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DOI:
10.1016/j.chb.2007.01.024

Document status and date:
Published: 01/05/2008

Document Version:
Peer reviewed version

This is a pre-print of:

Wopereis, I., Brand-Gruwel, S., & Vermetten, Y. (2008). The effect of embedded instruction on solving information problems. ***Computers in Human Behavior, 24,*** **738-752.**

The effect of embedded instruction on solving information problems

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Abstract

In higher education students are often faced with information problems: tasks or assignments that require them to identify information needs, locate corresponding information sources, extract and organize relevant information from each source, and synthesize information from a variety of sources. Explicit and intensive instruction is necessary, because solving information problems is a complex cognitive skill. In this study instruction for Information Problem Solving (IPS) was embedded in a competence and web-based course for distance education students about research methodology in the field of Psychology. Eight of the sixteen students following this course received a version of the course with embedded IPS instruction. The other half received a variant of the course without extra IPS instruction. The analysis of the thinking aloud protocols revealed that after the course students in the experimental condition regulate the IPS process more often than students in the control condition. They also judged the information found more often.

Introduction

In modern society both in personal and professional life the ability to tackle information problems is increasingly important. Rapid technological change and proliferating information sources make that individuals more than ever before require abilities that enable them to identify information needs, to locate corresponding information sources, to extract and organize relevant information from each source, and to synthesize information from a variety of sources into cogent, productive uses. This set of interrelated abilities is referred to as Information Seeking (Kuhlthau, 1991, 1993, 2004; Marchionini, 1995; Vakkari, 1999; Wallace, Kupperman, Krajcik, & Soloway, 2000; Wilson, 1999), Information Literacy (Association of College and Research Libraries [ACRL], 2000; Bawden, 2001; Todd, 1995) or Information Problem Solving (Eisenberg & Berkowitz, 1990, 1992; Eisenberg & Johnson, 2002; Land & Greene, 2000; Moore, 1995; Wolf, Brush, & Saye, 2003) and –as an entity– is regarded an essential contemporary skill. The skill – as from now denominated in this paper as Information Problem Solving (IPS) – is considered complex, since it (a) includes a substantial number of constituent skills and (b) comprises constituent skills that involve conscious cognitive processing (cf. Van Merriënboer, 1997). Figure 1 presents the IPS skill and its scope. This representation is the result of a literature study and a series of principled skill decompositions (see Brand-Gruwel and Wopereis (2006), Brand-Gruwel, Wopereis, and Vermetten (2005), Feddes, Brand-Gruwel, Vermetten, and Wopereis (2003), and Walraven, Brand-Gruwel, and Boshuizen (this issue) for comprehensive analyses). It shows the complex nature of IPS and emphasizes the importance of higher-level strategies for controlling the execution of the constituent skills by making regulation as a distinct constituent skill category explicit. Especially when information problems are complex or ill-structured, the ability to regulate (orientation, steering, monitoring, and testing) is increasingly important (Hill, 1999; Hill & Hannafin, 1997; Rogers & Swan, 2004, Stadtler & Bromme, 2005, this issue).

Insert Figure 1 about here

The complexity of IPS can be illustrated by zooming in on the concept *information problem*. Just as 'normal' problems, information problems can be described in view of four elements: (a) an initial state, (b) a goal state, (c) a solution that enables the transition from the given state to the goal state, and (d) the problem solving process itself (cf. Newell & Simon, 1972). In case of an information problem, the initial state of the problem is an information need, the goal state is the situation when this need is fulfilled (information is found, processed, and presented), the solution is a set or sequence of IPS strategies, and the (information) problem solving process itself is the application of this set or sequence. According to Jonassen (1997) problems can be located on a continuum from well-structured to ill-structured. A problem is well-structured when the initial state of a problem is well-defined, the goal state is known, and the procedure for solving the problem is clear-cut (Jonassen, 1997; Vakkari, 1999). For instance, in case of writing an essay on the world's tallest freestanding structures on land, the problem of not knowing the height of the Canadian National Tower in Toronto is well-structured and can easily be solved, since all elements of the information problem are clear. In this example the height of the tower (an unambiguous goal) is easily found by the execution of the following sequence of IPS strategies: (a) selection of a search engine (Google), (b) selection of keywords ('height', and 'Canadian National Tower'), (c) selection of source(s) from the Google results page (Wikipedia article about the CN Tower), and (d) selection of information within the article (553.5 meters).

According to Jonassen (2000) finding relevant information on the Internet, like the example mentioned, is an instance of a rule-using problem. The purpose of this type of problem is obvious: find the most relevant information in the least amount of time. It requires selecting search terms, constructing effective search arguments, implementing the search strategy, and evaluating the utility and credibility of information found. Jonassen (2000, p. 77) further argues that rule-using problems become decidedly more ill-structured in case multiple search strategies are possible.

When all the elements of a problem are unknown or vague, a problem is defined as unstructured (Vakkari, 1999) or ill-structured (Jonassen, 1997). In tasks where the problem structure is poor, the predeterminability of its information requirements (needs), process and outcome is low (Byström & Järvelin, 1995; Vakkari, 1999). These tasks are usually more demanding than the aforementioned example of a fact-finding task (cf. Jonassen, 2000; Lazonder, Biemans, & Wopereis, 2000). Research is a typical example of a task where the underlying information problem is ill-structured. For instance, in case of doing experimental research an important constituent of the task is a thorough examination of previous research on the topic at issue. A literature study is necessary in order to examine the domain of interest and to formulate new and interesting hypotheses. Although the initial state and goal state of an information problem within a literature study can be relatively clear-cut, the strategies for searching, selecting, processing, and presenting information are far more comprehensive and complex compared to well-structured fact-finding tasks.

In the present study we focus on the IPS skill that is firmly rooted in complex professional tasks (in the case at issue: doing psychological research where IPS is especially important with regard to literature search). In general, information problems central to complex professional tasks can be classified as ill-structured, since the information need (initial state of the problem) is mostly vague, the outcome is typically uncertain (cf. Jonassen, 2000), but above all, the set of IPS strategies that can be applied to solve the problem is large. Selecting the appropriate strategies, monitoring the execution of strategies, and evaluating the results of applied strategies for solving information problems requires regulation skills. These skills are crucial for IPS and even on a (professional) university level the ability to regulate the IPS process cannot be taken for granted. Brand-Gruwel et al. (2005), and Stadtler and Bromme (2005, this issue) therefore recommend extensive IPS training with a focus on regulation or metacognitive skills.

In (higher) education it is increasingly recognized that explicit IPS instruction is needed to achieve an adequate level of IPS expertise (ACRL, 2000; Johnston & Webber, 2003; Larkin & Pines, 2005; Moore, 2002; Walton & Archer, 2004). However, in cases where IPS instruction is a part of the curriculum, the way it is designed and integrated differs and it is questionable whether these different kinds of instruction are equally effective. In this study the effect of well-designed and well-integrated IPS instruction is the focus of research. Before we expand on the focus of research, two important principles of instruction for learning complex cognitive skills will be briefly discussed.

Recent instructional theories emphasize the importance of authentic learning tasks as the driving force for learning (Merrill, 2002; Reigeluth, 1999; Van Merriënboer, 1997, 2001, 2007; Van Merriënboer, Kirschner, & Kester, 2003; Van Merriënboer & Sweller, 2005). Authentic learning tasks are based on real-life tasks and are aimed at the integration of knowledge, skills, and attitudes necessary for effective ‘overall’ task performance. The knowledge, skills, and attitudes that constitute a complex cognitive skill should not be taught separately in different instructional (sub) tasks, but integrative in so-called whole tasks (e.g., projects, problem based learning tasks, etcetera). According to Van Merriënboer (1997, 2007) the expression that the sum is more than its parts holds for learning complex cognitive skills. Brown (1997) argues that authentic tasks motivate students and stimulate students' active involvement. In (higher) education, learning tasks should therefore mimic the tasks students will encounter in their professional, post-educational life. In other words, the first principle of instruction says that whole (and real-life) professional tasks should be the point of departure for instruction. Skills like *defining an information problem*, *searching information*, or *presenting information,* should not be taught in separate instructional units, but together and in concord with other constituent skills of the professional task (e.g., higher order skills like critical thinking and reasoning or statistical skills).

A recognized risk of the 'whole task' principle is that learners get overwhelmed by the complexity of the task (Van Merriënboer et al., 2003). Especially novice learners find it difficult to carry out whole tasks (Nadolski, Kirschner, & Van Merriënboer, 2006). Hence, for learning to occur it is important to support the learner and provide tools or strategies that scaffold the learning process. Scaffolding can be regarded as another principle of instruction and includes a combination of performance support and fading (Collins, Brown, & Newman, 1989; Van Merriënboer et al., 2003). One approach to scaffold the learning process is the use of *process worksheets* (Hummel, Paas, & Koper, 2004; Mettes, Pilot, & Roossink, 1981; Van Merriënboer, 1997). According to Nadolski et al. (2006) a process worksheet provides a systematic approach to problem solving for the whole learning task. It presents descriptions of the problem solving phases, and hints or rules of thumb that may help to successfully complete each phase. For an interesting example of a process worksheet, see Mettes et al. (1981).

Powerful scaffolds that can be added to process worksheets are so-called *driving questions.* Driving questions are open questions given at the start of a phase. They support the problem-solving process within the phases of whole learning tasks (Nadolski et al., 2006). In case these questions focus on regulation skills like orientation, monitoring, steering, and testing, they can be regarded as regulation tools. Regulation tools and strategies are important when learning the IPS skill that is firmly rooted in professional tasks (Brand-Gruwel et al., 2005; Lazonder, 2003; Stadtler & Bromme, 2005, this issue). In conclusion, process oriented support or scaffolds are essential in learning the IPS skill that is rooted in complex professional tasks and can be regarded an important principle of instruction. When instruction is mainly focused on the learner's processes of knowledge construction and utilization, the instruction is also defined as *process oriented instruction* (Vermunt, 1992, 1995; Vermunt & Vermetten, 2004).

In this introduction it is argued that IPS is complex and that it requires explicit and extensive training to reach an adequate level of expertise. In order to be effective it is argued that (a) instruction should focus on whole task learning where IPS instruction is embedded in professional task instruction ('whole task' as a first principle of instruction) and (b) that the instruction should be guided by process worksheets accompanied with driving questions ('scaffolding' as a second principle of instruction). The purpose of this research is to determine the effect of the embedded IPS instruction on IPS task performance. We hypothesize that students who receive the integrated instruction on IPS will execute the IPS skill and its constituent skills more intensively. Furthermore, we expect that students in the experimental condition regulate the IPS process more often, leading to better IPS performance.

Method

Participants

Sixteen Psychology students (15 female, 1 male; mean age 44.64, *SD*=6.90, range 38-65) from the Open University of the Netherlands (OUNL) participated in this study. The students started their study at different points in time, but had completed a similar number of units of credit before attending the course in which the study was situated.

Materials

Intervention. At the Open University of the Netherlands a new innovative competence-based and web-based Psychology curriculum for research methodology has been developed (see Van Buuren & Giesbertz, 2000). In a virtual research center students learn the research competence by attending a series of research methodology courses where they are confronted with authentic tasks. Typical of each course is the whole task approach (Merrill, 2002; Van Merriënboer, 1997; Van Merriënboer & Sweller, 2005): in every course students learn to complete all phases of the research cycle by solving an authentic problem. In the beginning of the research methodology curriculum study tasks consist of simple realistic problems. At the end students are confronted with complex problems. This simple to complex instructional sequence is divided into twelve levels of complexity (called IMTO course 1 till 12; see Van Buuren & Giesbertz, 2000). The instruction for solving information problems was embedded in the IMTO-3 course. The study task in IMTO-3 was subdivided into eight assignments or sub-tasks. Students in the experimental condition received instruction on IPS in the second and eighth sub-task. During the first assignment students were introduced into the psychological subject of the course, i.e., ‘attachment’. This psychological concept can be described as the tendency to seek closeness to another person and feel secure when that person is present. The learning objective of the second sub-task was to seek and select information on the subject ‘attachment’. Students were asked to search the Internet and visit the library, discuss in groups the articles found, and present the results. During this search for information, students from the experimental group were taught how to seek information efficiently. They got a reader with information about the steps to be taken and a process worksheet to guide them through the steps. For instance, on the worksheet students formulated a central question and defined the problem; they made a mind map about their prior knowledge of the content and had to structure the information found. In this worksheet reflective questions were also prominent. Students had to write down if a step was successful or if there were problems while going through the step. In the third and fourth assignments the students conducted statistical analyses. In the fifth assignment students performed a self-assessment. Students looked upon themselves as ‘learners’ and established how their research and information problem-solving skills developed over the course. The sixth and seventh assignments were again devoted to statistical analyses. In the last assignment students had to write a paper in which they described the literature and the research results. In this assignment experimental students again worked with a process worksheet in order to structure information found and to organize and present the information in a proper way. They made, for instance, an outline of the paper and decided which literature to use for the introduction of the paper. Again reflection questions had to be answered.

Research on collaborative learning shows that group learning fosters deep learning (cf. Johnson & Johnson, 2003). Therefore, in the new research methodology curriculum students performed the study tasks in groups of four. In order to promote group learning the students were offered tools for communication and document sharing. These tools –Outlook Express

Newsgroups for a-synchronous communication and document sharing and NetMeeting for synchronous communication– were part of the communication unit of the virtual research center. Besides the communication unit the virtual research center provided students with a study task information unit (for task descriptions, learning goals, and criteria for assessment) and a resource unit that contained procedural and supportive information for solving the study task.

Tasks for measuring the information problem-solving skill. During the pre-test and the post-test the participants were asked to solve an information problem while thinking aloud. The task description of the pre-test was: As a student you attend a course about ‘the human memory’. There are different theories about why people’s memory is not always reliable. You get the assignment to write an essay of 400 – 600 words about psychological explanations for the phenomenon remembering and the reliability of memory. The task description of the post-test was: As a student you attend a course about ‘stress’. There are different theories about psychological factors that influence stress or burn out. You get the assignment to write an essay of 400 – 600 words about the relation between personal factors and excessive stressor burn out. These two topics were chosen because of the psychological content and the fact that the students did not have any education about the topics in their study. Students got one and a half hours to complete the task. During the completion they could use the Internet to gather information or refer to three psychological handbooks (Atkinson, Atkinson, Smith, & Bem, 1993; Gleitman, 1991; Roediger, Deutsch Capaldi, Paris, Polivy, & Herman, 1996) that were handed over. For writing the essay students were asked to use MS Word.

Instrument to analyze the thinking aloud protocols. An inductive-deductive method was used to develop the coding system for analyzing the thinking aloud protocols. The coding system was based on the protocols and the model described in the Introduction, and was tested and readjusted in a few iterations. For scoring the protocols two kinds of codes were used: descriptive codes and interpretative codes (Miles & Huberman, 1994). Descriptive codes entail little interpretation and can be attributed to segments of the text in a straightforward way. Interpretative codes require more interpretation by the rater. The scoring system itself consisted of three types of categories, organized in three columns that were scored simultaneously. The first and second columns pertained to the constituent skills and their sub-skills. In the first column, the constituent skills of information problem solving were scored in an exclusive and exhaustive way. In the second column, the categories representing the sub-skills were scored. For instance, the skill ‘define problem’ consisted of four sub-skills: (a) read the task, (b) explain or concretize the problem, (c) activate prior knowledge, and (d) determine the task requirements. In the third column regulation of the process was scored. These categories could be scored independently of the scoring in both other columns. Regulation of the process included (a) monitoring and steering of one’s own working process, (b) orientation on the process, and (c) testing of the results during and after the process. Each of these regulation components was divided in sub components. For instance orientation on the process consisted of: orientation on time, orientation on task, and orientation on the defined problem.

Regulation ability questionnaire. Vermunt (1992) developed a questionnaire for measuring students’ learning style. For this study only the three scales concerning regulation activities were used. The scales were: self-regulation (10 items), external regulation (10 items) and lack of regulation (5 items). These scales give an idea about how people regulate their learning.

Prior knowledge on searching information. In order to measure the experiences of the students with searching literature in a library and while using Internet students received six statements. For every statement they filled out: a) This is a routine for me, b) I am experienced in doing this, c) I can manage this or d) I am totally inexperienced in doing this. For these six items a 4-point Likert scale was used. The six items concerned: Experience with searching in a library, experience with searching psychological literature in a university library, experience with searching psychological literature using Internet, experience with searching psychological literature using special data-systems, experience with Internet in general and experience with Internet for study purpose.

Design and Procedure

The study was set up according to a pre-test post-test control-group design. During the pre-test prior knowledge on searching for information was administered. Also the regulation ability and the ability to solve information problems were measured. After the pre-test students followed the course and the students in the experimental condition got the embedded instruction about solving information problems. The experimental and control condition used different websites and different news-groups for discussion, in order to make sure that no interaction between the students of the experimental and control condition could take place. After the course that lasted 25 weeks, the post-test was administered. The ability to solve information problems was measured again.

During the course three students from the control condition dropped out for different reasons. As a result, the analyses were done with eight students in the experimental condition and five in the control condition.

Data Analyses

Four trained raters scored in pairs eight protocols and video registrations by using the coding system. For each of the eight protocols inter-rater reliability coefficients (Cohen's Kappa) were calculated. Table 1 provides an overview of the coefficients. It shows that the inter-rater agreement ranges from 'fair' to 'almost perfect' (cf. Landis & Koch, 1977).

Insert Table 1 about here

For the eight in pairs scored protocols the raters reached consensus on the statements they disagreed on. One trained rater scored the remaining protocols. ANCOVAs were used to analyze the differences between the two conditions on the use of the constituent skills, their sub-skills and the regulation variables for the pre-test and the post-test. For each analysis the score on the pre-test variable functioned as covariate.

Results

Prior knowledge and regulation ability. Before determining the effect of the IPS instruction, the students of the experimental group and the control group were compared with respect to their prior knowledge about searching for information and their ability to regulate the IPS process. Table 2 presents an overview of the means and standard deviations on the prior knowledge questions of the experimental and control group. Table 3 does the same for the regulation ability variables.

Insert Table 2 about here

Insert Table 3 about here

No differences were found between the control and experimental group with regard to prior knowledge and regulation ability. Therefore it was not necessary to take these variables into account in the remaining analyses.

Time Investment in the Different Skills. The average time the experimental students spent to complete the task was 88.66 minutes (*SD* = 3.37) during the pre-test and 88.5 minutes (*SD* = 5.26) during the post-test. The average time spent by the control group students was 91.16 minutes (*SD* = 2.75) for the pre-test and 84.70 (*SD*=9.32) for the post-test. The differences for the pre-test and the post-test between the two groups were not significant. Note that the time spent by the control group during the pre-test was the maximum available time. As a result, a ceiling effect occurred. Table 4 shows the means and standard deviations of the time investment in the constituent skills by the students of the experimental and control condition. The time investment in this table is given in percentages because the total time investment differed somewhat between the students of the two groups. Also the standard deviations were high.

Insert Table 4 about here

In general the students spent much time scanning text and organizing and presenting information. Time invested in defining the problem is minimal in both conditions. What strikes one most is that the standard deviations are in general high. Thus, individual differences in the experimental and control group are substantial. Results of co-variance analyses revealed a significant difference only for the variable ‘Scan information’, $F(1, 12) = 5.83$, $MSE = 118.58$, $p < .05$, $\eta_p^2 =$

.368. During the post-test students of the experimental condition spent more time scanning than students of the control condition.

Differences in the Frequency of Use of the Constituent Skills and their Sub-skills. Co-variance analyses were used to analyze the difference between the control and the experimental group and to determine if the IPS instruction brings about some changes in the student's ability to solve information problems. Table 5 presents an overview of the number of times constituent skills and the accompanying sub-skills were performed by students of the experimental and the control group during the pre-test and post-test.

Insert Table 5 about here

The frequencies of the constituent skills and sub-skills in Table 5 show that the process of IPS is iterative. Especially after defining the problem students go back and forth between searching and scanning information. This iterative character of the process is even more visible within the information-scanning phase.

For all participants the constituent skill '*define problem*' occurred only once, at the beginning of the task. When students looked back upon the task description during the performance of the task and, for instance, took notice of the task requirements, this was scored as 'orientation on the task' (a sub-skill of the regulation variable 'orientation') and not as 'define problem'. With regard to the sub-skills of this constituent skill, no differences were found between the experimental and control condition.

While *searching for information,* it appears that after the course students of the experimental group used the table of contents of a book more often than the students of the control group, $F(1,12) = 5.29$, $MSE = 10.327$, $p < .05$, $\eta_p^2 = .346$. No significant differences were found for the other sub-skills of this constituent skill.

Two sub-skills of the constituent skill ‘*Scan information’* showed significant differences. After the course students of the experimental group scanned texts more often than the students from the control condition, $F(1,12) = 10.66$, $MSE = 37.207$, $p < .01$, $\eta_p^2 = .516$. They also judged the information more often, $F(1,12) = 9.36$, $MSE = 19.737$, $p < .05$, $\eta_p^2 = .484$.

For the constituent skills ‘*Process information’* and ‘*Organize and present information’* no significant differences were found between the experimental and the control condition. The constituent skill ‘organize and present information’ only occurred a few times. Most students organized and presented the information found at the end of the process. Furthermore, the students in both conditions did not formulate the problem when starting to write the argument.

Effects on regulation. During the training the emphasis was on the regulation of the process. The analysis of the protocols gave insight into how often students regulate their IPS process. Table 6 presents the mean and standard deviation with respect to the regulation variables for the experimental and control group before and after the course.

Insert Table 6 about here

Co-variance analyses showed a significant difference between the experimental and control group on the variable ‘*monitoring / steering*’, $F(1,12) = 5.35$, $MSE = 36{,}257$, $p < .05$, $\eta_p^2 = .348$. Students in the experimental condition monitor and steer their process more often. Although no significant differences were found for the variables ‘orientation’ and ‘testing’ the total amount of regulation activities was significant on a 10% level, $F(1,12) = 4.23$, $MSE = 138.556$, $p < .10$, $\eta_p^2 = .297$.

Discussion

In the present study the effect of integrated IPS instruction (as part of whole task professional skill training) is being measured. The aim of the study was to find out what the effect of instruction was on the execution of the IPS skill. Frequencies of skill performance on a pre-test and post-test were calculated to measure differences between students who received the embedded IPS instruction and those who did not. Our hypothesis was that students who received the integrated instruction on IPS would execute the IPS skill and the accompanying constituent skills more explicitly than students who did not. Moreover, we expected that students in the experimental group would regulate the IPS process more often after the experiment.

The results of the present study indicate that after the course students of the experimental condition spent more time scanning text compared with the students of the control condition. Individual differences in both groups were considerable, indicated by the high standard deviations. Time spent on defining the problem was overall low, what may indicate that students are not yet experts in information problem solving. Research by Brand-Gruwel et al. (2005) reveals that experts spend considerably more time on defining the problem than novices. Similarly you might expect that ‘more instructed (or experienced)’ students also use more time to examine the information problem.

Looking at the frequencies of the sub-skills of the constituent skills no large differences were found. The instruction had some effect on searching and scanning information. In particular, the embedded instruction had a significant and positive effect on the use of tables of contents of psychological handbooks during information searching and scanning text and judging information in the information-scanning phase. Especially judging the information more often as part of information scanning by students of the experimental group is promising, since judging information is regarded as an essential skill in the IPS process (e.g., Kuhlthau, 1993, 2004).

Furthermore, results reveal a positive effect on the number of times students regulate their process. The students in the experimental group regulated the IPS process more often after receiving IPS instruction and this was especially the case with respect to the sub-skill 'monitoring and steering the process'. Being fully aware of regulation means 'pouncing on the process' and this has a positive effect on the quality of learning (Vermunt, 1998). Good quality of regulation with regard to IPS is important. Research by Hill (1999), Hill and Hannafin (1997), Land and Greene (2000), and Marchionini (1995), for instance, reveal that the quality of regulation is related to the effectiveness and efficiency of the IPS process.

The embedded instruction seems to have a positive effect on regulating the IPS process, especially when reflective questions are integrated into the instruction. Further, the embedded instruction has no significant effect with respect to frequencies of other constituent skills. The experimental group performed only three sub-skills of two constituent skills more often.

A limitation of this study is that it was not possible to assess the quality of the products. In the present study students had to write a concept article. Unfortunately, due to time management problems (a regulation aspect!), most of the students were not able to finish the task properly. This resulted in incomparable and thus immeasurable products. Since the focus in the present study was on the process of IPS, we excluded this measure in the analysis of the IPS process. In a new study on integrated IPS instruction, measuring the quality of final pre-test and post-test products is part of the study (Brand-Gruwel & Wopereis, 2006).

A final remark concerns the integrated instruction. Although we think the embedded IPS instruction we developed contributes to solving information problems more efficiently, the effect can be more substantial. An important prior condition we had to face was that the IPS instruction had to fit in an existing instructional framework. An important restriction was that just one information problem could be dealt with in the present course. For learning complex cognitive skills it is important that students face different problems in different contexts (Merrill, 2002; Perkins & Salomon, 1989; Van Merriënboer, 1997, 2007; Van Merriënboer, Kirschner, & Kester, 2003). The IPS (sub) tasks of the present course were part of a larger whole task (to carry out a psychological experiment). This task is large and therefore subdividing this task in smaller units of learning and subsequently using a back-chaining-sequencing approach to define task classes would be a better solution to tackle the transfer problem (Van Merriënboer, 1997). According to this scenario, students learn to solve a wider variety of information problems. In a new study these instructional design aspects are taken into consideration (Brand-Gruwel & Wopereis, 2006).

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Figure 1

IPS skills hierarchy

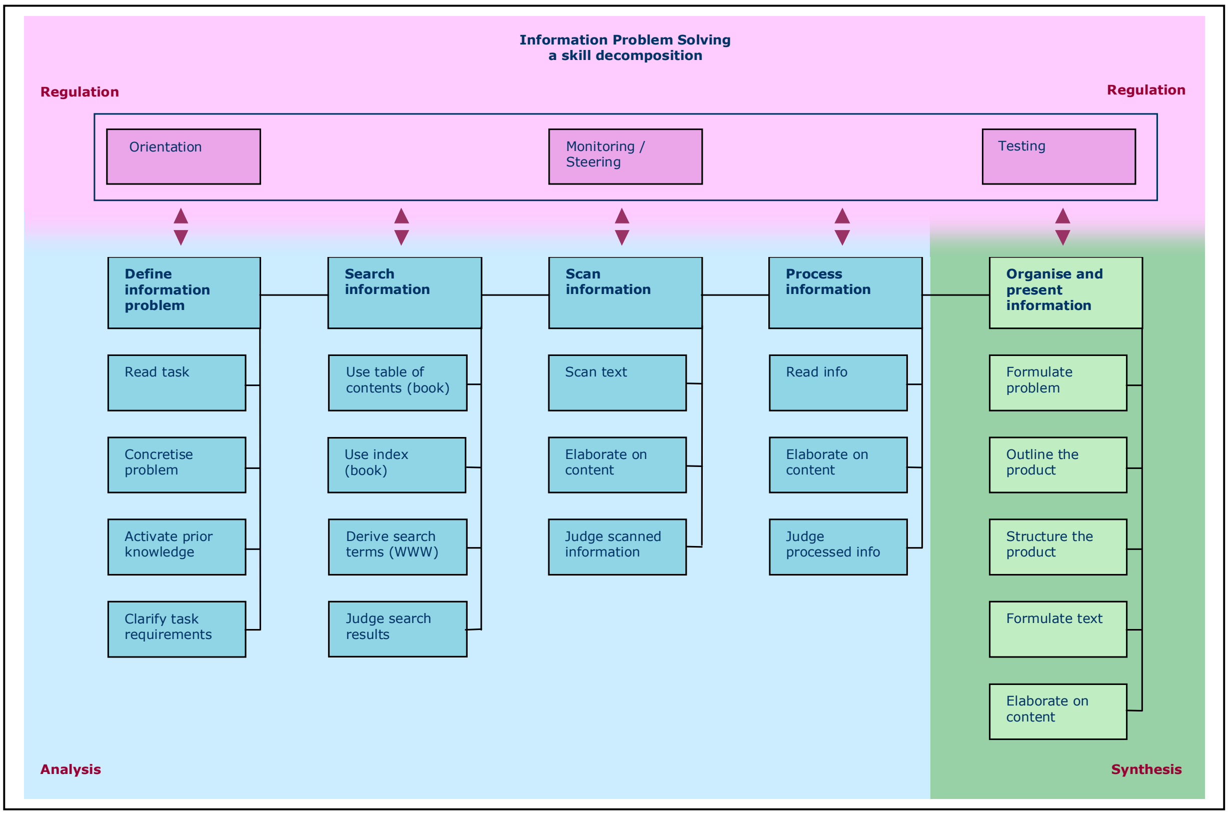

Table 1

Inter-rater Reliability (Cohen's Kappa) on the Constituent Skills and on Regulation

Protocol	Define problem	Search information	Scan information	Process information	Organize and present information	Regulation	Total
1	.87	.76	.85	1.00	.67	.58	.78
2	.75	1.00	.75	Not scored	.81	.62	.76
3	.60	.88	.58	1.00	.78	.60	.77
4	1.00	.79	.83	Not scored	.84	.56	.80
5	1.00	.63	.63	Not scored	.62	.40	.68
6	1.00	.65	.64	1.00	.66	.61	.68
7	.63	.79	.62	.65	.62	.56	.65
8	.65	.55	.63	.79	.63	.54	.63
Overall	.74	.76	.69	.89	.70	.56	

NB: Protocols 1 to 4 are scored by rater A and B, protocols 5 to 8 by rater C and D.

Table 2

Means and Standard Deviations of the Control and Experimental Condition on Prior Knowledge about Searching During the Pre-test

	Experimental group		Control group	
	M	*SD*	*M*	*SD*
Experience with searching in a library	2.13	0.99	2.20	0.45
Experience with searching psychological literature in a university library	3.25	0.89	3.20	1.30
Experience with searching psychological literature using Internet	3.13	0.83	2.60	1.14
Experience with searching psychological literature using special data-systems	3.75	0.46	3.75	0.50
Experience with Internet in general	2.25	0.71	1.80	0.84
Experience with Internet for study purpose	2.75	0.89	3.00	1.23

Table 3

Means and Standard Deviations of the Control and Experimental Condition on the Reported Regulation during the Pre-test

	Experimental group		Control group	
	M	*SD*	*M*	*SD*
Self regulation	2.29	0.80	2.76	0.52
External regulation	3.43	0.82	3.48	0.54
No regulation	2.40	1.18	2.60	1.09

Table 4

Differences in Time Invested in the Constituent Skills between Students of the Experimental and Control Group in Percentage of Time

	Experimental (*n* = 8)				Control (*n* = 5)			
	pre-test		post-test		pre-test		post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Define problem	3.59	1.13	5.02	2.16	5.78	1.75	6.33	3.20
Search information	15.74	9.99	16.13	5.05	19.72	6.23	17.01	19.39
Scan information*	35.23	20.68	35.32	17.60	37.03	7.89	22.04	14.09
Process information	23.99	21.92	13.65	16.02	5.38	6.42	15.11	10.12
Organize and present info.	21.46	11.40	29.88	22.59	32.10	9.32	39.51	24.29

*$p < .05$ (significant after the instruction)

Table 5

Number of Times a Skill was performed by Students of the Experimental and Control Condition

	Experimental				Control			
	Pre-test		Post-test		Pre-test		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Define problem	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
– Read task	1.75	1.04	1.88	0.84	1.20	0.45	1.60	0.89
– Concretize problem	1.13	0.84	0.75	0.46	0.80	0.84	1.20	0.45
– Activate prior knowledge	0.25	0.46	0.13	0.35	0.40	0.89	0.40	0.55
– Clarify task requirements	0.25	0.46	0.13	0.35	0.20	0.45	0.60	0.89
Search information	6.00	1.31	6.88	2.59	5.60	1.95	4.80	1.48
– Use table of contents (book) *	2.25	2.12	2.25	1.83	2.20	2.49	0.40	0.89
– Use index (book)	2.38	2.62	1.63	2.77	2.40	2.70	3.40	1.34
– Derive search terms (internet)	1.50	2.51	2.50	2.51	0.00	0.00	1.60	3.05
– Judge search results	3.13	5.41	4.50	5.83	0.60	0.89	3.80	5.93
Scan information	6.00	1.93	8.00	2.98	4.80	1.48	4.80	1.48
– Scan text *	19.75	14.91	19.25	6.67	15.60	7.73	8.00	4.12
– Judge scanned information *	18.63	15.83	15.00	4.17	15.00	11.51	6.80	5.02
– Elaborate on content	12.50	11.05	11.38	3.38	11.00	11.25	6.60	7.02
Process information	2.25	2.25	1.50	1.60	1.40	1.14	2.25	2.22
– Read	10.13	11.31	2.38	3.25	2.00	2.12	3.60	2.19
– Elaborate on content	8.25	8.63	3.25	4.06	3.20	4.09	4.40	2.70
– Judge processed information	6.38	6.52	2.75	4.98	3.00	3.54	2.40	1.52
Organize and Present info.	1.25	0.46	2.75	2.31	1.80	1.48	3.00	2.16
– Formulate problem	0.25	0.46	0.00	0.00	0.40	0.55	0.00	0.00
– Outline the product	1.63	1.19	1.00	1.00	1.20	1.10	1.00	1.20
– Structure the product	3.38	3.34	4.75	3.73	3.60	4.98	5.60	5.03
– Formulate text	7.63	5.21	12.00	5.56	7.20	5.31	13.60	13.53
– Elaborate on content	4.00	3.93	6.50	4.90	3.20	2.05	7.60	6.80

*$p < .05$ (significant after the instruction)

Table 6

Means and Standard Deviations for the Control and Experimental Students on the Regulation Variables in the Pre-test and Post-test

	Experimental				Control			
	Pre-test		Post-test		Pre-test		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Monitoring / Steering*	16.13	8.49	21.75	7.17	14.60	3.98	12.60	5.18
Orientation	19.13	12.44	15.50	6.70	14.60	6.43	9.40	7.80
Testing	3.75	5.12	2.38	2.20	3.40	3.44	4.80	7.98
Total regulation^{+}	39.00	22.55	39.63	10.65	32.60	9.32	26.80	13.48

*$p < .05$ (significant after the instruction)

$^{+}p < .10$ (significant after the instruction)