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NEW LEARNING ENVIRONMENTS FOR WRITING: INTELLIGENT TUTORING SYSTEMS

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Numerosos metaanálisis han demostrado cómo el uso de la tecnología es una práctica efectiva en el campo de la instrucción en escritura. Sin embargo, la mayor parte de estos estudios se han centrado en los efectos del procesador de Word para mejorar la escritura de los estudiantes. Este trabajo investiga y muestra los efectos de nuevas formas de instrucción en la escritura, como son los Sistemas de Tutoría Inteligente (STI), una de las herramientas más sofisticadas dentro del campo de los entornos virtuales de aprendizaje. Se ha revisado sistemáticamente la literatura de la última década procedente de Web of Science, ScienceDirect y Scopus. El potencial de los Sistemas de Tutoría Inteligente está claramente respaldado por los hallazgos actuales. Sin embargo, hay resultados contradictorios con respecto al rendimiento de los estudiantes. Esta revisión plantea una discusión sobre los resultados de cara a comprender mejor la relación entre tecnología e instrucción en escritura.
Palabras clave: *Escritura, Instrucción, Tutoría Inteligente, Sistemas.*

Abundant meta-analyses have shown how the use of technology is an effective practice in the field of writing instruction. However, most of these studies have focused on the effects of the word processor on improving student writing. This article investigates and shows the effects of new forms of instruction in writing, such as intelligent tutoring systems (ITS), one of the most sophisticated tools in the field of virtual learning environments. The literature of the last decade from Web of Science, ScienceDirect and Scopus has been systematically reviewed. The potential of intelligent tutoring systems is clearly supported by the current findings. However, there are contradictory results concerning students' performance. This review presents a discussion on the results in order to understand in more detail the relationship between technology and instruction in writing.
Key words: *Writing, Instruction, Intelligent tutoring, Systems.*

In recent decades, the relationship between technology and education has been an important focus of research in disciplines such as educational psychology or computer engineering (Lajoie & Azevedo, 2006). Within the field of writing instruction, numerous studies have focused on how technology may be able to support not only the teaching of written competence, but also the writing process of students with and without learning difficulties (Crinon & Legros, 2002; Englert, Wu, & Zhao, 2005; MacArthur, 2006; MacArthur, 2009; Morphy & Graham, 2012; Peterson-Karlan, 2007; Quinlan, 2004).

The debate surrounding the results on the effects of technology has been divided into two categories according to the technologies that support the different components of the writing process (Hayes & Flower, 1980). These are: a) the use of tools that support the more mechanical aspects of writing such as spelling, grammar or vocabulary (Barrera III, Rule & Diemart, 2001; Lowther, Ross, & Morrison, 2003; MacArthur & Cavalier, 2004) and b) the use of programs that support higher order processes, such as planning, metacognition or textual revision (De Smet, Brand-Gruwel, Leijten, & Kirschner, 2014; Wilson & Czik, 2016; Zaid, 2011).

Within the first category, one of the most examined tools has been the word processor, whose significant effects on students' written performance has been well demonstrated (Goldberg, Russell, & Cook, 2003). Other types of software such as spell-checkers, word prediction software and speech recognition have also proven to be effective in supporting the transcription process, especially in students with learning difficulties (Peterson-Karlan, 2011). While it is true that, a priori, these tools add certain advantages with regard to writing by hand, the truth is that they have little to do with instruction in processes and subprocesses of a higher order such as metacognition or planning (Bangert-Drowns, 1993; MacArthur, 2006). In this sense, the research has highlighted the fundamental role played by the deployment of planning processes and textual revision in the acquisition of adequate written competence and how learners of all ages have problems developing these skills (MacArthur, Graham, & Fitzgerald, 2008). The technological advances have tried to respond to this problem by developing different systems or software packages to instruct in each of the processes and subprocesses that writing involves, although not necessarily in the same software package (Pan & Zbikowski, 1997). Consequently, it is possible to find specific tools to stimulate planning strategies, such as electronic maps and dia-

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grams (De Smet, Brand-Gruwel, Broekkamp, & Kirschner, 2012) as well as language processing programs, such as AWE (Automated Writing Evaluation) or AEE (Automated Essay Evaluation) systems that offer a combination of feedback and evaluation that, while it varies in quantity, depending on the system, it does not vary not in quality (Shermis, Burstein, Elliot, Miel, & Folt, 2017; Warschauer & Ware, 2006)

One way to provide a context that simultaneously integrates the instruction of the entire writing process, in combination with practice and textual evaluation, is through intelligent tutoring systems (ITS) (Allen, Jacovina, Danielle, & McNamara, 2017). ITSs, as Lajoie and Azevedo (2006) state, are one of the most sophisticated tools in the area of virtual environments. Based on one-on-one interaction between the student and the system, their purpose is to involve students in various types of cognitive processing and to promote optimal learning (Lajoie & Azevedo, 2006; Shute, Lajoie, & Gluck, 2000). The majority of ITSs in their design, integrate three main modules (Carbonell, 1970; Cataldi & Lage, 2009; Lenhard, Baier, Endlich, Schneide, & Hoffmann, 2013): a) a tutorial module that instructs in knowledge, selects teaching strategies and monitors the student's performance during the lesson attending to their learning style; b) a student module that stores knowledge about the learner through continuous cognitive assessment; c) a domain module that collects the whole of the content, materials and other system parameters necessary for the functioning of the ITS. The interaction between these modules seems to emulate the behavior of a human tutor by dynamically and systematically controlling and adapting students' individual learning (Azevedo & Hadwin, 2005).

Well-designed ITSs have shown significant gains in learning from very different domains (Shute, Lajoie, & Gluck, 2000). Wijekumar, Meyer, and Lei (2013) designed an ITS to improve the reading comprehension of 4th and 5th grade primary school students. The ITS based on strategic instruction, provided practice with scaffolding and transfer tasks, as well as individual evaluation and feedback cycles on performance in each task. The authors found that the classrooms that integrated the ITS compared to the control groups showed a better performance with moderate to large effect sizes in all the evaluation measures. In the same line, Graesser et al. (2003) implemented "Why/AutoTutor" a tutor which guided in the resolution and construction of answers to qualitative physics problems, offering evaluation and feedback on the learning of university students. The results of the study revealed that the group that used Why/AutoTutor obtained the highest learning gain compared to the group that received the same content, but in the traditional format, and the control group without learning material. Therefore, and according to Vanlehn (2011), ITSs are effective means of instruction insofar as they provide guidance and learning materials, and they can accurately assess students, diagnose performance deficiencies and use this information to adapt the learning experience appropriately (Shute, Lajoie, & Gluck, 2000).

Based on the above, there is no doubt about the growing interest of researchers and educators in the use of new technologies, and the relationship between these technologies and writing performance. Therefore, it is necessary to analyze the published research to offer up-to-date information that has implications for educational practice. Through a systematic review, it is intended to show the state of the art around what types of ITS are available for learning writing skills and what their effects are.

METHOD

Search and selection process

The systematic search included the analysis of the works published in the period from 2000 to the present. The starting date was 2000, coinciding with the rise of ICT in the field of writing (Peterson-Karlan, 2011). The following databases were used: Web of Science, ScienceDirect and Scopus, using the following keywords: writing, writing instruction, and intelligent tutoring systems. In parallel, a manual search was carried out on the following meta-analyses: "Meta-analysis of writing instruction for adolescent students" (Graham & Perin, 2007); "Meta-analysis of writing instruction for students in the elementary grades" (Graham, McKeown, Kiuhara, & Harris, 2012); "Teaching children to write: A meta-analysis of writing intervention research" (Koster, Tribushinina, Jong, & Bergh, 2015); "Meta-analysis of single subject design writing intervention research" (Rogers & Graham, 2008); "Meta-analysis of writing interventions for students with learning disabilities" (Gillespie & Graham, 2014).

Inclusion and exclusion criteria

In line with the objective of the present study, for the investigations to be included in this study, the following inclusion criteria were taken into account. Studies had to (a) have as their main objective the analysis of the effect of the tool on the written product and/or in the cognitive processes involved in writing, that is, planning, transcription and revision (Hayes & Flower, 1980); (b) be an experimental, quasi-experimental or single-case study; (c) include a measure of the quality of the written product and/or improvement in cognitive processes; (d) be studies of primary, secondary or higher education.

As exclusion criteria, the following measures were adopted: (a) studies whose interventions took place in a sample of students with special educational needs were discarded (given the heterogeneity of the SEN concept and due to the very nature of these types of students who require specific interventions different from the usual ones (Mónico, Pérez-Sotomayor, Areces, Rodríguez, & García, 2017)); (b) investigations in which the ITS was exclusively applied as a support tool in the writing process without offering any type of instruction were excluded; (c) book chapters or unpublished works were also not taken into account for this review.

Coding of studies

The content of each article was codified in a database that in-

cluded the following fields: a) authors; b) country; c) objective; d) design; e) sample; f) intelligent tutoring system; g) evaluated variables; and h) results obtained. The selected studies are shown in Table 1.

RESULTS

The search process resulted in 542 references the titles and abstracts of which were examined. After considering the inclusion criteria, 98% were excluded, with a total of 6 empirical studies being obtained. Figure 1 shows the flow chart representing the procedure followed in the literature search. The description of the studies is detailed below according to the purpose of the system: a) designed to instruct and support the writing process (n = 4); b) designed to instruct in specific writing skills (e.g., summarizing, argument and counter-argument or creative writing) (n = 2).

ITS designed to instruct in the writing process

Holdich and Chung (2003) implemented a smart tutor, Harry, with elementary school students to provide instruction in higher order processes. Harry is based on an expert writing model that imparts knowledge about different subprocesses; brainstorming, planning, composition, proofreading-editing, offering scaffolding during each of the tasks. Using the 'What's next?' strategy the student builds the narrative step by step. The posttest results showed that the students who used Harry wrote better stories and used a proofreading process characteristic of mature writers. In the study by Rowley and Meyer (2003), the

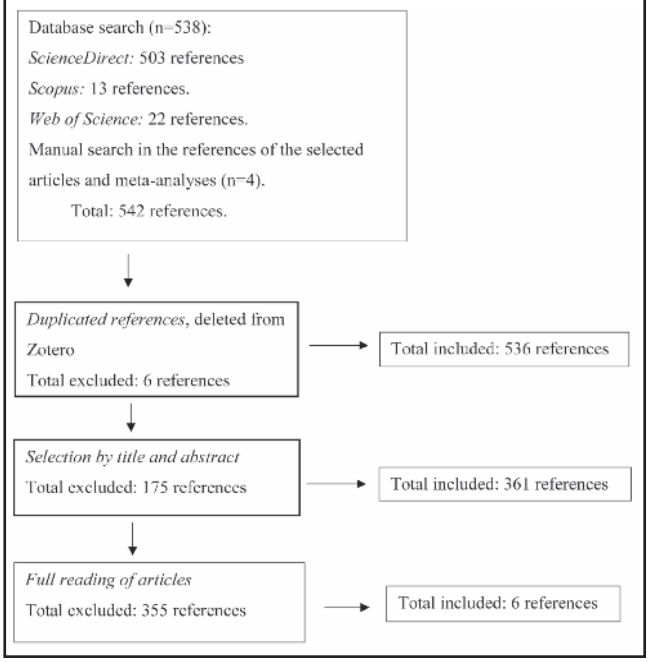
TABLE 1
SYNTHESIS OF THE ARTICLES INCLUDED IN THE REVIEW ACCORDING TO THE INCLUSION CRITERIA

Source	Country	Objective	Methodological Design	N	Type of Sample	Intelligent Tutoring System	Evaluated Variables	Results
Rowley & Meyer, (2003)	USA	To check the effectiveness of a smart tutor in improving writing performance	Quasi-experimental with control group	471	Primary and secondary education	CTW	Structure Coherence Vocabulary Grammar	There are no significant differences between the experimental group and the control group
Roscoe & McNamara, (2013)	USA	To evaluate the effect of an ITS on written performance	Quasi-experimental without control group	141	Secondary education	W-Pal	Length Structure Cohesion Lexicon	Significant differences pre/posttest
Proske, Narciss & McNamara, (2012)	USA	To investigate whether the use of an ITS facilitates learning to write of scientific texts	Quasi-experimental with control group	42	Higher education	Escribo	Textual quality Productivity Time on the task	Significant differences between the experimental group and the control group.There are no significant differences between the experimental group and the control group
Holdich & Chung, (2003)	UK	To test the hypothesis that an ITS can change theway children approach the task of writing and improve their performance	Case studies with control group	5	Primary education	Harry	Vocabulary Punctuation Productivity Syntaxis	Significant differences between experimental subjects and control subjects
Sung et al. (2016)	Island of Taiwan	To improve summarizing skills	Quasi-experimental without control group	154	Primary education	ITS based on latent semantic analysis	Productivity Content Nº of revisions	Significant differences between the experimental groups (with/without semantic and conceptual feedback)
Franzke et al. (2005)	USA	To evaluate the effect of an intelligent tutor in the learning of writing abstracts	Quasi-experimental with control group	121	Secondary education	Summary Street	Quality Organization Mechanics Style	Significant differences between the experimental group and the control group

Note: ITS= Intelligent Tutoring System

CTW (Computer Tutor for Writers) software was used with primary and secondary school students. With the help of a tutor called "Maestro", the students had to complete different work modules distributed in five categories: a) setting objectives and analyzing ideas; (b) analysis of the topic and techniques for organizing ideas; (c) planning and preparation of plans and diagrams; (d) writing of the text: creation of sentences and paragraphs; (e) proofreading and selection of the editing process. The authors did not find significant differences in the textual quality of the control and experimental groups. The learning of the students in the control group decreased by 1%, and only 36 students in the experimental group obtained a gain of 11%. In the same line Proske, Narciss and Proske (2012) developed a learning environment, Escribo [I write], to guide and facilitate the writing of scientific texts to students of higher education. Escribo organizes the writing process into five subtasks so that students acquire awareness and knowledge about each of the activities involved in successful academic writing: a) collecting information; b) planning; c) writing; d) proofreading the text. When the students finished the task, they were provided with informative feedback, giving them opportunities to go back and repeat and correct textual errors. The authors showed that the university students who worked with Escribo wrote more coherent texts and spent more time planning. The authors Roscoe and McNamara (2013) designed W-Pal (Writing Pal)—a system to improve the writing of secondary school students. W-Pal is composed of eight modules of strategic instruction taught by pedagogical agents through video-lessons, in combination with games-based practice and writing practice, offering automated training evaluation and feedback. The analysis and comparison of the pre/posttest textual products revealed that after instruction using W-pal, the texts were of greater length, with better structure, coherence and with a more sophisticated vocabulary.

FIGURA 1
PROCESO DE SELECCIÓN DE LA MUESTRA DE ARTÍCULOS A ANALIZAR



ITS designed for instruction in specific writing skills

In order to facilitate the task of summarizing, Franzke, Kintsch, Caccamise, Johnson and Dooley (2005) used Summary Street®, a tutor that offers a context of support for students from 13 to 14 years to practice writing summaries. Through latent semantic analysis, Summary Street compares the similarity of meaning between a student's summary and the source text, offering information that allows us to know the extent to which the summary adequately covers the main ideas and the aspects that need more work. The feedback offered by the system involved the students in successive review cycles until the content criteria were met. The research showed that summaries written with Summary Street were superior in several measures: general quality, more complete, and better organized content, even when the original texts became longer and more complex. Similarly, Sung et al. (2016) developed an intelligent evaluation system to improve the summary writing of primary school students. The system provided two types of feedback: semantics and concept. The first compared the semantic similarity between sentences of the student's summary and a summary by experts. The second provided a conceptual map to help understand the structure of the source text and highlighted the words in the student's summary that were relevant to the concept map. In this study, the authors examined the effects of both types of feedback. The results showed that a) only the feedback on the concept significantly affected the improvement in writing summaries and b) the number of revisions was significantly lower in the posttest. The authors argued that this phenomenon supports the idea that, once writing skills are mastered, a satisfactory result can be obtained with fewer revisions.

DISCUSSION AND CONCLUSIONS

Research on written composition is a complex task insofar as writing is a multidimensional phenomenon that is difficult to master (De la Paz, 2007; Flower & Hayes, 1980). From the scientific advances of the last years it is possible to affirm that, the way to control it depends, not only on the explicit or implicit instruction in the knowledge and the strategies for developing it, but also on the context in which the writing is produced (Graham, Harris, & Chambers, 2016; Graham, Gillespie, & McKeown, 2003). Providing a supportive context for learning to write requires consideration of the tools that are used for both instruction and composition (Graham, Gillespie, & McKeown, 2003). A promising tool is the ITS which, based on artificial intelligence, allows us to transfer strategic and individualized knowledge accompanied by a dynamic evaluation of the stu-

dent's progress (Holdich & Chung, 2003; Proske, Narciss, & McNamara, 2012; Roscoe & McNamara, 2013; Rowley & Meyer, 2003). However, as noted in the present work, the research does not yield consistent results. One possible explanation is in relation to the ability of the system to provide formative feedback. In the study by Rowley and Meyer (2003), although it instructed in all of the processes involved in writing, no feedback was offered while the students completed the writing tasks. On the contrary, in the investigations by Holdich and Chung (2003), Proske, Narciss, and McNamara (2012), and Roscoe and McNamara (2013), although instruction was provided in a smaller number of processes, they offered a combination of practice and feedback on the textual product that seemed to be a decisive factor in achieving positive results in terms of textual quality.

In this aspect, the literature has shown that giving constructive feedback as part of teaching is a crucial factor that significantly improves written performance (Graham, Hebert, & Harris, 2015). However, the control of such feedback, that is, what type of feedback it is (positive or negative) (Mitrovic, Ohlsson, & Barrow, 2013), how it should be shown (giving-answer strategies, or prompting-answer strategies) (Ferreira & Atkinson, 2009), and at what point in the learning, represents one of the most difficult aspects to solve (Allen, Jacovina, & McNamara, 2017; Baker, Gersten, & Scanlon, 2002). While this decision should be derived from theoretical models and, to a greater extent, from the results of the empirical research (Shute, Lajoie, & Gluck, 2000), the fact is that the poor and insufficient research linked to the actual task of writing, characterized by being "an ill-defined domain" represents a challenge for researchers (Aleven et al., 2008; Fournier-Viger, Nkambou, & Nguifo, 2010; Roscoe & McNamara, 2013). However, there are more and more ITSs that incorporate AES (automated essay scoring) and AWE (automated writing evaluation) systems as advisory tools that provide performance data at the process or product level. In the studies where the ITS integrated these systems (Franzke et al., 2005; Proske, Narciss, & McNamara, 2012; Roscoe & McNamara, 2013; Sung et al., 2016), the results suggested that students not only improve in aspects at a mechanical or microstructural level such as grammar or spelling, but also at the macrostructural or content level, even with fewer revisions (Sung et al., 2016).

Based on the results derived from this review, we can affirm that ITSs can be a support tool for teachers as they avoid some inherent difficulties in the teaching process, such as the nature of the class itself or the lack of time. In this sense, ITSs can offer greater availability to focus on the set of instructional objectives involved in writing (Graham, Gillespie, & McKeown, 2013), such as how to involve students in planning or revision activities, beyond teaching spelling or grammar; providing individual and specific support to each student according to their needs or the possibility of continuous and immediate practice and feedback.

However, the question is, are ITSs a fully effective resource? A direct answer to this question cannot be given for several reasons. First, and according to the literature (MacArthur, 2006), few studies have been developed in this area, which makes it difficult to generalize the results. Even when researchers use the same technology, it is no guarantee for obtaining conclusive results while contextual variables play a crucial and mediating role in the results. Contextual variables such as the role of the teacher in relation to the ITS, the duration of training and practical demonstration of the use of the tool, the learning environment (formal or informal), the previous experience of the teacher and the student with the software or learning activities, and the instructional objectives, must be variables presented completely to the reader (Chauhan, 2017; Schmid et al., 2014; Schwartz, Van Der Geest, & Kreuzen, 1992). It is of utmost importance to control and describe the content of these independent variables (Rijlaarsdam, Janssen, Rietdijk, & van Weijen, 2017) that would allow the replication of the interventions, ultimately, to obtain a deeper understanding of the relationships between technology and writing instruction. Therefore, if we want to advance in the study of artificial intelligence and its impact on instruction, it is necessary for research to continue working on the understanding, development or adaptation of this type of technology to discover which elements generate the greatest advances in performance and under what conditions.

To conclude, we ask ourselves what happens when students tackle learning in this type of virtual environment. In this sense, learning in virtual environments is especially demanding in terms of self-regulation of behavior (Azevedo et al., 2012). Consequently, it seems to be an important issue to examine the relationship among the processes of self-regulation, online learning, and writing performance (Allen & McNamara, 2015).

LIMITATIONS OF THE STUDY

Given the small number of studies included in our sample, the potential of the conclusions is limited. However, for our purpose, that is, to inform about new learning environments and instruction in writing, we find that the results are significant. It would be interesting if future studies could expand and verify the previous findings with research that uses not only ITSs, but also other types of technological tools.

CONFLICT OF INTERESTS

There is no conflict of interest

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