Information Problem-Solving Instruction

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1. Introduction

The impact of the Internet Age has prompted a paradigm shift in education. Nowadays most of our everyday learning is characterized by drawing knowledge from a wide variety of electronic resources. Learners from different levels are required to search, collect, and understand information from digital external sources and construct a solution to solve a task. This shift has never been more noticeable than amidst the current coronavirus pandemic. In this context, it is important to remember that educational research has identified information problem solving (henceforth IPS) as a complex process that requires the unfolding of complex higher-order cognitive skills, e.g., [1][2][3].

Although it is undeniable that younger generations of students appear to master the skills needed to navigate online digital resources, educational research confirms that, without explicit instruction, students underuse or even lack the IPS skills to find correct and reliable online resources and construct knowledge from them [4][5][6][7]. Therefore, educational research sees the need to provide students with adequate IPS skills to learn from online and digital resources. Furthermore, [8] claim that IPS skills instruction is crucial to promote quality, equality, and sustainable education because it has been found that students' performance in digital skills is initially associated with their socio-economic background, academic achievement and residence location.

Various theoretical models have been proposed to characterize the phases and the cognitive processes involved in IPS that are needed to transform the retrieved web information into knowledge [9]. However, these models describe the stages and cognitive competences involved in the process, but fail to show which the students' specific activities are in each stage and how to best support them. As a consequence, educational institutions and teachers find it difficult to teach the key IPS skills that could help students take full advantage of the opportunities the Internet provides for learning and building knowledge autonomously from online digital resources and in finding a suitable place and time in the curriculum [3][5].

In recent years, research has been carried out to analyse the effectiveness of teaching IPS using the Internet, e.g. [10][11][12][13]. However, further research is still needed to tailor the existing IPS models to specific groups of students and in specific learning contexts [3][9] and, by so doing, promote quality and sustainable education for all students.

Information problem solving (IPS) is a complex cognitive process considered as an important 21st century skill in combination with critical thinking [14]. [1][2][3]have defined a five-step approach to solving information problems based on a decomposition of the IPS process into constituent skills and subskills. This approach highlights the fact that during the implementation of all skills it is essential to activate regulation activities, such as orientation, monitoring, steering, and evaluating [15][16].

Figure 1. Five-step systematic approach to information problem solving, based on: [1][2][3].

Figure 1 shows this IPS model. Basically, it represents that, when students are confronted with an information problem or challenge. Considering that the resolution of the task as the solution to an information problem from online sources implies a complex cognitive process [12][15], in which secondary students face many challenges, it is essential for them to receive guidance and supervision through a well-designed educational intervention.

2. Types of Information Problem Solving Instruction

It is often claimed that the IPS skills are underdeveloped or absent without explicit instruction, even among “digital natives” [1][3][4][5][6][15]. However, educational research shows that students can be instructed to define better the problem and the information needed, generate more relevant search queries, adopt more evaluation criteria, select higher quality resources and deeply processed and presented information to answer an informational problem [10][17].

Over the last decades much effort has been made to investigate efficient instructional approaches for IPS and incorporate effective support for guiding students’ activity in searching, retrieving, evaluating and integrating information from multiple web sources (e.g., [3][4][10][11][12][13][15][18]). However, despite the researchers’ efforts made so far, their attempts have proved insufficient and further research is still needed in order to face and shed light on how formal IPS skills training could be designed in order to have a positive impact on student’s learning.

Our study is built on the basis of the four-component instructional design (4C/ID, for short) model [19] to design, implement and empirically test an innovative IPS instruction in secondary education. The 4C/ID model advocates the design of four components:

a. Learning tasks are understood as authentic real-life tasks and their solution requires the integration and coordination of skills, knowledge and attitudes.
b. Both supportive information and guidance are needed to develop cognitive models and strategies in order to complete the learning task.
c. Procedural information has to be carefully designed by providing step-by-step instruction and explicit skills and procedures.
d. Part-task practice should be included to provide enough training for recurrent skills.

In the arena of IPS instruction these four components have been translated according to the following principles: whole-task, embedded, and long-term instruction.

2.1. Whole-Task IPS Instruction

Whole-task instruction proposes the resolution of ill-structured, authentic and complex real-life situations in which students have to perform all the steps of the IPS process, from beginning to end, and students can find different ways to solve the task. A whole-task instruction has proved more effective to teach IPS complex skills than part-task fragmented instruction [10][19]. Whole-task instruction offers the possibility to provide support for all the IPS skills and practise them as a whole process in which one skill relates to and impacts on the others. By contrast, instructional approaches that focus only on practising specific searching or evaluating skills, e.g. [20], offer students very few occasions to coordinate and integrate all of the five IPS skills [19], and also to transfer [21].

Regarding the support needed, research provides evidence that it is possible to build on whole-task support to improve students' IPS skills in demanding learning and learning that is difficult to be achieved successfully [11][12][22][23][24]. The main approaches for giving support in IPS instruction and the outcomes obtained are the following five: driving questions, prompting, content representations tools, processing worksheets, and writing and communicating support.

2.2. Embedded Instruction

Embedding IPS training within a meaningful context with domain-specific instruction has proved more effective than standalone courses [25][26][27]. Embedding instruction has the potential to increase engagement, motivation, transfer, and deep learning [49]. Previous studies investigating embedded instruction have shown good results in primary education [28][29], secondary education [12][21][30], and higher education [13][31].

A literature review offers theoretical and empirical evidence on the effectiveness of whole-task and embedded IPS instruction. However, there are still scarce studies combining these two key instructional approaches. For instance, [10] investigated an embedded IPS course designed according to a whole-task approach and instructed ten student teachers in a quasi-experimental intervention research, finding positive results in the development of IPS skills and task performance. In another study, [20] successfully applied an embedded IPS instruction with psychology students. In this study, students obtained good learning outcomes and increased their frequency in some of their IPS constituent skills and regulation activities. More recently, [32] investigated student teachers' IPS skills through an embedded whole-task instruction in a 20-week course and reported that the instruction succeeded in developing cognitive strategies to tackle an information problem.

2.3. Long-Term Instruction

Long-term instruction for learning has been considered as the instruction that lasts over a quarter of the academic year [33], or even as the instructional course that may take place over two or three weeks [34]. In the specific field of IPS, a long-term instruction has been related with a curriculum-wide approach [6][18][32]. Most IPS intervention studies apply short term instructions and these studies report that some of the improvements on IPS skills reached by the participants disappeared after completing the course [10]. In this vein, researchers claimed the need of "a scaled-up version with more content, more task classes containing tasks of increasing complexity, offered over a longer period of time and embedded in a multitude of contexts, might prove very effective." [3] (p. 101). This claim is also shared by other studies, in which it is assumed that the whole-task approach to complex learning requires more learning tasks over longer periods than other kinds of instruction, but such practice will lead to better transfer to new settings when designed and conducted adequately [10][35].

In summary, despite the existence of studies confirming that embedded whole-task IPS instruction improves the students' IPS skills, there is still the need to know to what an extent the period of instruction of the IPS skills might have a positive impact on students' learning and performance results [36][22][37]. Furthermore, while most educational institutions acknowledge that IPS is an essential academic skill in this digital and knowledge era, they struggle with its implementation, and specifically in finding a suitable place and sizeable time in the curriculum for IPS integration [3][38]. IPS skills require domain-specific knowledge and in order to guarantee their transfer to daily activities, long-term, embedded, and supported IPS practice throughout the whole curriculum is needed [13][39].

Notwithstanding this necessity, most IPS instruction is often implemented as a separate course and loosely connected to the curricular contents (e.g. [11]) and secondary education students still face difficulties in their daily school activities [40][41]. Therefore, it is desirable to further investigate how to embed IPS research and instruction in real secondary classrooms and learn curricular contents to provide best practices, approaches and conclusive results of quality education for all students. To this end, this paper tackles this objective and provides answers to this educational challenge by discussing the design, development and empirical testing of a long-term, embedded, whole-task IPS instruction in secondary education. Specifically, our research investigates the longitudinal effects of a three-year IPS instruction on students' task-performance when solving complex digital problems.

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