage, in which the student was dealing with its information, and (4) *organizing and presenting information*, when the student was typing an answer at the task webpage.

The third set of variables (sub-skills) were: (1) search terms, (2) selected results, and (3) processing information.

(1) *Sub-skill search terms*. Each search-term was transcribed verbatim and so each protocol showed each search-term typed during the IPS tasks. Additionally, each search-term typed scored as appropriate (1 point) or inappropriate (0 points). For example, the search term *conditions planet life* typed in Google when the demand was *conditions that make a planet suitable for life*, was considered as appropriate, whereas *conditions of Mars to life* scored as inappropriate because that search term refers only to Mars while the demand refers to any planet. In addition, an appropriateness score was calculated as a percentage considering the number of search terms used and the number of appropriate search terms.

(2) *Sub-skill selected results*. Each result selected from a SERP by each participant was gathered and so each protocol showed all the selected results during each IPS task. Furthermore, each selected result scored as appropriate or inappropriate. The criteria considered to evaluate each search result were both usability and reliability (Gerjets, Kammerer, & Werner, 2011). A selected result was considered usable when its content (title, description, URL, and other information available in the SERP) followed the question to be answered, and was considered as reliable when the author or source was plausible. Each selected result scored as appropriate (1 point) when it was both usable and reliable, and as inappropriate (0 points) when it was either not usable or unreliable. Again, an appropriateness score was calculated as a percentage considering the number of total selected results and the number of correct ones.

(3) *Sub-skill processing information*. Each webpage consulted by participants was analyzed to determine whether it contained useful and reliable information to solve the question. Each time that the student closed a webpage in which there was not (more) relevant information scored as appropriate, and each time that student closed a webpage which contained relevant information, scored as inappropriate. In addition, each time that a student took relevant information from the webpage scored as appropriate, and each time that the student took irrelevant information scored as inappropriate. An appropriateness score was calculated as a percentage considering the total number of pages visited and the number of appropriate processing of the information.

Finally, the fourth set of variables (regulation activities) consisted of: orientation on the task, monitoring-steering, and testing. *Orientation on the task* was considered when students consulted the demand (that is, defined the problem while solving the task) in a deep way. *Monitoring-steering* was considered when students refined the search terms, when they corrected mistakes while typing a set of search terms or an answer, and when they closed non useful windows to better manage the useful ones. *Testing* was considered when students deleted or (re)typed the search terms after typing them, and when they deleted or corrected mistakes after typing a sentence or a text in giving the answer.

Figure 1 shows the variables considered in this study and gives an overview of the interrelation among them—the two way arrows in the figure represent the iterative direction among skills, which are not always performed in a linear way (Eisenberg & Berkowitz, 1990; Wopereis, Brand-Gruwel, & Vermetten, 2008).

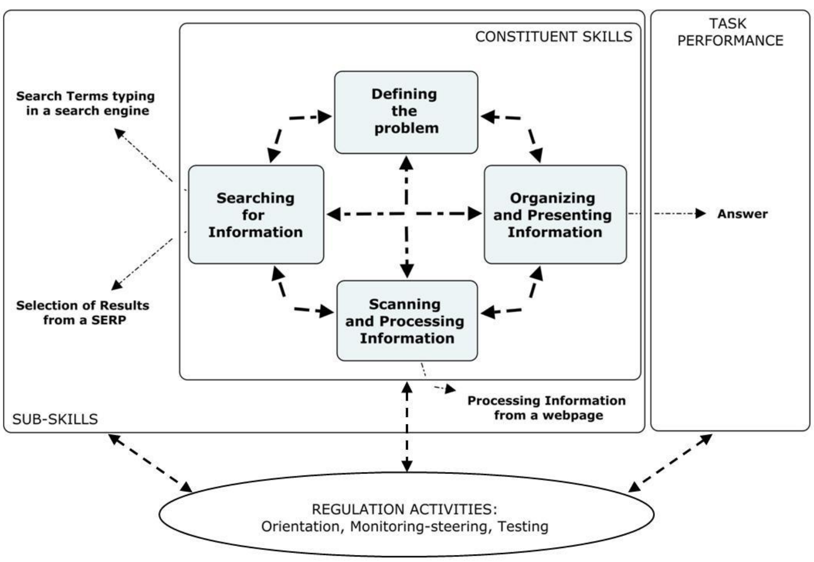

Figure 1. Variables considered in this study

In order to give insight about the IPS process and task performance performed by the students while solving an information problem, we will elaborate for each student, the following: (a) IPS pattern, (b) IPS sequence, and (c) in-depth description of the IPS process and task performance.

(a) *IPS pattern*. An IPS pattern is composed by the quantitative measurements of the following variables: task performance, time spent on the task resolution, frequency of skills performed, and appropriateness scores of the three sub-skills (search terms, selected results, and processing of the information). Table 1 shows the quantitative variables which outline the IPS patterns.

Table 1. Variables considered for the analysis of each student's IPS pattern

Variable	Description	Value
Task performance	Answer's correctness	Low=correct
		High=incorrect
Time spent	Minutes that student spent solving the question	Numerical
Frequency of skills performed	Number of total times that student performed the constituent skills to solve the question	Numerical
Sub-skill: search terms	Appropriateness score	Low<25%
		Medium=26-75%
		High>76%
Sub-skill: selected results	Appropriateness score	Low<25%
		Medium=26-75%
		High>76%
Sub-skill: processing of information	Appropriateness score	Low<25%
		Medium=26-75%
		High>76%

Two raters familiar with the IPS task, the materials, and the coding scheme, scored the variables of one student (17% of the total). Interrater reliability yielded a Cohen's kappa higher than .80. One rater scored the remaining students' variables.

The quantitative value of each variable per student will allow us to identify distinctive IPS patterns, which will help us to compare and describe the different IPS sequences performed by the students.

(b) *IPS sequence*. An IPS sequence is a graphical illustration of each step given by the participant during the resolution of the task. This sequence shows the actions performed over time, the order in which each one was performed, the switches between the skills, the times that each sub-skill was performed and whether it was appropriate or not, as well as the total time of the execution of the task.

(c) *In-depth description of the IPS process and task performance*. The complementation of the IPS patterns and the IPS sequences will allow us to better describe, analyze, and understand the IPS process and task performance executed by each participant. These in-depth descriptions will contain additional elements, which will come from the context analyses of each IPS process. For instance, these new elements are the regulation activities, which are more interpretative and context-based.

3. Results

The main objectives of this study are to provide detailed and qualitative account of how secondary students solve an IPS task, and to identify the IPS skills, sub-skills, and regulation activities that have more incidence in students' ability to solve a problem using digital information on the Web in order to draw educative guidelines. In this section, firstly, we present a summary of each participant as regards their variables' measurement in a quantitative way (IPS pattern). Secondly, we graphically illustrate and thoroughly analyze the sequence performed by each participant (IPS sequence). These detailed descriptions of students' experiences will facilitate an ongoing discussion about the IPS skills that have a great incidence in solving information-problems while using the Internet to learn in secondary classrooms.

Table 2 shows the variables which summarize the IPS pattern of each participant of this study. The first three participants (Axel, Pam, and Peter) performed their tasks in an unsuccessful way, due to the incorrectness of their answers. In contrast, the other three participants (Ashley, Myriam, and Moses) performed the learning tasks in a successful way.

Table 2. Participants' IPS patterns during their task

Participants	Task performance	Time spent (minutes)	Frequency of skills	Appropriateness of ST	Appropriateness of SR	Appropriateness of PI
Axel	low	12:57	12	low	medium	high
Pam	low	6:50	19	low	low	medium
Peter	low	7:47	11	medium	medium	medium
Ashley	high	8:05	10	low	medium	high
Myriam	high	8:00	20	medium	high	high
Moses	high	6:04	18	high	high	high

Table legend: ST (search terms), SR (selected results), PI (processing of the information).

In order to give better understanding of the IPS processes performed by the participants, we have drawn graphical illustrations and describe them in a more qualitative way. Figure 2 shows the IPS sequences performed by each participant during the task. The numbers in each illustration indicate the order in which every skill was performed. The reader is suggested to follow the numbered arrows in the illustration to better understand the sequence. The first numbers in the illustration are highlighted for easier access.

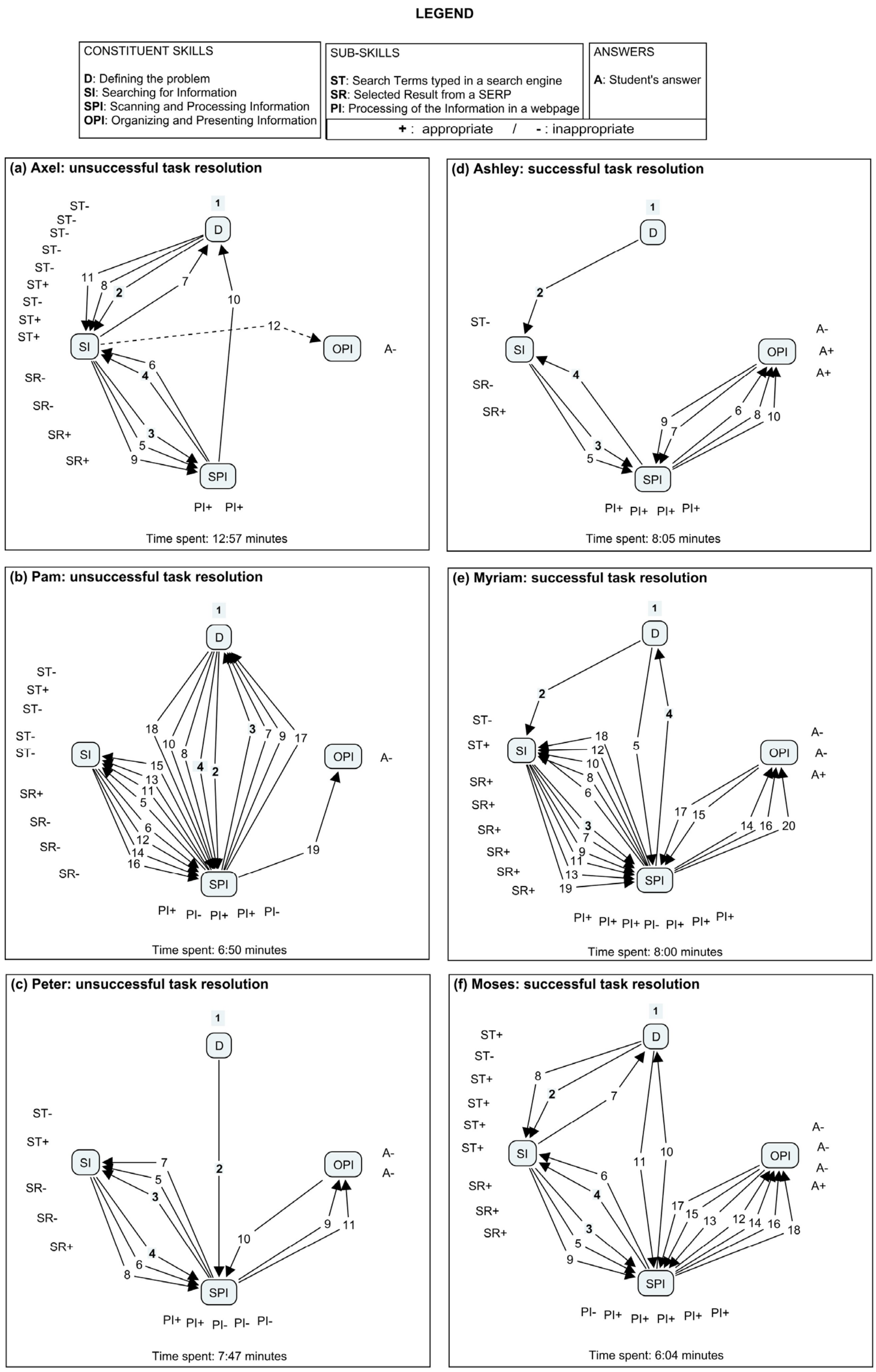

Figure 2. IPS sequences performed by each participant during the task

3.1 Axel (Unsuccessful Task Resolution)

As can be appreciate in Figure 2a, Axel performed the task unsuccessfully. In particular, this student performed 12 constituent skills and spent a total time of 12:57 minutes; it means, 12 minutes and 57 seconds. After several attempts, he came up with appropriate Search Terms (ST) and appropriate Selected Results (SR). Axel did an appropriate Processing of the Information (PI) of the webpages that he opened up, but it should be interpreted with caution because there were only two occasions to process the information and, besides, the content of the pages were so irrelevant that it was obvious that this student was not able to find relevant information, and he had to close the pages sooner or later. As can be appreciated in Table 2, this student's pattern shows low level of ST, middle of SR and high of PI. Axel did not find information to solve the problem adequately, despite the long time devoted trying it. On the one hand, even though the fact of consulting the problem twice during the task resolution, he did it in an inadequate way. As a result, he typed in a ST wrongly (see numbers 7 and 8, and numbers 10 and 11). On the other hand, the many attempts in specifying the ST typed in a search engine made him to spend so much time in doing it, that he was lacked of time to perform other important skills, such as scanning, processing, organizing, and presenting the information. In other words, if he had specified better ST in fewer attempts, he would have had more time to explore other webpages to find relevant information and solve correctly the task.

3.2 Pam (Unsuccessful Task Resolution)

Pam (Figure 2b) solved the task unsuccessfully. This student performed 19 constituent skills and spent 6:50 minutes to answer the question. Although she attempted several times to type in ST and to select results, very few of them were appropriate. Her pattern show low levels of ST and SR, and middle level of PI (Table 2). As a consequence of these behaviors, Pam was not able to find relevant information, nor did she give a good answer to the task. In the same way as Axel, Pam consulted the assignment in a wrong way, and as a consequence she typed in inappropriate search terms, selected an inadequate result, and processed wrongly the information. Although Pam performed the ST better than Axel, she spent a lot of time trying to select an appropriate result from a SERP, which hindered her to find a good website that provide appropriate information to solve the task.

3.3 Peter (Unsuccessful Task Resolution)

Peter (Figure 2c) performed 11 skills altogether and spent 7:47 minutes on them. His pattern's levels are middle in ST, SR and PI (Table 2). Peter was not able to find relevant information and, as a result, he did not solve the problem appropriately. Although Peter came with adequate ST and SR, he spent an excessive amount of time attempting it. Maybe if he had consulted the demand, he would be able to do that in less time. Furthermore, he lacked in PI while consulting the webpages; thus, he did not find useful and reliable information to solve the problem satisfactorily.

3.4 Ashley (Successful Task Resolution)

As can be seen in Figure 2d, Ashley performed 10 constituent skills and spent 8:05 minutes on them. In Table 2, the levels that characterize Ashley pattern are: low in ST, middle in SR and high in PI. Although her first ST and SR were inappropriate, she could select an appropriate result from the SERP, which allowed her to find relevant information. As she processed the information appropriately on the webpages consulted, she was able to locate an adequate webpage and a relevant piece of information to solve the problem satisfactorily. Contrarily to the previous students' sequences, Ashley devoted little time to the skill search information (that is, to ST and SR); thus, she spent plenty of time scanning and processing the information as well as organizing and presenting it. In addition, Ashley monitored her process of organizing and presenting the information found in the Internet, by correcting her typing in a constant way and changing a sentence after writing it, which reveals monitoring and testing activities during the performance of this student.

3.5 Myriam (Successful Task Resolution)

Myriam (Figure 2e) performed 20 constituent skills and spent 8:00 minutes to solve the learning task. Table 2 shows the levels of the variables performed by Myriam: middle in ST, and high in SR and PI. Although she failed in her first attempt to type ST, she improved them later. The consultation of the problem done during this task resolution was a critical factor which made her improve the other skills. Immediately after consulting the demand, Myriam was able to identify the irrelevant information on the webpage, to specify an appropriate ST —by refining the search term typed previously, and to select an appropriate SR. Furthermore, the fact that Myriam consulted several appropriate webpages and that she performed an adequate PI, allowed collecting and integrating different pieces of information, which improved the answer given by this student.

3.6 Moses (Successful Task Resolution)

Figure 2f shows the task executed by Moses, who performed 18 skills and spent 6:04 minutes to solve the task in a satisfactory way. Moses reached high levels in ST, SR and PI (Table 2). It is worth to be remarked that the consultation of the problem during the task resolution helped him to specify ST and SR adequately, and to appropriately perform the PI. In addition, Moses' sequence was highlighted by his dedication to assess the results retrieved from a SERP, by spending time in doing that. As a result, he only accessed the necessary webpages, which allowed him to focus in its content to adequately solve the question in a short period of time. As Myriam also did, saving time in the skill search for information permitted him to scan and process the information on the webpages as well as organizing and presenting it as a resolution of the task. Moses also showed regulation activities, such as: (1) refining most of the search terms he typed, (2) closing the non useful webpages previously opened, and (3) correcting mistakes during and after writing the answer.

In the following section, we compare the students' patterns and sequences to highlight important IPS skills, sub-skills, and regulation activities that have great incidence in the ability to solve the problem using digital information from the WWW.

4. Discussion

The results presented above show that the constituent skills, sub-skills, and regulation activities involved in IPS are highly interrelated—students frequently switch between skills, and the result accomplished by one sub-skill is often the input for another sub-skill; therefore, the coordination between these skills is very important, as other studies also highlighted (i.e., Argelagós & Pifarré, 2012; Brand-Gruwel et al., 2005; Brand-Gruwel et al., 2009; Kuiper et al., 2008; Lazonder & Rouet, 2008). In the following paragraphs, we discuss the impact that each constituent skill and sub-skill has on solving the digital problem successfully, as well as we point out the incidence of regulation activities involved during students' IPS processes.

In our study, the students who used properly the constituent skill *defining the problem* could succeed in solving the digital task. First of all, this skill can be divided into defining the problem for the first time at the beginning of the task, and consulting the problem during the task. Consulting the problem acquires regulation significance and has been considered as *orientation on the task* (e.g., Brand-Gruwel et al., 2005). The tasks solved by Alex and Pam are two examples of consulting the problem in a superficial way—thus, they did not get a good insight about the demand of the task. As a result, they did not improve their ST, SR, and failed in PI. In contrast, Myriam and Moses consulted the problem in a deeper way; and as a consequence they were able to specify better ST, to select more appropriate results, and to find relevant information and discart irrelevant information.

Consulting the problem in a deep way during the task resolution, or, in other words, being orientated on the task—was a key IPS skill that improved other constituent skills and sub-skills, and therefore impacted the successful resolution of the problem using digital information on the Web, as other studies also reported (Brand-Gruwel et al., 2009).

Regarding the constituent skill *searching information*, and its sub-skills ST and SR, it can be remarked the importance of spending the necessary time in the critical moments. When students did not focus on specifying the ST, they wasted time trying to select an appropriate result from a wrong SERP. In addition, when students did not use time in assessing the results accordingly to their usability and reliability before selecting a result, the consequence was a set of moves onwards and backwards between the SERP and the websites, which meant a sequence of unproductive actions to solve the digital task. Axel, Pam, and Peter, who were not succeeding in solving the leaning task, presented this sequence of actions (Figure 2). In contrast, students who devoted time to specify ST and to assess and reflect about the SERP before selecting a result, they succeed in solving the digital task (i.e., Ashley, Myriam, and Moses). Students' skills related to ST and SR are, indeed, influential skills to solve a problem satisfactorily (Gerjets et al., 2011).

In this regard, the regulation activity played a critical role in specifying ST. In particular, the refinement of ST when the previous ones did not produce good results helped students to overcome the difficulties of specifying appropriate ST and, in consequence, to find useful search results in the SERP. An example of this can be seen in Myriam and Moses' resolutions. When Myriam typed the ST for the first time, she failed; however, she refined them and got an appropriate ST, which retrieved a good list of hits in the SERP. Moses refined his ST for four times; he typed a ST and then he consulted the search results on the SERP; afterwards he refined the previous ST and again assessed the results. Finally, the refinement process led him to obtain a better SERP in order to select an appropriate website in which he could extract relevant information to solve the learning task. This process has been identified by a regulation activity, particularly, as monitoring (de Jong & Simmons, 1988; Moore, 1995).

As regards the skill *scanning and processing information*, the qualitative analyses of this study gave us insight to identify different levels on performing this constituent skill. Scanning a webpage consists in getting an overview and judging the information on usability and reliability to decide whether or not the information must be linked to the problem given and can be trustworthy, whereas processing the information refers to deep reading, elaborating the content, and assessing the Web information (Brand-Gruwel et al., 2005; Brand-Gruwel et al., 2009; Mason et al., 2014). Our students—particularly Ashley, Myriam, and Moses—performed good actions on scanning and processing information, revealed by the indicators that they took advantage of the useful and reliable information from the webpages visited and they also discarded the irrelevant information.

We also observed an indicator of regulation activities concerning the management of the webpages visited, scanned, and processed. Moses worked with several webpages at the same time—he kept them opened in different windows. When he finally found an appropriate webpage and he realized that sometimes he failed in opening the correct window to process its information, he immediately closed the unnecessary windows. This action shows a monitoring behavior that indeed made more efficient his process of consulting the information in the selected webpage. Previous studies have called this kind of process as knowledge about different cognitive demands of different learning tasks (Garner & Alexander, 1987) and as procedural knowledge of strategies to employ when unsuccessful (Land & Green, 2000).

In relation to the skill *organizing and presenting the information*, the students who moved between the webpage and the task page to give an answer, obtained a high-quality answer in their task resolution. This was the case of Ashley, Myriam, and Moses, which after writing their answer to the task, both of them completed and improved it by consulting the same webpage or other ones. In contrast, Axel and Pam performed this skill only once, and their answers were incorrect or incomplete. Therefore, if they had compared the new information found with previous information, they would have probably solved the task better, as Ashley, Myriam, and Moses did.

Regulation activities can also be identified in some students' IPS sequences as regards the constituent skill organizing and presenting information. For instance, Alex, Ashley, and Moses kept correcting their mistakes while typing their answer. This behavior could be an indicator of monitoring because it could reveal *the finger on the pulse* expressed by de Jong and Simmons (1988). In addition, Ashley and Moses showed actions that also reveal regulation activities, in particular, testing; they changed and improved some sentences after having typed them, which means a good behavior of re-reading the answers typed. Monitoring and testing helped students, i.e., Ashley and Moses—to detect spelling, grammatical, or content problems in their answers, as well as to enhance them (Hill, 1999; Stenberg, 1986).

4.1 Conclusion and Educative Guidelines for Instructional Design

Our study confirms the role of the main constituent skills to solve digital tasks (define the problem, searching information, scanning information, processing information, organizing and presenting information) that are governed by regulation processes (Brand-Gruwel et al., 2005; Brand-Gruwel et al., 2009).

Besides, our qualitative analyses of IPS process and task performance of six cases revealed that there are some IPS skills that act as critical to solve the digital problem successfully. Our study stressed the key role of the next two constituent skills: (1) defining the problem in a deep way, which allows students guiding their web-search and IPS execution, and (2) searching information, which is a key skill to learn with digital information on Internet.

Furthermore, our study highlighted that, in searching information, the sub-skills that we considered as critical are the following two: (1) specifying appropriate search terms in order to obtain the most accurate SERP in short time, and (2) selecting appropriate results from a SERP to avoid accessing unnecessary websites. The adequate execution of these two sub-skills are crucial because it allows to locate the necessary information in an enough period of time; otherwise time will be needed in order to accomplish the other required skills to solve the information problem satisfactorily as for instance: scanning and processing information at the selected website or organizing and presenting the information as an answer to the IPS task.

Moreover, our research also considered key skills for solving the digital problem successfully, the regulation activities, in particular the following three: (1) orientation on the task, which implies a deep consultation of the problem requirements throughout the execution of the IPS task to be able to adjust the actions needed, (2) monitoring, as a continuous supervision of the IPS task execution (specificly, refinement of search terms typed, correcting what is being typed, and closing unnecessary windows), and (3) testing the search terms before entering them or the text written as an answer, in order to decide whether it is solving the initial problem or whether contrarily some information is still needed. Regulation activities may improve other IPS abilities, as the constituent skills and sub-skills, and therefore they may influence the quality of the IPS processes and task performances of the students.

4.2 Instructional Applications

Secondary education has to equip students with the necessary competences to become active and critical citizens in our Information Society and able to learn form different sources on Internet. From our perspective, secondary education should embed the learning of IPS skills. Results from our study stress the need to teach secondary students the skills *defining the problem* and *search information*, the sub-skills *search terms* and *selection of the results*, and the regulation activities *orientation on the task*, *monitoring*, and *testing*.

Taking into account the considerations discussed above as well as the theoretical and methodological contributions of other studies, we propose that the design of an IPS learning process should be based on the following three instructional principles: (1) *embedding* the IPS skills in the scholar curriculum to learn the current subjects through meaningful and authentic contents, (2) *structuring* the students' problem solving, and (3) *supporting* the students' problem resolution by a series of scaffolds to guide the students' progress.

(1) Related to the first instructional principle, IPS skills should be acquired and *embedded* within a relevant and meaningful learning content. Some effective embedded instruction research studies have showed a positive impact on learning IPS skills (Argelagós & Pifarré, 2012; Britt & Aglinskas, 2002; Frerejean et al., 2016; Hutchison & Colwell, 2014), on enhancing students' performance on domain contents (Raes et al., 2012), and on transferring IPS skills to other contexts (Walraven, Brand-Gruwel, & Boshuizen, 2010).

(2) As regards to the second instructional principle, *structuring* the instruction, it is worth highlighting the importance of guiding students through the whole learning process of information problem resolution. Scaffolding helps to accomplish all the steps needed to successfully solve a problem through providing a layer of structure between student and Internet (Segers & Verhoeven, 2009). A good structured instruction on IPS could be an instruction that follows the Inquiry-Web Learning methodology as proposed in WebQuest (Dodge, 1995).

(3) Related to the third instructional principle, *supporting* the instruction, we claim the necessity to design lessons which could provide scaffolds in each IPS skill and sub-skill in order to tackle information problems. Educational research has already provided successful evidence about the improvement of IPS skills and individual learning in a technology environment by implementing appropriate questions and reflection prompts that trigger students to activate key cognitive processes to solve the learning task (Raes et al., 2012; Mason et al., 2014; Walhout et al., 2015). Scaffolds could be embedded in the IPS task to give guidance and support to learn IPS skills and sub-skills, and gradually withdraw them as the instructional process progresses.

Following previous studies (Badía & Becerril, 2015; Pifarré, 2009; Pifarré, Cobos, & Argelagós, 2014; Walraven et al., 2010; Wopereis et al., 2008), the instructional process might be scaffolded by means of questions, worksheets, scripts, and prompts (Stadler & Brome, 2008). For instance, scaffolds could be designed as it follows: (a) driving questions in order to encourage the activation of students' prior knowledge; (b) prompts to perform a specific IPS skill, i.e., "write down the specific information you will need to solve this problem" (skill defining the problem); (c) pop-up messages to guide a search; and (d) worksheets to promote reflection about search terms or selection of the results (skill searching information).

Figure 3 presents some examples about how these scaffolds could be designed in an instructional web-based activity.

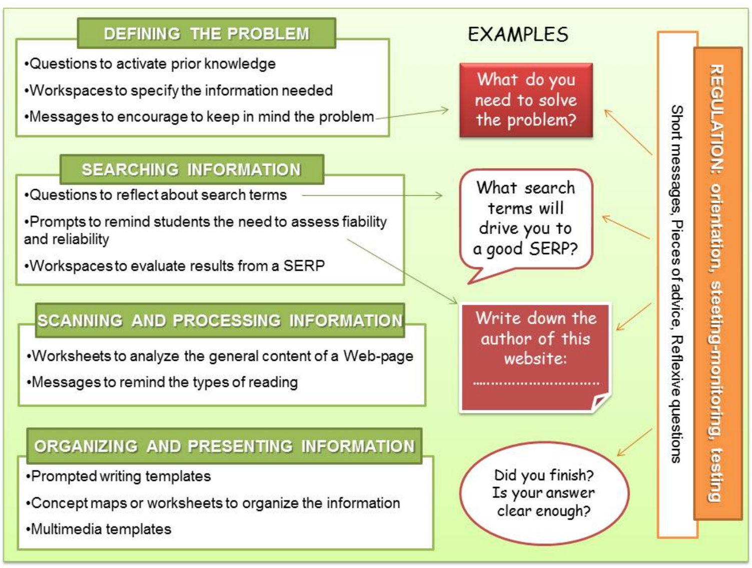

Figure 3. Scaffolds of each skill during an instructional process (adapted from Argelagós & Pifarré, 2012)

The present study is an attempt to give an insight into the learning process that secondary students follow when they use Web information to learn, and to draw educational guidelines for the design of IPS instruction at school. Nonetheless, our findings must be carefully interpreted due to the following two limitations. First, the technique used to collect the data was the log-file technique, which may bring the risk to missinterpret the actions made by the participants (Argelagós, Jarodzka, & Pifarré, 2011). As this technique only captures the actions made on the screen, some actions can easily be misinterpreted. The election of this technique was due to the ecological validity and the unobtrusiveness of the technique (Wopereis & Van Merriënboer, 2011); however, the cognitive processes involved in IPS could be more in-depth analysed through other techniques as, for instance, eye-tracking (Holmqvist, Nyström, Andersson, Dewhurst, Jarodzka, & Van de Weijer, 2011) or cued-retrospective reports (Van Gog, Paas, Van Merriënboer, & Witte, 2005) though they can only be applied in laboratory settings. Second, the sample considered for this study 6 students might be a slightly limited segment.

Notwithstanding the above limitations, this paper examined the key skills that secondary students need to solve a problem using digital information to learn curricular contents. Our findings draw inferences to help secondary students to enhance their IPS skills in everyday classrooms. We claim that this study might contribute to coaching secondary students into digital competences that may allow them an adequate use of web information.

Acknowledgments

This research was funded by the Ministerio de Ciencia y Tecnología of the Spanish Government (Project Numbers: EDU2009-11656 and EDU2012-32415). The authors would like to thank the teachers and the pupils for their participation in the study reported in this paper.

References

Argelagós, E., & Pifarré, M. (2012). Improving information problem solving skills in secondary education through embedded instruction. *Computers in Human Behavior*, *28*(2), 515-526. http://dx.doi.org/10.1016/j.chb.2011.10.024

Argelagós, E., Jarodzka, H., & Pifarré, M. (2011, August). *Measuring cognitive processes involved in web search: log files, eye-movements and cued retrospective reports compared*. Paper presented at the 12nd Biennial Conference EARLI (European Association for Research on Learning and Instruction), Exeter, United Kingdom.

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology*, *29*(3), 344-370. http://dx.doi.org/10.1016/j.cedpsych.2003.09.002

Badía, A., & Becerril, L. (2015). Collaborative solving of information problems and group learning outcomes in secondary education. *Journal for the Study of Education and Development*, *38*(1), 67-101. http://dx.doi.org/10.1080/02103702.2014.996403

Bannert, M., & Reimann, P. (2011). Supporting self-regulated hypermedia learning through prompts. *Instructional Science*, *40*(1), 193-211. http://dx.doi.org/10.1007/s11251-011-9167-4

Brand-Gruwel, S., Wopereis, I., & Vermetten, Y. (2005). Information problem solving by experts and novices: Analysis of a complex cognitive skill. *Computers in Human Behavior*, *21*(3), 487-508. http://dx.doi.org/10.1016/j.chb.2004.10.005

Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education*, *53*(4), 1207-1217. http://dx.doi.org/10.1016/j.compedu.2009.06.004

Britt, M. A., & Aglinskas, C. (2002). Improving students' ability to identify and use source information. *Cognition and Instruction*, *20*(4), 485-522. http://dx.doi.org/10.1207/S1532690XCI2004_2

de Jong, F. P. C. M., & Simmons, P. R. J. (1988). Self reglation in text processing. *European Journal of Psychology of Education*, *3*, 177-190. http://dx.doi.org/10.1007/BF03172655

Dodge, B. (1995). WebQuests: A technique for internet-based learning. *Distance Educator*, *1*(2), 10-13.

Eisenberg, M. B., & Berkowitz, R. E. (1990). *Information problem-solving: The big six skills approach to library and information skills instruction*. Norwood, NJ: Ablex.

Fidel, R. et al. (1999). A visit to the information mall: Web searching behavior of high school students. *Journal of the American Society of Information Science*, *50*(1), 24-37. http://dx.doi.org/10.1002/(SICI)1097-4571(1999)50:1%3C24::AID-ASI5%3E3.0.CO;2-W

Frerejean, J., van Strien, J. L., Kirschner, P. A., & Brand-Gruwel, S. (2016). Completion strategy or emphasis manipulation? Task support for teaching information problem solving. *Computers in Human Behavior*, *62*, 90-104. http://dx.doi.org/10.1016/j.chb.2016.03.048

Garner, R., & Alexander, P. A. (1987). Metacognition: Answered and unanswered questions. *Educational Psychologist*, *24*, 143-158. http://dx.doi.org/10.1207/s15326985ep2402_2

Gerjets, P., Kammerer, Y., & Werner, B. (2011). Measuring spontaneous and instructed evaluation processes during Web search: Integrating concurrent thinking-aloud protocols and eye-tracking data. *Learning and Instruction*, *21*, 220-231. http://dx.doi.org/10.1016/j.learninstruc.2010.02.005

Goldman, S. R. (2011). Commentary: Choosing and using multiple information sources: Some new findings and emergent issues. *Learning and Instruction*, *21*(2), 238-242. http://dx.doi.org/10.1016/j.learninstruc.2010.02.006

Hill, J. R. (1999). A conceptual framework for understanding information seeking in open-ended information services. *Educational Technology, Research and Development*, *47*(1), 5-27. http://dx.doi.org/10.1007/BF02299474

Holmqvist, K., Nyström, N., Andersson, R., Dewhurst, R., Jarodzka, H., & van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford, UK: Oxford University Press.

Hutchison, A. C., & Colwell, J. (2014). The potential of digital technologies to support literacy instruction relevant to the common core state standards. *Journal of Adolescent & Adult Literacy*, *58*(2), 147-156. http://dx.doi.org/10.1002/jaal.335

Kuiper, E., Volman, M., & Terwel, J. (2009). Developing Web literacy in collaborative inquiry activities. *Computers & Education*, *52*(3), 668-680. http://dx.doi.org/10.1016/ j.compedu.2008.11.010.

Ladbrook, J., & Probert, E. (2011). Information skills and critical literacy: Where are our digikids at with online searching and are their teachers helping? *Australasian Journal of Educational Technology*, *27*(1), 105-121. http://dx.doi.org/10.14742/ajet.986

Land, S. M., & Green, B. A. (2000). Project-based learning with the World Wide Web: A quantitative study of resource integration. *Educational Technology, Research and Development*, *48*(1), 45-68. http://dx.doi.org/10.1007/BF02313485

Lazonder, A. W., & Rouet, J.-F. (2008). Information problem solving instruction: Some cognitive and metacognitive issues. *Computers in Human Behavior*, *24*(3), 753-765. http://dx.doi.org/10.1016/j.chb.2007.01.025

Lorenzen, M. (2002). The land of confusion? High school students and their use of the world wide web for research. *Research Strategies*, *18*(2), 151-163. http://dx.doi.org/10.1016/S0734-3310(02)00074-5

MaKinster, J. G., Beghetto, R. A., & Plucker, J. A. (2002). Why can't I find Newton's third law? Case studies of students' use of the web as a science resource. *Journal of Science Education and Technology*, *11*(2), 155-172. http://dx.doi.org/10.1023/A:1014617530297

Mason, L., Junyent, A. A., & Tornatora, M. C. (2014). Epistemic evaluation and comprehension of web-source information on controversial science-related topics: Effects of a short-term instructional intervention. *Computers & Education*, *76*, 143-157. http://dx.doi.org/10.1016/j.compedu.2014.03.016

Moore, P. (1995). Information problem solving: A wider view of library skills. *Contemporary Educational Psychology*, *20*(1), 1-31. http://dx.doi.org/10.1006/ceps.1995.1001

Pifarré, M. (2009). Inquiry Web-based learning to enhance knowledge construction in Science: A study in Secondary Education. In B. A. Morris, & G. M. Ferguson (Eds.), *Computer-Assisted Teaching: New Developments*. New York: Nova Science Publishers, Inc.

Pifarré, M., Cobos, R., & Argelagós, E. (2014). Incidence of group awareness information on students' collaborative learning processes. *Journal of Computer Assisted Learning*, *30*(4), 300-317. http://dx.doi.org/10.1111/jcal.12043

Probert, E. (2009). Information literacy skills: Teacher understandings and practice. *Computers & Education*, *53*(1), 24-33. http://dx.doi.org/10.1016/j.compedu.2008.12.018

Quintana, C., Zhang, M., & Krajcik, J. (2005). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist*, *40*(4), 235-244. http://dx.doi.org/10.1207/s15326985ep4004_5

Raes, A., Schellens, T., De Wever, B., & Vanderhoven, E. (2012). Scaffolding information problem solving in web-based collaborative inquiry learning. *Computers & Education*, *59*(1), 82-94. http://dx.doi.org/10.1016/j.compedu.2011.11.010

Rouet, J.-F., Ros, C., Goumi, A., Macedo-Rouet, M., & Dinet, J. (2011). The influence of surface and deep cues on primary and secondary school students' assessment of relevance in Web menus. *Learning and Instruction*, *21*(2), 205-219. http://dx.doi.org/10.1016/j.learninstruc.2010.02.007

Segers, E., & Verhoeven, L. (2009). Learning in a sheltered Internet environment: The use of WebQuests. *Learning and Instruction*, *19*(5), 423-432. http://dx.doi.org/10.1016/j.learninstruc.2009.02.017

Stadtler, M., & Bromme, R. (2008). Effects of the metacognitive tool met.a.ware on the web search of laypersons. *Computers in Human Behavior*, *24*, 716-737. http://dx.doi.org/10.1016/j.chb.2007.01.023

Stenberg, R. J. (1986). Inside intelligence. *American Scientist*, *74*, 137-143.

Van Deursen, A. J., Görzig, A., Van Delzen, M., Perik, H. T., & Stegeman, A. G. (2014). Primary School Children's Internet Skills: A Report on Performance Tests of Operational, Formal, Information, and Strategic Internet Skills. *International Journal of Communication*, *8*, 1343-1365. Retrieved from http://ijoc.org/index.php/ijoc/article/view/2407/1135

Van Gog, T., Paas, F., van Merriënboer, J. J. G., & Witte, P. (2005). Uncovering the problem-solving process: Cued retrospective reporting versus concurrent and retrospective reporting. *Journal of Experimental Psychology: Applied*, *11*, 237-244. http://dx.doi.org/10.1037/1076-898X.11.4.237

Walhout, J., Brand-Gruwel, S., Jarodzka, H., van Dijk, M., de Groot, R., & Kirschner, P. A. (2015). Learning and navigating in hypertext: Navigational support by hierarchical menu or tag cloud? *Computers in Human Behavior*, *46*, 218-227. http://dx.doi.org/10.1016/j.chb.2015.01.025

Wallace, R., Kupperman, J., Krajcik, J., & Soloway, E. (2000). Science on the Web: Students Online in a Sixth-Grade Classroom. *Journal of the Learning Sciences*, *9*(1), 75-104. http://dx.doi.org/10.1207/s15327809jls0901_5

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. P. A. (2008) Information-problem solving: A review of problems students encounter and instructional solutions. *Computers in Human Behavior*, *24*, 623-648. http://dx.doi.org/10.1016/j.chb.2007.01.030

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. P. A. (2009). How students evaluate information and sources when searching the World Wide Web for information. *Computers & Education*, *25*, 234-246. http://dx.doi.org/10.1016/j.compedu.2008.08.003

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. P. A. (2010). Fostering transfer of web searchers' evaluation skills: A field test of two transfer theories. *Computers in Human Behavior*, *26*, 716-728. http://dx.doi.org/10.1037/0022-0663.91.2.301

Wood, D. (2009). Comments on "Learning with ICT: New perspectives on help seeking and information searching". *Computers & Education*, *53*(4), 1048-1051. http://dx.doi.org/10.1016/j.compedu.2009.07.002

Wopereis, I. G. J. H., & Van Merriënboer, J. J. G. (2011). Evaluating text-based information on the World Wide Web. *Learning and Instruction*, *21*(2), 232-237. http://dx.doi.org/10.1016/j.learninstruc.2010.02.003

Wopereis, I., Brand-Gruwel, S., & Vermetten, Y. (2008). The effect of embedded instruction on solving information problems. *Computers in Human Behavior*, *24*(3), 738-752. http://dx.doi.org/10.1016/j.chb.2007.01.024