UN SISTEMA DE TUTORÍA INTELIGENTE PARA LA MEJORA DE LA COMPETENCIA ESCRITA DEL ALUMNADO DE PRIMARIA

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RESUMEN

Diferentes revisiones empíricas y meta-análisis en el ámbito de la instrucción en escritura han señalado la instrucción en estrategias y el uso de programas informáticos como apoyo instruccional en las tareas de composición escrita como dos formas efectivas para favorecer la adquisición de una competencia escrita en el alumnado (ver Graham & Perin, 2007). En este estudio se presenta el desarrollo de un sistema de tutoría inteligente, denominado CSRI-OL (*Cognitive Self-Regulation Instruction On-Line*), que precisamente aúna estas dos dimensiones instruccionales: la instrucción estratégica y autorregulada para la enseñanza de estrategias de planificación, redacción y revisión textual (ver Fidalgo & Torrance, 2018; Fidalgo, Torrance, Rijlaarsdam, van den Bergh, & Álvarez, 2015; Fidalgo, Torrance, & García, 2008; Torrance, Fidalgo, & García, 2007) y las potencialidades del planteamiento de dicha instrucción en un entorno on-line a través de una aplicación informática (ver para una revisión MacArthur, 2016). El objetivo de este estudio es proporcionar una descripción de las principales características y componentes del Sistema de Tutoría Inteligente CSRI-OL, analizando críticamente tanto las principales dificultades que conlleva la adaptación de un complejo enfoque instruccional multi-componente como es la instrucción estratégica a un entorno virtual, como, las principales potencialidades que abre al campo científico y educativo el desarrollo de sistemas de tutoría inteligente como el que se presenta. Finalmente, se discuten las líneas futuras de investigación a seguir en torno al análisis componencial de la instrucción estratégica en torno a dos dimensiones: qué componentes se enseñan y cómo se enseñan. Nota: Proyecto financiado por el Ministerio de Economía, Industria y Competitividad (EDU2015-67484-P. MINECO/FEDER), concedido a la Dra. Fidalgo.

Palabras clave: composición escrita; instrucción estratégica; sistema de tutoría inteligente; nuevas tecnologías

ABSTRACT

An intelligent tutoring system to improve primary students' writing competence. Several empirical reviews and meta-analysis in the field of writing instruction point to strategy instruction and the use of computer programs as instructional support in writing composition tasks, as two effective ways of promoting students' acquisition of writing competence (see Graham & Perin, 2007). In this study, we present the development of an intelligent tutorial system called CSRI-OL (*Cognitive Self-Regulation Instruction On-Line*), which combines the aforementioned dimensions: self-regulated strategy instruction to teach planning, editing and revising strategies (see Fidalgo & Torrance, 2018; Fidalgo, Torrance, Rijlaarsdam, van den Bergh, & Álvarez, 2015; Fidalgo, Torrance, & García, 2008; Torrance, Fidalgo, & García, 2007); and the potentialities of framing this instruction into an online environment through a computer application (see review by MacArthur, 2016). The present study aims to provide a detailed description of CSRI-OL main features and components. We, therefore, critically analyse the difficulties entailed by the adaptation of a complex and multi-component instructional approach such as strategy instruction to a virtual environment, as well as the potentialities of an intelligent tutorial system in the scientific and educational field. Finally, we discuss new research lines on the componential analysis of strategy instruction around two dimensions: what components must be taught and how they must be taught. Note: Project founded by Ministerio de Economía, Industria y Competitividad (EDU2015-67484-P. MINECO/FEDER), awarded to Dra. Fidalgo.

Keywords: writing composition; strategy instruction; intelligent tutorial system; new technologies

INTRODUCTION

One of the main goals of Primary Education is for students to get domain of writing skills. However, different educational reports across borders, have highlighted students' low writing performance, below of the required standards of achievement (Department for Education, 2012; Festas et al.,2015; Kuhlemeier, Van Til, Feenstra & Hemker, 2013; Ministerio de Educación de España, 2009; NCES, 2011; Queensland government, 2018). This global educational need demands to seek for more effective writing instructional practices.

From a scientific point of view, different meta-analyses on writing instruction have arisen in the past few years. Graham and Harris (2018) conducted a meta-analysis of the existing meta-analyses in the writing instruction field, including more than 20 meta-analyses. A recurrent finding obtained in all of them is that strategy-focused instruction is one of the most effective instructional practices to improve students' writing quality. An average weighted effect size of 1.26 for strategy-focused instruction has been reported in the recent synthesis of the existing meta-analyses on writing instruction (Graham & Harris, 2018).

The goal of strategy-focused instruction is for students to get a self-regulated control of their own writing process, by providing them with specific strategies for planning, drafting and/or revising texts. One of the main features of strategy-focused instruction is its complexity concerning what is taught and how it is taught. As for the first dimension, it teaches metacognitive knowledge about the features of high quality texts together with specific strategies for setting goals and regulating the high-level cognitive processes of planning, drafting and revising.

Regarding the second dimension, how it is taught, strategy instruction follows a complex instructional sequence. This includes different instructional components, such as: a) direct instruction of metacognitive knowledge about the features of good quality texts to set specific product-goals and about high-level cognitive writing processes such as planning, drafting and revising; b)

cognitive modelling of the specific writing strategies for setting goals and/or regulating the writing process taught; and c) extensive writing practice supported by scaffolds, such as supporting materials, mnemonic rules and so on. All these scaffolds are progressively withdrawn in order to promote students' interiorization and self-regulated control of the specific strategies taught.

The complex nature of strategy-focused instruction may hamper its generalization to regular educational contexts and its inclusion in the writing school curriculum, despite its higher effectiveness compared to other instructional practices. In fact, some studies focused on analysing the inclusion of evidence-based practices such as strategy instruction in schools among different countries have indicated that strategy instruction was scarcely used in all contexts and educational levels considered (Cutler & Graham, 2008; De Smedt, Van Keer & Merchie, 2016; Dockrell, Marshall & Wyse, 2015; Graham, Capizzi, Harris, Hebert & Morphy, 2014; Gilbert & Graham, 2010; Kiuhara, Graham & Hawken, 2009). Teachers may find it challenging to use strategy instruction in their regular classes without external support from an expert in this kind of instruction. It also may not be easily adapted by teachers to specific features of different students' needs. Additionally, it may demand too much time from teachers to prepare, apply and evaluate strategy-focused instruction in their classrooms. For these reasons, the development of computer-based systems that incorporate explicit strategy instruction could be a major step on the inclusion of this effective kind of instruction in schools.

However, the design of an intelligent tutor system for strategy-focused writing instruction is particularly challenging due to several reasons. The first one, shared by all computer-based tools and techniques that support writing instruction, is linked to the ill-defined nature of writing. The open and problem-solving nature of the writing task, where individual writers can set specific writing goals achieved through diverse writing strategies, makes it more complex to determine the specific features of skilled writing or how to compose a high-quality text. That makes it difficult to provide individualized formative feedback to students, which seems to be a key point in the effectiveness of computer-based writing tutors (Roscoe & McNamara, 2013).

Another challenge of designing intelligent tutor systems for strategy instruction in writing lies on the complex nature of strategy instruction. Although strategy-focused instruction can take a variety of forms, its instructional sequence can be synthetized in at least three main steps: first, direct teaching to develop explicit, strategic knowledge, tied to mnemonics of strategies for both setting product goals and shaping the writing processes; second, modelling of the self-regulated application of writing strategies in different writing tasks by different models; and students' emulation/practice of the strategies with peers or teachers' feedback, progressively reducing the level of scaffolding and increasing students' own responsibility and self-regulation of the writing task. This sequence entails the teaching of different strategies to manage the complex and recursive nature of the writing process. According to pioneering theoretical models of writing (Hayes & Flower, 1980), it would demand: specific strategies to self-regulate one's own writing behavior according to the recursive nature of the writing process; planning processes, which involves generating and organizing ideas, and setting goals; and drafting processes, related to the translation of specific generated ideas into a coherent text which will be then read, evaluated and revised to achieve the intended product-goals. Due to this complexity and the ill-defined nature of writing a detailed description and in-depth analysis of the components of the intelligent tutoring system, such as what is presented in this study, seems, therefore, particularly necessary.

The present study aims to present a detailed description of the structure and components of an intelligent tutoring system for strategy-focused writing instruction designed to be applied in an online environment.

METHOD

Participants

The program was designed to be validated with a sample of students in upper-primary education (10-12 years). At this age, students have already achieved a reasonable level of mastery in transcription skills, such as handwriting and spelling. There is, therefore, minimum risk of these low-level processes competing against high-level skills (planning or revising) for the same cognitive resources (McCutchen, 1996). Writing instruction in this educational stage should, therefore, focus on self-regulation strategies which allow students to structure and organize their texts (Zimmerman & Bandura, 1994). Several studies have demonstrated the efficacy of strategy-focused writing instruction with upper-elementary students (Fidalgo, Torrance, & García, 2008; Fidalgo, Torrance, Rijlaarsdam, van den Bergh, & Álvarez, 2015; López, Torrance, Rijlaarsdam, & Fidalgo, 2017; Torrance, Fidalgo & García, 2007). These previous empirical evidences provide the background to the Intelligent Tutor System design.

The Cognitive Self-Regulation Instruction Program

The design of an intelligent tutoring system for strategy instruction in writing must be based on a deep knowledge about strategy-focused instruction. It is, however, difficult to get this knowledge, given the little space scientific literature devotes to describe the instructional programs and their specific features, techniques and scaffolds, which could be key in order to understand their effectiveness.

The CSRI-OL intelligent tutor system analysed in this study is based on a previous pencil-based Cognitive Self-Regulation Instruction Program designed by the first author, named CSRI, whose effectiveness to improve the writing competence of typically-developing students of upper Primary grades in regular classroom settings has been empirically tested in different studies by the research team (Fidalgo et al., 2015; Fidalgo, Torrance & Robledo, 2011; Torrance et al., 2007; Torrance, Fidalgo & Robledo, 2015). In fact, the effectiveness of this the intervention was maintained even two years after completing the CSRI program, which supports the long-term benefits of this instruction (Fidalgo et al., 2008).

An in-depth analysis about the macro-design rules of the CSRI such as its main purposes, instructional stages and sequence, as well as the micro-design features of each instructional component, such as, learning and teaching activities, students and teachers' supporting materials or specific strategies and techniques, can be found in Fidalgo and Torrance (2018). An example of the instructional program with specific supportive and instructional materials can be found in Fidalgo, Torrance and López-Campelo (2018). Nevertheless, in order to get a clearer picture of the intelligent Tutor system designed, it seems suitable to present a brief description about the background of the CSRI program.

Main Instructional Components.

CSRI involves four stages of instruction implemented sequentially: direct teaching, cognitive modelling, and two stages -first in pairs and then alone- in which students emulate the strategies that they have observed by thinking aloud on the specific steps of the strategy and self-instructions to self-regulate their behaviour.

The *direct instruction* component provides students with explicit, strategic knowledge, tied to mnemonics of the strategies taught. This component includes three main instructional stages: activation of students' background knowledge about writing and writing process, explicit teaching of meta-cognitive knowledge of the writing processes and the specific features of good quality texts,

memorization and retention of the essential knowledge through mnemonics about the specific cognitive strategies taught.

In the second component, *modelling,* the instructor models the strategies explicitly taught in the first, direct-instruction stage, by thinking aloud while composing text in front of the class. This involves modelling that intentionally includes students' typical mistakes or forgetfulness, which are then solved. It, therefore, provides a mastery model of a self-regulated way to implement the writing process. During modelling, all students' cognitive resources must focus on observing the model, paying special attention to the specific steps and self-instructions provided. Afterwards, as a learning practice, this second component ends up promoting students' reflection on the instructor's most important thoughts during the modelling.

The last component deals with *students' writing practice*, first writing in pairs, which supposes a higher scaffolding, and then individually. There are three main features of these emulative components. Initially, students' writing receives considerable scaffolding through supporting instructional materials and peers' feedback in collaborative writing. This scaffolding must be gradually withdrawn until it disappears, for students to progressively internalize the strategies. Second, students' thinking aloud is prompted during writing practice. That externalization of the writing process makes it possible to provide feedback about the writing processed activated at the same time. It is also probable that overt verbalizations in themselves help to develop self-regulation within the specific context of the design of this program (Schunk, 1986). During practice, the instructor must provide direct feedback on the extent to which students are adopting the strategies appropriately and correctly, that is, formative feedback instead of a final summative feedback about the written products. The level of scaffolding and support during students' practice should ensure that they experience successful use of the writing strategies they have been taught. This promotes positive self-efficacy beliefs, encouraging students to attribute their success to the writing strategies taught, which, in turn, is likely to increase their motivation when performing subsequent tasks.

Writing Strategies.

CSRI provides specific cognitive strategies related to the key steps of the writing processes of planning, drafting and revising or about key features of written products within a specific genre. All of these strategies are centered around the VOWELS mnemonic, which provides a framework for understanding what constitutes a good quality text (independently of genre): O [Objetivo] Objective or purpose of the text; A [Audiencia] = Audience, suitable content according to the audience of the text; I [Ideas] = Ideas, generation of ideas related to the theme of the text; U [Unir ideas] = Unite ideas, organization of ideas in a hierarchical structure of main, secondary ideas and examples; E [Esquema or Estructura] = Schema of your text, with the right structure.

As for the strategies linked to the writing processes, the general planning strategy is named POD, based on the strategy used in previous studies (Mason, Harris & Graham, 2002): P [Pensar ideas] = Think about ideas, this first step encourages the writer to generate ideas related to the topic of the text; O [Organizar ideas] = Organize your ideas following the vowels which help to systematize and structure the content; D [Desarrollar el texto] = Develop your text; this step encourages students to use the plans already devised and to continue the planning process while writing. The second "Organize" component of POD is specifically associated with The Vowels: When organizing ideas students are taught to consider each of the Vowels criteria in turn.

As for the specific writing strategy for the revising process, it is called LEA mnemonic: L [Lee el texto] = Read the text, students have to read their text several times: several comprehensive readings, paying attention to the content of their texts, and also quick readings, paying attention to for-

mal aspects of their texts(spelling, capitalization, etc). When students are reading the text, they have to coordinate the two additional sub-processes of evaluating and diagnosing the different aspects of the text: E [Evalúa el texto] = Evaluate the different contents and formal aspects of the text to see if they are right or wrong; and, if necessary, A [Actúa] = Do the necessary changes to improve the text. The different aspects of the text are again organized through the vowels mnemonic.

Finally, the writing strategy focused on the drafting process highlights the three main parts of a textual structure, IDC, introduction, development and conclusion. Again, the Vowels mnemonic provides criteria to support students' decisions about the content, structure and language of the text.

RESULTS

Our results describe the structure and components of the CSRI-OL Intelligent Tutoring system. In its design, it was essential to ensure the maintenance of the key instructional elements and components of strategy-focused instruction, while it takes advantage of the potential benefits that a computer environment provides to traditional instructional contexts. CSRI-OL is not defined as a computer-based tool to support or complement teachers' instruction. It was designed as an intelligent self-sufficient tutor system to provide students with individualized strategy-focused based on their needs. It demanded, therefore, several design requirements described in the following sections.

Main characters

Several animated agents who play different roles either as expert teachers or novate students are included in the program. The expert agents have three main functions in the program: giving tutorials along the implementation of the program, explaining the strategies and providing guidance and formative feedback on students' practice.

The student agents have two roles: as models during the observational learning phase during the instruction, and as main characters representing each student in the computer environment of the program. When designing those student characters, it was taken into account that modelling provides greater benefits when the observer perceives the model to be similar to themselves, as reported by previous studies (Braaksma, Van den Bergh, Rijlaarsdam & Couzijn, 2001). At the same time, students can provide the character with their own personal features, so that they see themselves as closely represented by the character as possible.

Strategy Modules

Four parallel modules of the CSRI-OL program were designed in order to include the different strategies of the CSRI program focused on planning, drafting and revising processes of writing or on the key features of good quality texts. Each module corresponds to one strategy. This modularization of the different strategies makes it possible to decide what specific module/strategy might be more appropriate for students according to their own writing style. This responds to the matching or compensatory approach proposed by the aptitude-treatment-interaction paradigm (Kieft, Rijlaarsdam & Van den Bergh 2008; Kieft, Rijlaarsdam, Galbraith & Van den Bergh, 2007). Decisions on the suitability of each module for teachers according to the grades or needs of their classrooms students can also be made.

Strategy Components

In each module, three different components, which reflect the three main components of strategy-focused instruction – direct teaching, modelling, writing practice –, are available for teaching each strategy. This design makes it possible to use these components flexibly. For example, it is possible to change the instructional sequence or omit some of them according to students, teachers or researchers' interests.

Students' Practices

There are two kinds of students' game-based practices included in the CSRI-OL program. One is included after the strategy lessons on the direct teaching component, to promote students' memorization of the strategies through mnemonic rules training. Its purposed is to guarantee that all students automatize the different steps of the strategy before progressing to the next component of the program. It is necessary to control that remembering the strategy does not overload students' cognitive resources while writing. Another set of game-based practices is included after the model's exemplifications of the strategy on the modelling component. It promotes students' reflection about the modelling observed and guides students to focus on the really important actions/thoughts of the modelling observed.

Both game-based practices combine different games, such as, puzzles, letter soups, speed quiz and so on, in order to keep students from getting bored. In all of them students receive specific feedback on their performance and rewards that they can change for different accessories to customize their personal agent in the program. The difficulty level of the games can go up and down progressively according to students' performance. It is necessary to make sure that students experience success in order to motivate them.

Students' Writing Practice: Scaffolds and Feedback.

The writing practice included in this program differs from the emulative practice component of the initial CSRI program, in the omission of the initial collaborative practice in pairs. To overcome this limit as much as possible, the first writing practice in CSRI-OL are additionally supported by an animated agent who prompts the application of the different steps of the strategy throughout the writing process. The intensity of this scaffolding decreases progressively, from a continuous remind of the strategy, to punctual references to some steps, until it disappears in a second writing practice phase only supported by specific materials.

A key point of the writing practice component of the program is the kind of feedback that students receive. In this sense, a formative feedback is provided focused not on the result obtained, but on the writing process followed according to the strategy, and on how to change it to improve texts quality. Additionally, the difficulty level of the writing tasks does not remain fixed across the whole program. In fact, it can decrease according to students' writing performance and the kind of formative feedback provided.

CONCLUSION

Though this intelligent tutoring system is based on a previous well-validated strategy-focused program to improve upper Primary students' writing skills it is necessary to check its effectiveness in the computer-based environment. Comparative studies of parallel forms of strategy-focused instruction - CSRI or CSRI-OL programs- will make it possible to explore the potential benefits of a computer-based environment to improve students' writing skills, or to promote more adaptive modulating variables in writing, such as motivation, self-efficacy, and attitudes.

At the same time, in the scientific instructional field, the modular design of the CSRI-OL intelligent tutoring system prompts specific research on the comparative effect of different modules or components on different student populations, at different ages and so on. This is a specially interesting and current research line on the writing instructional field, focused on the componential analyses about what components of strategy instruction are the most crucial or essential or contribute more to develop students' writing skills (De la Paz, 2007; Graham & Perin, 2007; Rijlaarsdam et al., 2008).

Finally, from an educational perspective, the flexibility of the CSRI-OL design, makes it possible to adapt it to specific students' needs, writing styles, motivations and so on. This might be the key to promote a higher use of strategy-focused instruction on writing instruction at schools.

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