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Integration of the information problem-solving skill in an educational programme: The effects of learning with authentic tasks

Saskia Brand-Gruwel and Iwan Wopereis

Open University of the Netherlands

Correspondence concerning this paper should be addressed to Saskia Brand-Gruwel, Open University of the Netherlands, Educational Technology Expertise Center, PO Box 2960, 6401 DL Heerlen, The Netherlands. E-mail : saskia.brand-gruwel@ou.nl

Abstract

In education students increasingly deal with learning tasks that require them to identify information needs, locate information sources, extract and organise information from each source, and synthesise information from a variety of sources. These activities together can be defined as Information-Problem Solving (IPS). IPS instruction is needed, because students frequently use superficial strategies for searching and processing information. In this study IPS instruction is embedded in a competence-based teachers education programme. The effect of the integrated instruction on students' IPS process and task performance are determined. Analysis of thinking aloud protocols shows that IPS instruction has a positive effect on students' regulation activities, ability to clarify task requirements and needed information, and the ability to judge the quality of sources and information. Students also paid more attention to processing of information. Furthermore, an effect was found on task performance.

Keywords: Information problem solving, Instructional design, Regulation, Information seeking

Introduction

Presently, in education students are often confronted with learning tasks or assignments that require them to identify information needs, locate information sources, extract and organise information from each source, and synthesise information from a variety of sources. This set of activities can be defined as Information-Problem Solving[1] (Brand-Gruwel, Wopereis & Vermetten, 2005; Eisenberg & Berkowitz, 1990; Moore, 1995) and characterised as a higher-order skill. A higher-order skill refers to strategic knowledge and skills aimed at problem solving, inventive thinking, independent and meaningful learning (Perkins & Salomon, 1989), and can be conceived as a mental tool that students have at their disposal to make sure their own learning and thinking processes are effective and efficient.

The fact that IPS is a complex higher-order skill means that learning to solve information problems is more than just 'doing it' and that extensive and explicit instruction, designed according to a instruction design method for complex cognitive skills (e.g. Merrill 2002; Van Merrienboer, 1997), is necessary in order to acquire the skill (Brand-Gruwel et al., 2005). The aim of this study is to integrate IPS instruction in a competence-based educational programme and to determine the effect of the integrated instruction on the way students solve information problems, on students' task performance and to evaluate the new designed instruction in which authentic tasks play a central role. The hypothesis is that students who receive the integrated instruction will execute the IPS skill more accurate and explicit and deliver products of a higher quality than students who do not receive the instruction. Furthermore, it is expected that students who receive the instruction are positive about the integration of the IPS instruction in their programme and about the use of authentic tasks.

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1 In literature the term 'Information seeking' is often used as a synonym.

Before going into research concerning IPS instruction, we will describe the concept 'Information problem' and give an analysis of the IPS kill.

An information problem can be described as a problem that requires information for solving it, and that requires a person to define the problem, search for information, select and judge sources and information, integrate found information with prior knowledge and formulate a solution. Examples of information problems are: 'What time does the plane to New York on the 5th of February from the International Airport in LA leave?', 'Give an explanation of similarities between French and English vocabulary?', or 'Sometimes hailstones are as small as a grains of sugar and sometimes as big as golf balls. How can you explain this difference in size?' Information problems can be categorised; there are problems that require facts, problems that ask for a description of a construct, and problems that require connecting constructs. It may be obvious that fact finding is less complex than solving problems that require connecting constructs. Moreover, Mosenthal (1998) tried to classify problems by defining the type of information requested. This information can be persons, amounts, goals, causes, effects (or outcomes, results), evidences, opinions, explanations, equivalents and differences. Problems that require persons or amounts are most easy.

Solving an information problem comes down to using a set of constituent and regulation skills. Figure 1 presents a model for IPS, called IPS-I (cf. Brand-Gruwel et al., 2005). IPS-I stands for Information Problem Solving using Internet. It represents the skills needed for solving an information problem while using Internet for searching information. The model is based on the IPS process of 26 students who searched for information on the World Wide Web while thinking aloud.

Insert Figure 1 about here

The IPS skill consists of five constituent skills: define information problem, search information, scan information, process information, and organise and present information. As can be seen in the model all constituent skills can be divided into sub skills. For a more detailed description of the sub skills we refer to Brand-Gruwel et al. (2005). Furthermore, regulation is seen as an important aspect in the whole process. Especially, with the WWW as an extensive source of information source a strong appeal to peoples' regulation ability is made. Regulatory aspects such as planning, monitoring and evaluating play a key role in the execution of the skill (Boekhorst, 2003; Brand-Gruwel, et al., 2005; Hill, 1999; Lazonder, 2003).

Students are often assumed to develop the complex higher-order IPS skills by oneself. However, studies of Bilal (2000), Kafai and Bates (1997), Large and Beheshti (2000), Makinster, Beghetto and Plucker (2002) and Wallace, Kupperman, Krajcik and Soloway (2000) reveal that although students know how to use a search engine, students (young and old) do, for instance, have problems with identifying search terms and judging sources and information. Moreover, many people lack regulatory skills such as planning, monitoring and evaluating while solving an information problem and searching the WWW for information (Branch, 2001; Lazonder, 2000)

Only a few studies can be found concerning IPS instruction. Lazonder (2001) instructed children in basic search skills and self-regulatory skills but found that instruction in self-regulatory skills did not enhance performance on the search tasks. Britt and Aglinskas (2002) developed a computer application for teaching sourcing (identifying critical features of the source like author, author's position, date, document type etc), contextualisation (identifying relevant features of a source that can be useful in creating a context for historical information) and corroboration (checking facts or interpretations from one source against other sources) in the context of researching a historical controversy. Results show that the experimental condition outperformed the control condition and that sourcing skills improved. In a study by Stadtler, Bromme and Stahl (2005) adults with little medical knowledge were provided with evaluation and monitoring prompts while searching the WWW on a medical topic. Results reveal that adults' knowledge on sources, knowledge about facts, and comprehension improved. Colaric (2003) examined instructional treatments helping adults using a search engine, including specifying search terms. All instructional treatments were effective for increasing declarative, syntactic and semantic knowledge. Wopereis, Brand-Gruwel and Vermetten (2005) evaluated an instruction on IPS integrated in professional distance education skill training. Adults in the experimental condition were taught how to solve information problems and regulated their IPS process efficiently, using the model of Brand-Gruwel et al. (2005). After the instruction students of the experimental condition judged information and regulated the process more often than students of the control condition.

These examples of instruction focussed mainly on parts of the IPS skill. Most interventions are on searching, scanning information and on regulation and do not included instruction in how to define the problem or how to process the information. From the fact that only a few studies focus on IPS instruction it can be concluded that promoting and stimulating IPS in educational settings is not self-evident. The next question that arises is: How can IPS instruction best be designed, keeping in mind that the IPS skill can be characterised as a higher-order skill?

In general, there are various opinions about how instruction can be designed in order to enhance students' higher-order skills. Some researchers argue that higher-order skills can be learned in specially designed courses, because the skills are the same across disciplines (e.g. Paul, 1992). On the other hand Mc Peck (1981) states that generalisable thinking skills do not exist, and thus critical-thinking skills cannot be learned in isolation from a subject. In this line of thinking Brown (1997) has the opinion that higher-order skills must be taught in the context of a specific subject matter, in such a way that transfer to other domains is possible. Brown points out the importance of using real-life problems, because it motivates and stimulates active involvement. Moreover, Ten Dam and Volman (2004) reviewed empirical research to answer the question: which instructional strategies are 'effective' in enhancing critical thinking; a higher-order skill? They found that characteristics of instruction assuming to enhance critical thinking are: paying attention to the development of the epistemological beliefs of students; promoting active learning; a problem-based curriculum; and stimulating interaction between students. They also conclude that special 'critical-thinking programs' (i.e. higher-order skills) are usually not resulting in transferable and durable effects. This confirms the subject-specificity position as posed by Brown (1997). In our study be take this subject-specificity position as a starting point

The aim of the study is to find out what the effect of the integrated IPS instruction is on students' IPS process (that is the use the different constituent skills, sub skills and reflection activities) and on the task performance. Students' prior WWW knowledge will be taken into account, to control for possible moderation effects. The hypothesis is that students who receive the integrated instruction will execute the skill more accurate and explicit and deliver a product with more quality than students who do not receive the instruction. Furthermore, the IPS instruction will be evaluated to gain insight in how instruction in IPS can be best designed.

Method

Participants

Sixteen students (15 female, 1 male; mean age 21.13, *SD*=1.86) from two teacher-training colleges for secondary Dutch language education in the Netherlands participated in this study.

Ten students from one college formed the experimental condition and five students from the other college formed the control condition.

Materials

Intervention. As a part of their educational programme students in the experimental condition received a resource based-learning course about dyslexia in which IPS instruction was integrated. The course was set up according to the 'Four Component Instructional Design (4C/ID) model' (Van Merriënboer, 1997; Van Merriënboer, Clarke & De Croock, 2002). The 4C/ID model provides guidelines for designing instruction for learning complex cognitive skills. One of the main assumptions is that complex skills should be learned by completing authentic and comprehensive tasks. In this section the intervention will be described according to the four components of the 4C/ID-model.

The first component is *learning tasks*. Learning tasks in the 4C/ID-model can be characterised as authentic, comprehensive and whole tasks. They require from students to perform all the constituent skills that make up the whole complex skill during task performance. Learning tasks are organized in a sequence of task classes, representing simple-to-complex versions of the whole task. In a task class all tasks are of the same complexity level. In this study students worked at one set of four authentic IPS learning tasks (one task class). Each IPS learning task was equally complex. The complexity level of the task class was determined by matching complexity factors of IPS (Brand-Gruwel, et al. 2004) with students' IPS ability level or actually their zone of approximate development. An example of a factor is: the problems described in the tasks require the connection of concepts. The embedded instructional support faded across the learning tasks within the task class. During the first learning task the support level was high. A subject matter expert modelled IPS performance and demonstrated in front of the students the completion of an IPS task and highlighted critical aspects of the IPS process. The information problems in the remaining three tasks had to be solved by the students themselves, but in the second and third task the level of support decreased. These tasks can be typified as completion problems: selected information and steps with regard to task completion were presented to the students in the study materials. The amount of information given diminished across the two tasks. The last task was a conventional problem. Apart from the structure (main IPS steps) no instructional support was given to the students in this task. Figure 2 presents the fourth learning task.

Insert Figure 2 here

The second component of the 4C/ID-model is '*Supportive information*'. This information is presented to the students to master the heuristic or non-routine aspects of the skill. Since most of the part skills of IPS are non-routines this component of the 4C/ID model is important. Two types of supportive information were provided to the students: (a) cognitive strategies, presented to the students as SAPs: Systematic Approaches for Problem solving in process worksheets and (b) mental models about IPS, presented as schemata and text in a reader.

Process worksheets were designed to support the IPS process of the students. For each step (based op the SAPs) of the IPS process guiding questions were formulated to help students to focus on solving (parts of) the information problem and monitoring the IPS process (regulation). For instance, a question in the SAP of 'define problem' was: Make a mind map of your prior knowledge.' In the first task the answers on guiding questions were given, but in the remaining tasks students had to answer them by themselves. The amount of guiding questions (i.e., instructional support) faded from the second till the fourth task.

Information to build up an advanced mental IPS model was provided in a reader. For each step and for regulation the reader included declarative, procedural and strategic knowledge.

The third component of the 4C/ID-model is *Procedural information.* This information is presented just in time to support the performance of routine aspects of the skill and can be characterised in terms of 'how to' instruction. Because the IPS skill does not have many routine aspects this kind of information was not explicitly provided. Routine aspects in the process are for instance using an Internet browser. It was expected that students do know how to use a browser. Furthermore, information about the use of other available electronic databases could be asked at the library employer.

The last component is called *Part-task practice*. Part-task practice is necessary when students need to learn new routines; which require a very high level of automatism. When the learning task cannot provide enough practice to reach the required performances level, part-tasks may offer the solution. In the IPS skill routines requiring a high level of automatism do not exist.

WWW Knowledge Questionnaire. To control for possible interference of students WWW knowledge a ten-item multiple-choice questionnaire was developed. Three items measured knowledge of search engines (Cronbach's alpha .77). An example of a question was: 'When using the word 'or' in a search engine you will get _________ hits than when you use the word 'and'? a) less; b) the same amount of; c) more; d) I do not know'. Seven items examined the students' knowledge of web browser use (Cronbach's alpha .73). Pictures of elements of the web browser were presented and students were asked if they knew and used this functionality. For instance: 'Do you know what the refresh button (picture) does and if so, do you use it?'

Tasks used to measure the IPS skill. To measure how students solve information problems, the participants received during the pre-test and the post-test an IPS task and were asked to think aloud while completing the task (in 60 minutes). The design of both tasks was identical: students were asked to solve an information problem and -as a result- had to produce an outline for a magazine article of 400 words. For searching information students had access to the WWW; for constructing the outline MS-Word could be used. Since the two IPS tasks were aimed at measuring the IPS skill, neutral topics were chosen. The IPS task of the pre-test was about how we must deal with the perishableness of food. The post-test IPS task was about the reliability of human memory. Although the topics seem quit different the tasks were of equal complexity according to the task complexity levels of Mosenthal (1998). In our case both tasks requires information that can be typified as evidence. Evidence to show that we must take the description ‘best before’ on food serious and evidence to show that our memory may be unreliable. Furthermore Mosenthal (1998) distinguishes different kind of tasks (locate task, cycle task, integrate task and generate task). Both tasks in this study can be characterised as an integrate task. Different pieces of information (opinions) must be integrated to come to an answer.

Prior knowledge measurement of topic pre-test and post-test IPS task. To control for prior knowledge on the subject matter of the pre and post-test task (perishableness of food and human memory respectively), students were asked to ventilate their knowledge of the topic by writing down statements. Domain knowledge can interfere with the IPS process; for instance, more domain knowledge makes it easier to derive search terms. For each task the statements were classified into five categories. These categories were derived from the statements student gave. The categories for the perishableness of food were: (a) definition or aspect of perishableness, (b) store’s policy, (c) tips for food storage, (d) food control authorities, and (e) perceptions about how to deal with perishable food. The categories concerning human memory were: (a) working of the brain, (b) types of memory, (c) how memory can be influenced negatively, (d) how memory can be influenced positively, and (e) diseases.

Coding system to analyse the thinking aloud protocols. The system to analyse the thinking aloud protocols was developed in earlier studies (Brand-Gruwel et al., 2005; Wopereis & Brand-Gruwel, 2005) in which together 26 protocols of adolescent and adult students were involved. An inductive-deductive method was used to develop the coding system for analysing the thinking aloud protocols. So, this means that the coding system was based on the protocols and the literature, and was tested and re-adjusted 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, organised in three columns that were scored simultaneously. In the first column, the constituent skills were scored in an exclusive and exhaustive way. Also the time invested in the constituent skills was administered. In the second column, the sub skills of each constituent skill were scored. Only the sub skills belonging to the constituent skill scored in the first column could be used. In the third column regulation activities were scored. These activities could be scored independently of the scoring in both other columns. Overall, the variables measured with this coding system are the constituent and sub skills, and regulation activities presented in Figure 1. As said, this coding system is developed and tested in studies by Brand-Gruwel et al. (2005) and Wopereis and Brand-Gruwel (2005). In the first study two trained raters scored six protocols and the video registrations by using the coding system. The interrater reliability (Cohen's Kappa) was calculated for these protocols and the raters reached consensus on the statements they disagreed on. In the second study four trained raters following the same procedure scored in pairs eight protocols and the video registrations. Table 1 gives an overview of the interrater reliabilities on the main skills, sub skills, and regulation for both studies.

Insert Table 1

Form to score the quality of the outlines (Task performance). With a form of 19 items the quality of the outlines was determined. The items were distributed among four categories: the structure of the outline (6 items), the quality of outline (9 items), the prerequisites taken into account (3 items), and the layout (1 item). A five-point Likert scale was used to score 17 items. Two items were scored on a dichotomous 'yes/no' scale. Examples of items were: 'Is there a title?' (yes / no),' The information for writing the outline is sufficient', 'With the information found the main question can be answered', and 'The information found is consistent' (1 = totally disagree, to 5 = totally agree).

Evaluation of the IPS-instruction. To evaluate the IPS instruction students filled out an evaluation form after completing a task. The questions / statements that will be reported in this study were: 1 The problem addressed in the task is relevant and interesting, 2) The task was instructive / helpful, 3) The task description was clear, 4) The task was of an appropriate level, 5) This task approach is an enrichment for education, 6) The task provided a contributing to my learning process, 7) The time set for the task was sufficient. On a five point Likert scale students indicated the level of agreement (1= totally disagree, 5 = totally agree). At the end of the course a focus group was held to let students respond on the instruction. The evaluation forms formed the input for the discussion during the session.

Design and Procedure

The study used a pre-test post-test control-group design. Five students from one college formed the control condition and the eleven students of the other college the experimental condition. During the pre-test prior students' WWW knowledge was measured and all students accomplished the IPS-task (perishableness of food) while thinking aloud, after students' prior knowledge on this topic was administered. During all sessions, which were individual, all computer actions, including Internet use, and the thinking aloud expressions of the participant were recorded on digital video. The product -an outline- the students had to deliver was stored. After the pre-test students in the experimental condition received the IPS instruction (10 weeks, 80 hours study time). During these weeks eight meetings of two hours were held to discuss students' progress and provide feedback on their products and process. The students in the control condition attended their regular programme. Learning IPS was not part of this programme. During the post-test the same procedure was followed as during the pre-test.

Results

Prior WWW knowledge. The pre-test results (t-tests) revealed no significant difference between the students in both conditions. Both groups of students scored similar with regard to knowledge of using search engines (exp.: M=1.70, *SD*=1.16; control: M=1.80, *SD*=.84) and knowledge of using a web browser (exp: M=5.20, *SD*=1.69; control: M=5.80, *SD*=1.64). So, it was not necessary to take these variables into account in the remaining analyses.

Prior knowledge of the topic of the pre-test and post-test IPS task. Before working on the IPS task during the pre-test students' prior knowledge about perishableness of food was scored.

The students in the experimental condition generated on average 1.50 statements (*SD* 1.08) and the students in the control condition 1.40 (*SD* 1.14). This difference was not significant. In both conditions most statements were about the definition or aspect about the perishableness of food and about tips for food storage. The task students accomplished after the instruction was about the reliability of human memory. The students in the experimental condition generated on average 2,3 statements (*SD* 1.16) and the students in the control condition 2.20 (*SD* 1.10). This difference was not significant. So, prior knowledge had no effect on the task performance during the pre-test and the post-test.

Time Investment in the Different Skills. Knowing that no differences were found between the condition on prior WWW knowledge and on the topic of the used IPS-tasks, students thinking aloud protocols were analysed. Table 2 shows the means and standard deviations of the time investment in the constituent skills by the students in both conditions. The time investment in this Table is given in percentages. Figure 3 provides a graphical representation of the results.

Insert Table 2 about here

Insert Figure 3 about here

Students in the experimental condition spent an average of 44.64 min. (*SD* = 15.03) in order to complete the pre-test IPS task. The average time spent by the control condition was 55.32 min. (*SD* = 7.50). This difference was not significant. Furthermore, no differences between the two conditions with regard to time investment in the constituent skills were found. So, the pre-test data was not used as a co-variant while analysing the post-test data. During the post-test students in the experimental condition completed the task in an average time of 33.70 min (*SD* = 12.07), and students in the control condition used an average of 40.99 min. (*SD* = 8.97) for task completion. This difference was not significant. Although, differences in time spent on ‘Defining the problem' and 'Processing information' can be seen between the conditions during the post-test, these differences were not significant due to high standard deviations in both conditions.

Differences in the Frequency of Use of the Constituent Skills and Sub Skills. Table 3 presents an overview of the number of times constituent skills and the accompanying sub skills were performed by students in both conditions during the pre-test and post-test.

Insert Table 3 about here

Looking at the frequencies of the constituent skills and sub skills in Table 3 it can be concluded that the IPS process is iterative, which is consistent with other research on this subject (Brand-Gruwel et al., 2005). Especially after defining the problem students go back and forth between searching and scanning information.

Before determining whether the IPS instruction brings about changes in the student's ability to solve information problems t-tests were conducted to check whether there were differences between the conditions in the pre-test. Only significant differences were found on the sub skills 'Formulate text', $t(14)=-3.12$, $p<.05$, and 'Outline the product', $t(14)=-2.27$, $p<.05$ of the constituent skill 'Organise and present information'. Students in the control condition scored higher than the students in the experimental condition. For these variables co-variance analysis were used to determine the effect of the IPS instruction. For the other variables t-tests were used.

For all participants the constituent skill '*Define problem'* occurred only once, namely 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 regulation is 'orientation') and not as 'define problem'. Furthermore, during the post-test students in the experimental condition were more focused on the requirements of the task, $t(14)=3.13$, $p<.01$ and determined needed information more often,

$t(14)=2.75$, $p<.05$. For the constituent skill '*Searching information*' and it sub skills it appears that during the post-test students of both conditions did not significantly differ in how often they used these skills. On the constituent skill '*Scan information*' both condition did not significantly differ from each other after the instruction. However, a significant difference was found on the sub skill 'Judge source', $t(14)=3.43$, $p<.01$. The students in the experimental condition often thought about the reliability, actuality and relevance of sources. After the instruction the students in the experimental condition *processed information* more often than students from the control condition, $t(14)=2.52$, $p<.05$. Furthermore, the analyses showed on the sub skills 'Judge processed information' a significant difference, $t(14)=2.68$, $p<.05$. During the post-test no significant difference was found between the experimental and control condition with regard to the constituent skill '*Organise and present information'*. As mentioned, during the pre-test significant differences were found on the sub skills 'Formulate text' and 'Outline the product'. For these variables co-variance analysis were used to determine the effect of the IPS instruction, but no significant differences were found.

Effects on regulation. The analysis of the protocols gave insight in how often students regulate their ongoing process. Table 4 presents the mean and standard deviation with respect to the regulation variables for both conditions in the pre-test and post-test.

Insert Table 4 about here

Analyses revealed no significant differences between the conditions on the regulation variables measured during the pre-test. T-tests showed that during the post-test the students in the experimental condition regulate their ongoing process more often, $t(14)=2.48$, $p<.05$. When taken a closer look to the regulation variables no significant difference was found between the conditions concerning monitoring and steering the process, but the experimental students oriented more during the process, t(14)=2.18, $p<.05$, and also tested the process and the product more often, t(14)=2.47, $p<.05$.

The quality of the outlines. Table 5 presents the means and standard deviations for the experimental and control condition on the product variables.

Insert Table 5 about here

In the pre-test students in the experimental condition scored significant higher on 'Layout', t(14)=3.14, $p<.01$. On the other variables no significant differences were found. Furthermore, two items were scored with yes or no. Whereas four of the five students in the control condition formulated a title (80%), only 60% in the experimental students did. This difference was not significant, $\chi^2(1,N=15) = 0.60$, $p>.10$. Only 20% of the students in the experimental condition and 60% of the control students referred to sources. This difference was also not significant, $\chi^2(1,N=15) = 2.40$, $p>.10$. During the post-test students in the experimental condition scored significantly higher on the 'Quality of the outline', t(14)=2.14, $p<.05$, and on 'Task requirements', t(14)=3.62, $p<.01$. No difference was found on 'Structure of the outline' and on 'Layout'. For this latter variable co-variance analysis was conducted, because of the significant differences in the pre-test. In both conditions 60% of the students formulated a title. 40% of the experimental students and 20 % of the control students referred to sources. These differences were not significant.

Evaluation of the instruction. The students filled out four evaluation forms (one after each task). Table 6 gives an overview of the mean score and standard deviations for the four tasks together.

Insert Table 6 about here

As can be seen students were overall positive about the integrated IPS-instruction. The focus group discussion gave us more insight in how to improve the instruction and addressed design questions that are also important for future research. Students found it especially interesting to work with realistic problems and professional tasks. The process worksheets made students aware of the steps to be taken and students also mentioned that their process became more structured. On the other hand the sheets were to directive and students found the steering to tight. The reader with supportive information is not used proper. Students said that they look up thinks like how to search more efficient, but it was not used as supposed by the researchers. Problem appeared to be that students are unaware of their IPS incompetence. Students are convinced that they are expert searchers, but when giving them a mirror, they realise that the IPS process is not as smoothly as can be. They have to become aware of their competence and that the level of competence can be improved. Students suggested starting the instruction with the mirror and discussing the IPS process of the students more in depth, in order to adapt the instruction and the support to the students' ability and needs.

Discussion

In the present study the effect of integrated instruction in IPS (as part of whole task professional skill training) is determined. The aim of the study was to find out what the effect of instruction was on the execution of the IPS skill and on the products of the students. Time investment in the constituent skills and frequencies of skill performance on a pre-test and post-test were calculated to measure differences between students who received the embedded instruction and those who did not. Our hypothesis was that students who received the integrated IPS instruction would execute the IPS skill more accurate and explicit than students who did not. Moreover we expected that students in the experimental condition would regulate the process more often after the instruction and that the quality of the products would be better.

The results indicated that after the instruction students in the experimental condition spent more time on defining the problem and processing the information. However, due to high standard deviations in both conditions these differences in time investment were not significant. It can be concluded that the time spent on defining the problem was low. This indicates that students are not yet experts in IPS. Research of Brand-Gruwel et al. (2005) revealed that experts spend considerable 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.

With regard to the frequencies of constituent skills and sub skills it can be concluded that students in the experimental condition take the task requirements and the needed information more into account. They also judge sources more often. Especially the judgment of sources is regarded as an essential sub skill in the IPS process (e.g., Candy, Crebert, & O'Leary, 1994). Wallace, Kupperman, Krajcik and Soloway (2000) for instance found that sixth graders had difficulty evaluating Internet sites and extract relevant information for accomplishing a task. It is important to teach students how to evaluate sources and give them criteria for evaluating sources.

Results revealed no differences between the conditions for the constituent skill 'Search information'. However, what strikes us most is that students in both conditions struggled with identifying and structuring useful keywords and keyword phrases. They did hardly use the keywords in the task description as search terms, they used the same search terms over and over again, they did not narrow search terms when it was necessary, and they did not keep a record of used terms. These findings are consistent with earlier research (MaKinster, Beghetto, & Plucker, 2002). More instruction is needed, because using the appropriate search terms -especially when one is a novice on the topic- makes a difference.

Furthermore, it was found that students in the experimental condition spent a more time processing the information than students in the control condition. Processing information is very important for meaningful learning. However, it is often seen that students learn in a more surface way, especially when using a source as the WWW, which encourage a fast and surface way of working and learning.

Results reveal a positive effect on the number of times students regulated their IPS process. After receiving the instruction the students in the experimental condition oriented more on the task and task requirements and tested their process more often. Being fully aware of regulation means 'pouncing on the process' and this has a positive effect on the quality of the regulation. Studies by Hill (1999), Land and Greene (2000) and Marchionini (1995) reveal that the quality of regulation is related to the effectiveness and efficiency of IPS process. So, it can be stated that the embedded IPS instruction had a positive effect on the regulation of the IPS process.

The instruction also had a positive effect on the task performance. Compared to the students in the control condition the quality of the outlines from the students in the experimental condition was higher and the task requirements were better incorporated.

A limitation of this study is the number of participants. Only ten students followed the instruction and only five students functioned as a control condition. So, it is not allowed to generalise the results. However, results found are in line with other research as mentioned in the first part of this discussion.

We can conclude that in a curriculum embedded instruction in IPS is effective and can guide students in becoming an expert. But more adaptive instruction is needed, as mentioned by the students during the focus-group session. Students often are unaware of their incompetence and must be aware of their own ongoing process and the troubles the have to become a real expert in IPS. Different students face different problems and instruction must be adaptive and take the expertise level of students into account. More research on how the expertise level of students can be assessed and how instruction can be designed in an adaptive way is recommended.

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Figure 1

The Information-Problem Solving using Internet Model (IPS-I model) (based on Brand-Gruwel, et al., 2005)

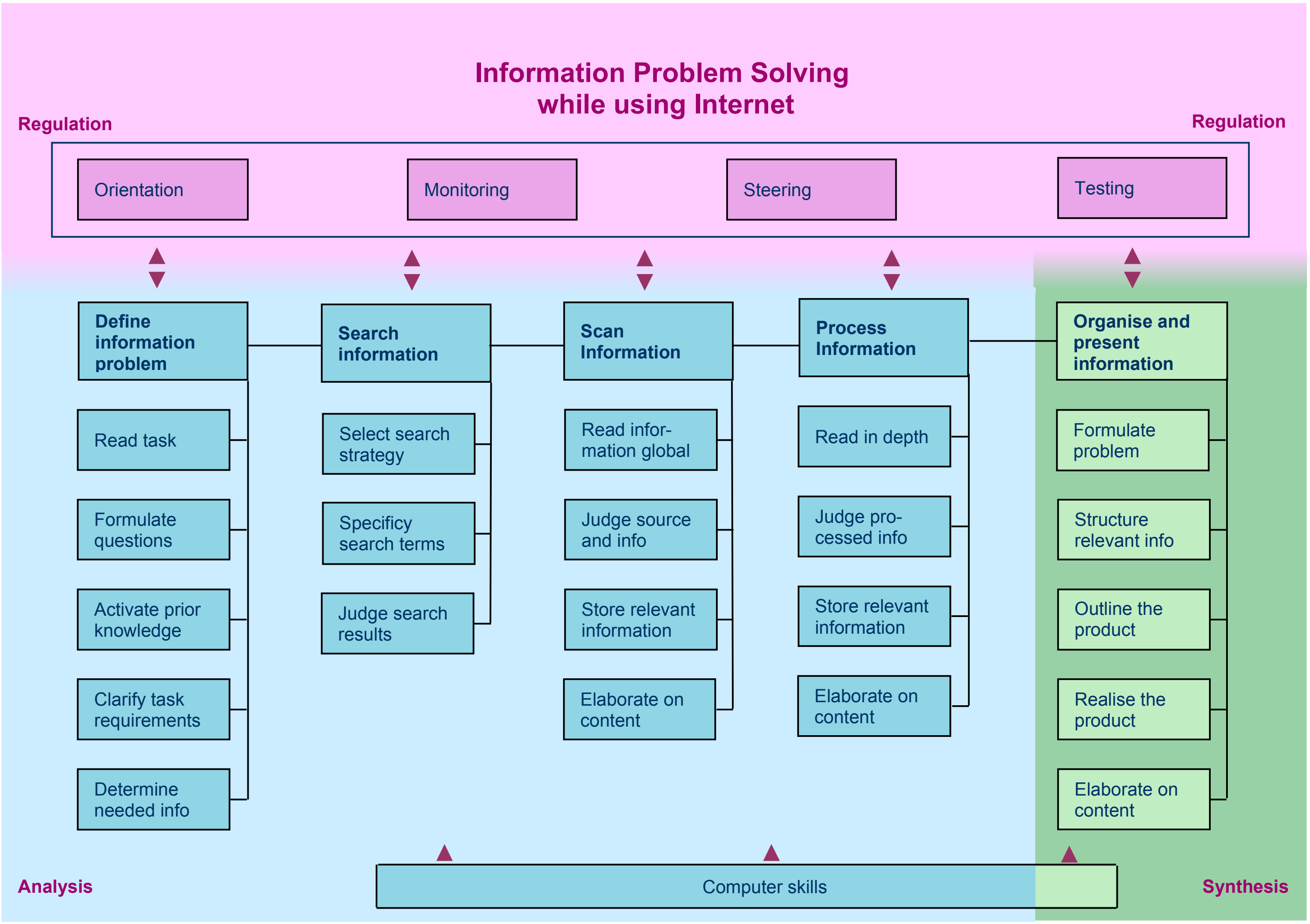
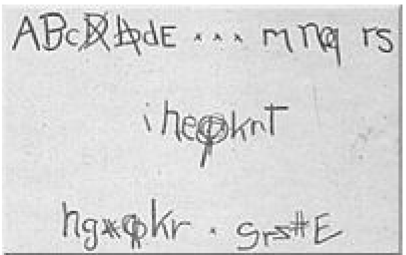


Figure 2
Task 4 of the IPS Task Class

Task 4: Inform parents and other person interested about dyslexia



On the school you are working all grade 9 students will, as usually at the beginning of the year, be tested on dyslexia. The test results suggested that there are students with serious linguistic and spelling problems, which can indicate dyslexia. In school children with dyslexia get intensive guidance and support. But not only in school also outside school all kind of agencies are available and offering treatments for children and information for parents or guardians about how to help the children. For parents and other person interested the school organises an information gathering about dyslexia. Two speakers will provide the audience with information about dyslexia. A psychologist will take about what dyslexia is and possible treatments. The schools remedial teacher will talk about the school policy in this matter and about what parents can do together with the teachers to help and guide their child. Because the audience will get a lot of information the schools principal asked you as a language teacher to write a brochure that can be handed out in which the information is brought together.

Figure 3.

Graphical Representation of the Differences in Time Invested in the Constituent Skills

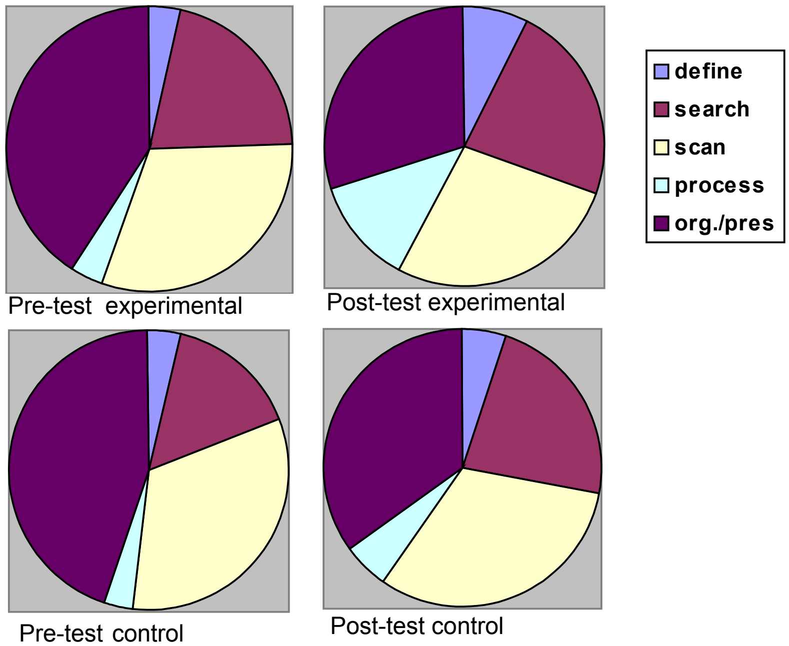


Table 1
Interrater Reliability (Cohen's Kappa) on the Main Skills and on Regulation calculated in previous studies.

	Study Brand-Gruwel et al. (2005)	Study Wopereis & Brand-Gruwel (2005)
Define problem	.64	.74
Search information	.72	.76
Scan information	.63	.69
Process information	.63	.89
Organise and present information	.66	.70
Regulation	.63	.57
Total	.70	.73

Table 2

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

	Experimental (n=10)				Control (n=5)			
	Pre-test		Post-test		Pre-test		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Define problem	3.52	1.61	7.89	3.26	3.77	1.08	5.24	2.05
Search info	20.93	9.14	22.58	11.63	15.64	4.46	22.84	10.20
Scan info	30.91	10.67	26.91	9.84	32.27	6.20	31.29	10.21
Process info	3.46	3.48	12.43	10.33	3.35	2.24	5.54	6.39
Organise/present info	41.18	12.21	30.19	10.97	44.97	8.43	35.08	21.88

Table 3

Number of Times a Skill was Performed by Students in 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	1.00	0.00	1.10	0.31	1.00	0.00	1.60	1.34
– Concretise problem	0.40	0.70	1.70	0.95	0.80	0.84	1.20	1.10
– Activate prior knowledge	0.00	0.00	0.60	0.84	0.00	0.00	0.20	0.45
– Clarify task requirements **	0.20	0.42	1.20	0.79	0.60	0.55	0.20	0.45
– Determine needed information *	0.40	0.60	1.00	0.67	0.20	0.45	0.20	0.45
Search information	12.80	3.82	17.20	6.03	14.6	7.50	20.00	11.94
– Search strategy	3.33	2.89	2.90	2.72	4.15	3.67	5.00	4.35
– Derive search terms (internet)	8.00	4.03	9.40	3.53	6.20	6.22	9.00	5.15
– Judge search results	15.90	5.49	21.20	7.36	15.60	8.14	23.60	13.43
Scan information	16.3	5.62	20.10	5.43	21.60	8.47	24.60	13.67
– Scan text	23.60	8.93	25.10	8.03	26.20	9.01	31.00	14.40
– Judge source **	0.80	1.23	4.50	2.59	1.20	0.84	0.40	0.55
– Judge scanned information	4.80	3.61	6.30	6.70	2.00	1.22	6.60	5.19
– Elaborate on content	1.40	1.35	3.70	2.91	0.40	0.55	1.80	1.92
– Store relevant information	3.70	2.16	5.30	3.50	5.40	1.52	7.00	3.54
Process information *	1.10	1.10	4.40	3.83	1.80	1.10	1.20	0.84
– Read	2.00	2.26	8.30	10.41	1.60	1.14	1.60	1.14
– Elaborate on content	0.80	1.03	5.70	9.10	0.80	1.10	1.40	1.14
– Judge processed information*	0.40	0.70	1.20	1.40	0.60	0.55	0.20	0.45
– Store processed information	0.60	0.70	1.60	1.58	0.20	0.45	0.60	0.55
Organise and Present info.	7.20	3.33	9.40	3.95	12.80	4.02	11.00	4.53
– Outline the product	5.60	2.42	7.70	3.47	8.60	2.41	7.20	3.77
– Structure the information	2.80	3.16	2.50	2.12	3.40	2.19	4.80	2.95
– Formulate text	5.60	2.55	6.20	7.88	11.40	4.77	6.20	1.79
– Elaborate on content	2.00	1.63	5.00	4.78	3.80	1.65	3.80	1.92
– Make references	0.50	0.70	2.00	1.33	2.40	3.36	0.40	0.89

* $p<.05$, ** $p<.01$ (significant effect after the instruction)

Table 4

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	10.50	4.06	13.90	7.99	11.80	2.77	8.40	4.88
Orientation	4.30	3.05	9.50	5.38	5.20	3.63	4.80	2.95
Testing *	1.00	0.67	2.40	2.22	1.80	1.79	0.40	0.89
Total regulation*	15.80	6.05	25.50	12.66	18.80	4.49	14.40	4.45

* p<.05 (significant after the instruction)

Table 5

Means and Standard Deviations for the Control and Experimental Students on the Product 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*
Structure of the outline Max. score = 25	16.10	2.23	17.90	4.58	13.60	4.77	13.60	4.04
Quality of the outline * Max. score = 45	25.20	7.69	31.67	8.91	21.80	7.33	23.40	5.55
Task requirements ** Max. score = 10	6.90	1.10	7.00	0.94	6.80	1.10	5.60	0,55
Layout Max. score =5	3.80	0.42	3.80	0.63	2.80	0.84	3.00	1.00

* p<.05, ** p<.01 (significant after the instruction)

Table 6
Mean and Standard Deviations on the Items of Task Evaluation Forms

	Experimental (N=10)	
	M	*SD*
1) The problem addressed in the task is relevant and interesting	4.2	0.63
2) The task was instructive / helpful	3.7	0.95
3) The task description was clear	4.1	0.57
4) The task was of an appropriate level	4.0	0.82
5) This task approach is an enrichment for education	3.5	1.08
6) The task provided a contributing to my learning process	4.1	0.99
7) The time set for the task was sufficient	3.8	0.92