

A Systematic Review on E-learning Environments for Promoting Critical Thinking in Higher Education



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Introduction

With the beginning of the twenty-first century, many challenges regarding the skills students and employees need in today's world have arisen (Rotherham & Willingham, 2010). These challenges are associated with new forms of information and communication technologies (ICTs), which allow for easier ways of moving, presenting, and representing information. Furthermore, ICTs affect teaching strategies, providing different approaches to incorporate core skills into the educational curriculum.

There is some consensus among educators about the need to establish certain core skills that should be taught in schools and included in the curriculum (Binkley et al., 2012). According to Lee et al. (2016), core skills include critical thinking (CT) skills, which are considered relevant because the problems that individuals have to face nowadays are ill defined and require CT in drawing on knowledge from a variety of fields (Gerber & Scott, 2011). Although CT is considered as a seminal goal in higher education (HE), scarce progress has been done regarding which instruction could result in greater CT outcomes (Ennis, 2016; Tiruneh, Verburgh & Elen, 2014). There is a wealth of theoretical studies on CT in HE, in contrast with few empirical investigations about which teaching strategies and learning environments better promote CT. Part of these studies suggest e-learning as a way to enhance CT, using diverse approaches and learning activities for achieving this goal.

This chapter seeks to contribute to the knowledge about what characteristics of e-learning environments help to promote CT among HE students. This review is necessary since no other has been previously performed. The current study develops

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a systematic review of empirical research in e-learning environments designed to foster CT in HE. We aim to provide an insight into successful instructional models based on e-learning intended to support CT skills in HE. In this sense, two research questions guide this study:

1. What are the characteristics of e-learning environments interventions intended to promote CT in HE?
2. Which characteristics of those e-learning environments contribute most to successful instructional models for the development of CT?

Learning to Think Critically in Higher Education. Teaching Approaches, Interventions, and Learning Environments

Researchers have offered many definitions of CT (e.g. Ennis, 1962; Facione, 1990; Siegel, 1988). The Delphi panel of the American Philosophical Association (APA), in which 46 leading experts in CT have participated, such as Ennis, Facione, and Paul, offers a consensual and broad definition of CT and identifies six skills (interpretation, analysis, evaluation, inference, explanation, and self-regulation). Furthermore, the findings of the Delphi panel allowed Facione and Facione (1992) to establish seven dispositions (e.g., inquisitiveness, open-mindedness).

According to the experts of the Delphi panel, CT cannot be considered as a body of knowledge to be delivered to students just as any other school subject. CT should be embedded in the content programmes that are specific for each discipline and which rely on the events of everyday life as the basis for developing one's CT. Following Paul's (2005) opinion, CT can be expressed in different ways. CT interventions in HE involve the promotion of higher order thinking skills in diverse disciplines and professional domains. Even though developing CT has been recognized as a primary goal in HE, many college faculty do not fully understand how effectively to teach and integrate CT in their course curricula (Paul, Elder, & Bartell, 1997).

Ten Dam and Volman (2004) highlight some key aspects in order to encourage students to think critically: (a) paying attention to the development of the epistemological beliefs of the students, (b) promoting active learning, (c) stimulating interactions among students, to exchange their point of view (Paul, 1992), and (d) using real-life contexts (Brown, 1997).

According to Ennis (1989), there are four main approaches for the promotion of CT that emerged from the attempt to provide a framework that would help researchers and professionals. The first one, the *general approach*, takes place when the abilities and dispositions and the content are taught separately. In generic courses, CT skills and dispositions are the course objective, without any specific subject matter (Abrami et al., 2008; 2015). The *infusion approach* is a subject-matter instruction in which students are encouraged to think critically about the addressed subject. In this approach, the general principles of CT are made explicit and the content of

the courses is important (Abrami et al., 2008, 2015). The *immersion approach* is similar to the previous one: both of them integrate CT into subject matter instruction but, in the immersion approach, the principles are not made explicit to the students, assuming that they will acquire the skills once they have engaged in the subject matter instruction (Tiruneh et al., 2014). The *mixed approach*, named by Sternberg (1986), is a combination of the general approach with either the infusion or the immersion approach. A recent study conducted by Tiruneh, Gu, de Cock, and Elen (2018) has found no significant differences between the immersion and infusion approach. Instead, they concluded that a systematic design of the instruction stimulates CT skills.

Furthermore, there are different approaches of CT interventions and strategies. We draw from Abrami et al.'s (2015) proposal who suggest that CT interventions can be categorized into individual study, dialogue, authentic or situated problems and mentoring, which are detailed in Table 1. From a wider perspective than the interventions presented by Abrami et al. (2015), Ennis (2016) proposes two CT teaching strategies. The first one, Problem-based learning (PBL), is one of the most widely used learning approaches nowadays in CT instruction, since it is motivating, challenging, and enjoyable (e.g., Niu, Behar-Horenstein, & Garvan, 2013 ; Norman & Schmidt, 2000 ; Pithers & Soden, 2000). PBL engages students in dealing with a subject matter, usually requiring some research, developing, testing, and discussing hypotheses or solutions and possible alternatives. The second strategy, Lecture-Discussion Teaching (LDT)), is the most common approach to college teaching, according to Ennis, and it consists of a lecture about the subject matter, followed by a discussion. Also, Hitchcock (2015) mentions lectures as a strategy and added computer-assisted instruction with built-in tutorial support using a specific software named LEMUR (Logical Evaluation Makes Understanding Real).

Apart from those aspects, other characteristics of learning environments are relevant for an effective CT instruction. Broadly, the learning environment or the

Table 1 CT interventions. Adapted from Abrami et al.'s (2015)

Categories	Description
Individual Study	Instructional techniques and learning activities that are based on the individual work of the students. Among these activities we can find reading, watching, active listening, reflecting and solving abstract problems on their own.
Dialogue	This instructional intervention has its roots in the Socratic method; that is the reason why the didactic strategy used to integrate the dialogue is the discussion. When engaged in critical dialogue, individuals are discussing a particular problem together. This discussion can adopt multiple forms such as whole-class debates, discussions within groups, and/or online discussion forums.
Authentic or Anchored Instruction	In this category, students are presented with genuine problems related or not with daily-life issues that engage them and stimulate them to ask questions. Simulations, role-playing, and dilemmas (e.g. medical, ethical) are included as possible methods.
Mentoring	Mentoring is one-on-one interaction between someone with more expertise and someone with less expertise. Tutoring, coaching, apprenticeship, or modelling are examples of mentoring.

social climate of the classroom concern the relationship between the characteristics of the group of students and the dynamics of the group, to create an atmosphere that allows for a more effective educational intervention (Fraser, Anderson, & Walberg, 1982). According to these authors, interactions between teachers and pupils or classroom structural characteristics, among others, determine the social behaviour of students, and, as a consequence, their CT skills.

Thinking Critically in E-learning Environments

There is an increasing attention in educational research on how e-learning environments may influence learning (Hirumi & Bai, 2010) and might support the development of core skills for the twenty-first century, such as CT skills.

There are diverse definitions of e-learning environments. This study is framed on the definition provided by Area's and Adell's (2009), who consider e-learning an education offered to individuals who are geographically distant or who interact with the teacher at different points in time using computer resources. According to Szabo and Schwartz (2011), e-learning environments present several benefits such as providing time outside the classroom while students can work collaboratively and discuss the topic through wikis, blogs, or forums. Research points out that this kind of environment favours CT skills among students (e.g. Saadé, Morin, & Thomas, 2012; Szabo & Schwartz, 2011; Yeh, 2009) since it enhances problem-solving, decision-making, collaboration, and higher-order thinking skills (Hopson, Simms, & Knezek, 2002). Drawing from Facione's CT definition (1991), a critical thinker should be a well-informed person, diligent in seeking relevant information and capable of making judgements based on evidence. E-learning offers students the possibility of practising some of these skills. It facilitates a learner-centred education with unlimited access to knowledge that requires contrasting and discerning reliable information (Zhang, Zhao, Zhou, & Nunamaker Jr., 2004), a process for which CT skills are important (Saadé et al., 2012).

According to Area and Adell (2009), there are three main e-learning approaches: (1) *face-to-face or on-site classrooms*, using online learning resources; (2) *blended learning (b-learning)*, combining face-to-face and virtual classroom; and (3) *online learning*, which takes place strictly in a virtual learning environment (VLE), understood as computer-based learning environments that favour interaction among participants who have access to a wide range of resources (Wilson, 1996). The last two approaches share the characteristic of allowing asynchronous discussions, giving the opportunity to use constructivist perspectives. Both of them also enable personalized learning regardless of time and space boundaries (Şendağ & Odabaşı, 2009). Apart from Area and Adell's (2009) proposal, we consider *flipped classroom* as another learning approach. In this approach, students are expected to prepare, by themselves and using ICTs, what used to be done in the scheduled class, while more

practical work is developed in the classroom (Bergman & Sams, 2012), what presents similarities with b-learning environments. Previous studies on e-learning (e.g. DeRuisseau, 2016; Snodgrass, 2011) have reported on the advantages of flipped classrooms and b-learning in promoting CT. For instance, they allow for more time devoted to CT activities in the classroom and favour collaboration among students, increasing their CT skills. In the comparison performed by Schumm, Webb, Turek, Jones, and Ballard (2006), between *face-to-face* and *online* classrooms, the results show that *online* discussions foster CT. They allow students to share knowledge and encourage them not only to analyse and assess themselves, but also to support their assertions or refute the opinions of others (Greenlaw & DeLoach, 2003).

One of the main concerns in e-learning environments, described by Gros (2011), is the creation of specific materials such as videoconference or instructional software. Currently, the e-learning model is testing the collaboration between students and teachers, making use of 2.0 tools. These tools present different functionalities. Hew and Cheung (2013) point out that online collaboration is promoted by *wikis*, since participants interact with each other to create and share information; whereas online reflection may be fostered through *e-portfolios* and *blogs*. In both cases, asynchronous and synchronous discussions take place. An asynchronous discussion is developed when students ask questions and think about their ideas and different points of view after reflective thinking (Cho, Lee, & Jonassen, 2011), whereas a synchronous discussion is carried out by means of virtual worlds and social networks (Hew & Cheung, 2013).

Research in e-learning has shown that students perceived this environment as an opportunity to participate in highly interactive dialogues with the teacher and other classmates, facilitating the discussion and argumentation skills involved in CT (Bolliger & Wasilik, 2009). Both CT and argumentation overlapped in their territories of engagement and both have pedagogical implications for learning and teaching in higher education (Andrews, 2015). Nevertheless, fostering CT through e-learning requires teachers' pedagogical knowledge on how to effectively use e-learning and digital tools (Szabo & Schwartz, 2011). Researchers advocate for active learning, implementing tasks of authentic situations, through project-based learning and challenging work, individualized or in collaborative groups (Ramirez & Bell, 1994). Moreover, teachers must improve their knowledge about (1) how to scaffold collaborative learning and foster dialogue and (2) tools to engage students in contrasting different information to develop CT skills (Kim, 2015; McLoughlin & Luca, 2000).

Despite the existence of previous studies pointing out the advantages of e-learning in promoting CT, further research is needed in this domain in order to know: (1) how to implement instructional strategies, learning philosophies, and collaborative learning in digital media (Saadé et al., 2012); (2) how to design instructional strategies to promote CT in wiki-based learning environments (Kim, 2015); (3) how to teach CT skills by means of the integration of e-learning (Yeh, 2009).

Methods

For addressing the research questions, a systematic review of the international literature is carried out integrating content analysis (Bardin, 2011).

Search Strategy The literature review was conducted by searching relevant peer-reviewed English language papers published from January 2013 to June 2017 (last 5 years). The reason for limiting the search to this period is that e-learning develops at a fast pace, therefore, its potential effects on learning outcomes, and challenges are presumably different now if compared to those of 5 years ago.

Reference Databases ERIC and Web of Science were used to look for relevant articles. The following keywords, closely related to our research objectives were applied in the search: e-learning environment and critical thinking. Moreover, we narrowed the search using Higher Education (HE) as a *descriptor* and focusing on journal articles.

Inclusion Criteria and Study Selection From the total number of papers found ($N = 45$), we selected those studies which fitted in with the aim of this chapter. In order to do so, articles were required to bring together these inclusion criteria: (1) being empirical, since a large part of the literature found appeared to be theoretical, (2) having a clear e-learning scenario, (3) being developed in HE, (4) having a well-defined intervention based on e-learning to promote CT, and (5) describing quantitative and/or qualitative results of this intervention.

The initial corpus of 45 papers from electronic databases was screened to select those relevant for our study. Two authors of this chapter examined the articles independently, applying the inclusion criteria mentioned above. In this examination, the authors performed a thorough reading of the articles to determine which of them were suitable for the study according to the inclusion criteria. The final outcome was a total of 19 studies. Of those, 14 papers were indexed in the Journal Citation Reports (JCR) and 5 in SCOPUS, 2 of which are also indexed in the Emerging Sources Citation Index (ESCI). These studies were finally analysed in order to fulfil the purpose of the present review. Figure 1 summarizes this process.

Data Analysis For addressing the first research question, about the characteristics of e-learning environments intended to promote CT, we analyse four dimensions: (1) general overview (type of study and field), (2) e-learning approach/tool/activity, (3) CT teaching approach (Ennis, 1989), (4) type of intervention (Abrami et al., 2015).

Regarding the second research question, the identification of which characteristics of e-learning environments contribute most to successful instructional models, the analysis focuses on CT assessment methods to get an idea about CT results. The application of fifth selection criteria (quantitative and/or qualitative results of this intervention) allows us to select those papers that describe the results of the

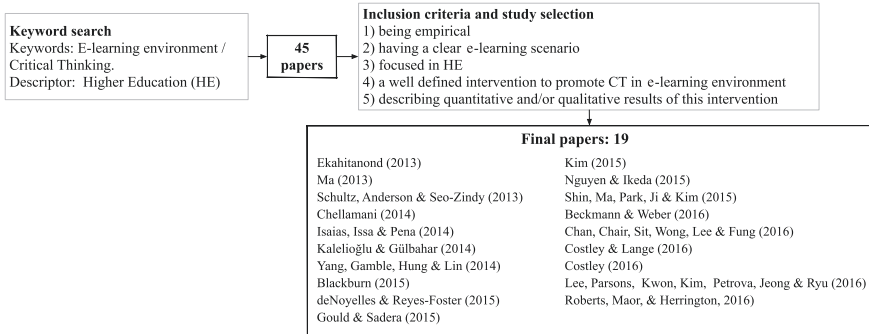


Fig. 1 Process followed for the selection of papers on e-learning

implementation. However, in order to answer the second research question, we pay attention to those that assess explicitly the development of CT. Thus, for the analysis of CT assessment, the process attends to these three aspects: (1) if CT is explicitly or implicitly assessed, (2) the dimension assessed: skills, dispositions or both, and (3) the assessment method followed in each paper. It has to be remarked, that only studies that use explicit assessment methods are considered, since they provide information about the results of the interventions in terms of CT development.

Results and Discussion

This section discusses and addresses the results of the two research questions consecutively.

Characterization of E-learning Environments for Promoting Critical Thinking

A repertoire of the characteristics of e-learning environments identified in the literature review, whose intention and goal is the promotion of CT, is presented in the following paragraphs and summarized in Table 2.

General Overview The studies ($N = 19$) belong to diverse fields in HE: education (4), language (4), nursing (2), earth and environment (1), communication (1), health (1), computer science (1), business (1), and industrial engineering (1). In addition, one of the studies is developed in several fields and two of them do not specify it. It should be highlighted that CT studies using e-learning are more frequent in social sciences than in sciences.

Table 2 Characteristics of the e-learning studies ($N = 19$) included in the systematic review

E-learning approach	E-learning tool	E-learning activities	Interventions (Abrami et al., 2015)
Online ($N = 4$)	VLE (3) (Moodle = 1)	Online discussions about commercials (Ekahitanond, 2013)	Authentic instruction+ dialogue
		Argumentation online about commercials (Ma, 2013)	Authentic instruction
		Create a business plan, eLectures, peer review (Beckmann & Weber, 2016)	Authentic instruction
	Blog & e-portfolio (1)	Assess prompts in an e-portfolio (Roberts, Maor, & Herrington, 2016)	Individual study
b-learning ($N = 13$)	VLE (4) (Moodle = 1)	Create a forecast, search information, lectures (Schultz et al., 2013)	Authentic instruction
		Online PBL about diabetes, heart diseases, and diet therapy (Gould & Sadera, 2015)	Authentic instruction
		Case-Based Learning (CBL) (Chan et al., 2016)	Authentic instruction
		Collaborative online activities, writing and reading in English (Yang, Gamble, Hung, & Lin, 2014)	Individual study + dialogue
	Wiki (2)	Analyse and synthesize articles, case studies, discussions (Isaias, Issa, & Pena, 2014)	Individual study + dialogue
		Criticism, edition, and creation of a wikibook (Kim, 2015)	Individual study + dialogue
	Online posting (2)	Online forum, online posting, and offline discourse (Costley, 2016; Costley & Lange, 2016)	Individual study + dialogue
	Blog (1)	Lectures, discussions, group work (Chellamani, 2014)	Individual study + dialogue
	Mobile learning game (1)	Mobile game-based learning (Lee et al., 2016)	Authentic instruction
	Website & e-mail (1)	Small group discussions around a prompt (deNoyelles & Reyes-Foster, 2015)	Dialogue
e-portfolio (1)	e-portfolio (Nguyen & Ikeda, 2015)	Individual study	
Chat (1)	Chat (Kalelioğlu & Gülbahar, 2014)	Dialogue	
On-site classroom ($N = 2$)	SBLi (1)	SBLi, lectures, real-world simulation, PBL (Blackburn, 2015)	Authentic instruction
	Simulation courseware (1)	Simulation courseware about nursing scenarios (Shin, Ma, Park, Ji, & Kim, 2015)	Authentic instruction

E-learning Approach The majority of studies (13 out of 19) are based on b-learning. The rest of the papers are conducted using online (4 out of 19) and on-site environments (2 out of 19). In these scenarios, we have found diverse *e-learning tools* for promoting CT. The most common ones are virtual learning environments (VLE) (9), like Moodle, which are spaces shared between teacher and students, common in online and b-learning environments. Also, some of these studies comprise blogs (2), e-portfolios (2), wikis (2), online posting (2), and e-mail (1). These tools contribute to asynchronous discussions in b-learning and online environments, allowing students to think about the topics and compare different points of view before giving an answer. Regarding on-site environments, one of the two studies carried out a simulation courseware and the other a Scenario-Based Learning interactive (SBLi).

E-learning Activities Most e-learning interventions promote CT by means of engaging students in discussions about different topics, such as the necessary skills for a teacher to reproduce real situations by applying different strategies (Chellamani, 2014), whereas in other studies, the discussions are related to the content of commercials (Ekahitanond, 2013; Ma, 2013). Another way intended to develop CT identified in some of the analysed papers, is to deal with potential real-life situations (authentic instruction), in which students have to investigate the problem itself and try to find a solution. This is the e-learning activity chosen, among others, by Schultz, Anderson, and Seo-Zindy (2013), who ask students to create a forecast. Gould and Sadera (2015) propose authentic instruction about diabetes, heart diseases, and diet therapy, engaging students in clinical reasoning. Beckmann and Weber (2016) ask students to create a business plan.

CT Teaching Approach Almost all studies follow the immersion approach (18 out of 19) to foster CT, which means that CT is embedded in the content of the discipline without making the principles explicit to the students. Only one study was conducted under an infusion approach, that is, CT principles being explicitly taught. This is the case of Yang et al. (2014), who investigated the effectiveness of CT-infused approach in English literacy instruction. In order to do so, a professor from the Institute of Education teaches students CT concepts and skills during face-to-face workshops and then students apply CT to asynchronous online discussions.

Types of CT Intervention Several papers involved authentic instruction (9 out of 19), that is, problems that students understand and in which they find motivation to think critically. This kind of intervention is closely related to the PBL strategy, which involves students in researching, developing, testing, and discussing hypothesis or solutions and alternatives, situations in which students should transfer knowledge to real situations (Ennis, 2016). According to the analysed papers, there are e-learning activities that follow this type of intervention, for instance, involving students in a case analysis about clinical case scenarios (Chan et al., 2016), mobile game-based learning (Lee et al., 2016), a simulation courseware (Shin, Ma, Park, Ji, & Kim, 2015) or a scenario-based learning interactive presented through cases

(Blackburn, 2015), all of them in a b-learning environment. Besides authentic instruction, other types of interventions identified in those papers are: dialogue (2), individual study (2) and dialogue & individual study (6). While individual study is fostered through assessment prompts in a e-portfolio (Nguyen & Ikeda, 2015; Roberts et al., 2016), dialogue requires being critical during small group discussions around a prompt (deNoyelles & Reyes-Foster, 2015) or in a chat (Kalelioğlu & Gülbahar, 2014).

Critical Thinking in E-learning: Assessment, Good Practices, and Difficulties

The analysis of the second research question, which characteristics of those e-learning environments contribute most to successful instructional models for the development of CT?, pays attention to the implementation and assessment methods used in the aforementioned papers. The reason for doing so is that this assessment allows us to determine whether or not this environment contributes to the development of CT skills and/or dispositions. After a brief description about the assessment methods and CT results, a synthesis of good practices for fostering CT is presented in this section.

Most studies assess CT explicitly (12 out of 19), whereas 5 do it implicitly and 2 papers do not assess CT. The studies that assess CT explicitly measure CT skills (10) and CT dispositions (2), using diverse quantitative and mixed methods. We have not identified any paper that assesses CT skills and dispositions jointly. Table 3 summarizes the results.

Concerning the instruments applied, four papers apply the Likert scale to get information about the students' perception of their own improvement in CT skills and dispositions. Two studies use pre-/post-test to analyse CT based in a reliable test: California Critical Thinking Disposition Inventory (Facione & Facione, 1992), California Critical Thinking Skills Test (Facione, Facione, Giancarlo, & Blohm, 2002), and Holistic Critical Thinking Scoring Rubric (Facione & Facione, 1994). Four studies perform a content analysis by coding the data using the CT diagnosis model established by Newman, Webb, and Cochrane (1995) and another one follows the CT categories proposed by Greenlaw and DeLoach (2003).

Taking into consideration the characteristics of the environment itself, the studies, which report better results, were carried out using diverse e-learning approaches and a large variety of activities and tools.

Regarding those that assess CT skills, some studies have reported good CT results like Ekahitanond (2013), who shows that online discussions about commercials (authentic instruction) promote students' CT skills (knowledge, comprehension, application, analysis, synthesis, evaluation). Also, Lee et al.'s (2016) study reveals that mobile game-based approach (authentic instruction) fosters collective

Table 3 Summary of CT explicit assessment method, CT results and e-learning environment

CT explicit assessment (N = 12 papers)	CT assessment method	Results: improvements in CT	E-learning resources and activities
CT skills (N = 10)	Survey Likert	Isaias, Issa & Pena (Isaias et al., 2014): Communication, critical review, research, search, and collaboration.	Case study Discussions
		Nguyen and Ikeda (2015): Metacognitive self-regulation and critical thinking.	E-portfolio
	Pre-/post-test and Questionnaire Likert	Ekahitanond (2013): Knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom’s taxonomy).	Critical inquiry model and peer feedback.
	CCTST and Holistic critical thinking scoring rubric	Yang et al. (2014): Analysis, inference, evaluation, induction, and deduction (CCTST).	Asynchronous online discussions and CT-integrated reading and writing activities
	Content analysis	Kim (2015): CT levels increase.	Criticism, edition, & creation of a wikibook
		Beckmann and Weber (2016): Knowledge, intensive, justification, and critical assessment (Newman, Webb, & Cochrane, 1995).	Virtual collaborative learning creates a business PPlan, e-lectures, peer review
		Lee et al. (2016): Clarification, assessment and novelty (Newman, 1997).	Mobile game-based learning
		Costley and Lange (2016): Relevance and importance (Newman et al., 1995).	Forum Discussions
Costley (2016): Relevance, importance, and linking ideas (Newman et al., 1995).		Forum Discussions	
Questionnaire	DeNoyelles and Reyes-Foster (2015): Higher scores of CT are reported.	Discussions Word clouds	
CT dispositions (N = 2)	CCTDI	Kalelioğlu and Gülbahar (2014): CT dispositions improve when students engage in mixed techniques group.	Chat
	Yoon’s CT disposition tool with Likert scale	Shin et al. (2015): Prudence, systematicity, healthy, scepticism, and intellectual eagerness (Yoon’s CTD) increase.	Simulation courseware: nursing scenarios

CCTST California critical thinking skills test, *CCTDI* California critical thinking disposition inventory

interactions that contribute to develop CT skills such as clarification, justification, and linking ideas. These match the findings of the research of deNoyelles and Reyes-Foster (2015), pointing out that CT and peer interaction have a positive correlation, so they positively affect each other. Costley (2016) examines to what extent participating in forums improves CT, concluding that the more forums students followed, the greater the improvement they experienced on their CT skills (relevance, importance, liking ideas, justification outside knowledge, etc.). Beckmann and Weber (2016) encourage students to create a business plan (authentic instruction) and defend it in a forum context. The results show that students introduce outside knowledge into the discussion improving their CT. Yang et al.'s (2014) study deserves a special mention given that it is the only one that comprises an infusion approach to develop CT skills. Quantitative results manifest a significant increase in overall CT skills (analysis, evaluation, inference, deductive and inductive reasoning) during asynchronous online discussion.

From the studies commented above, it seems that interactions among students and authentic instructions (nursing scenarios, mobile game-based) foster CT skills. However, two studies reveal that interactions among students could have a negative impact on CT skills. Costley and Lange (2016) examine how social presence and CT interact with each other and the results show that both variables have a negative relationship. The explanation given by these authors rests on Rourke, Anderson, Garrison and Archer's (1999) discussion, who indicate that excessive social presence may be detrimental for CT. Also, in the study carried out by Kim (2015), students are encouraged to create and evaluate a wiki, obtaining higher levels of CT when students make their own chapter than when they review peer's chapters.

Considering the studies that assess CT dispositions, the results are quite similar, pointing at interactions among students, and authentic instruction promotes CT dispositions. In particular, Kalelioğlu and Gülbahar (2014) compare different e-learning tools (six thinking hats, brainstorming, role playing, Socratic seminar, anyone here an expert) for fostering CT dispositions. From their quantitative results, they conclude that Socratic seminar group develops lower levels of CT dispositions. However, in the qualitative analysis, the mixed techniques group has shown higher levels of analyticity, open-mindedness, inquisitiveness, self-confidence, truth-seeking, and systematism. According to these researchers, this could happen because mixed techniques help students to notice the relevance of the discussion process thus increasing their motivation. The other study (Shin et al. (2015) concludes that the more the students are exposed to nursing scenarios, the better the scores obtained for CT dispositions. Nevertheless, all students experience a significant increase in the post-test to four dispositions: prudence, systematism, healthy scepticism, and intellectual eagerness.

Although the majority of the aforementioned studies (10 out of 12) have reported good results on the implementation of CT in e-learning environments, most of them point out limitations or difficulties in doing so. The main limitation is related to the small size of the sample. However, other studies have highlighted particular difficulties to be considered in future research. Ekahitanond (2013) and Shin and

Shin et al. (2015) point out that other variables, apart from those controlled in their studies, could contribute to an increase in students' CT skills. Nguyen and Ikeda (2015) consider that the improvement in some CT skills (particularly in self-regulation) could be due to the passage of time rather than to the use of e-portfolio. Furthermore, Kalelioğlu and Gülbahar (2014) have perceived that students were not familiar with virtual discussions and that may have an effect on the final results.

Conclusions and Challenges for Future Research

This systematic review has shown that there are diverse e-learning environments designed to promote CT among HE students. The analysis of the first research question shows that the most common e-learning approach is b-learning. This might be related that it is easy to integrate e-learning in a common classroom by means of different tools like Moodle, wikis, or forums. Forums yield particularly good results on the development of students' CT skills such as relevance, importance, liking ideas, or justification, as reported by Costley (2016). The majority of e-learning activities are based on asynchronous discussions about real situations (e.g. Ekahitanond, 2013; Kalelioğlu & Gülbahar, 2014). These discussions give students time to think about the topic and interact with each other despite spatial boundaries, which are important aspects to consider regarding CT development, which is in line with Şendağ and Odabaşı (2009) and Szabo and Schwartz (2011). Despite previous research pointed out the adequacy of CT instruction before applying it to achieve better learning outcomes (Abrami et al., 2008), the results of this systematic review show that all CT interventions followed an immersion approach, except one (Yang et al., 2014), which obtained good results. Our analysis does not enable to discern the reasons for choosing the immersion approach, nevertheless it allows us to conclude that students improve CT skills, which can be associated to a previous instruction on CT concepts and skills (Abrami et al., 2015).

The examination of the second research question allows us to identify two characteristics that seem to promote CT in e-learning environments. On the one hand, some studies have shown that cooperative or collaborative learning favours CT skills and dispositions, especially when students have to justify their ideas (deNoyelles & Reyes-Foster, 2015; Lee et al., 2016). On the other hand, authentic instruction like discussions about real-life problems (Niu et al., 2013), mobile game-based learning (Lee et al., 2016) or a scenario-based learning interactive presented through cases (Blackburn, 2015), can be associated with PBL strategy that is widely used nowadays in CT instruction, since it is motivating and challenging (Niu et al., 2013). This matches with previous research of Brown (1997), who suggests that, in order to engage students in thinking critically, didactic proposals should include realistic contexts.

Three challenges drawn from these results related to these dimensions of CT: (1) CT assessment, (2) CT dispositions and (3) diverse variables that might affect CT development, apart from the e-learning environment.

Regarding the first one, five (out of 19) studies assess CT implicitly, which means that the focus is not on the assessment of CT skills and dispositions, but on the adequacy of the e-learning environment and/or the development of the activity, since these elements may affect CT development, as Chellamani (2014) and Roberts et al. (2016) suggest. Some studies that explicitly analyse CT do not assess it using reliable methods for the evaluation of CT skills and dispositions. That is, Likert scale or subjective questionnaires focusing on students' perceptions about their own CT development, instead of using an objective method. Since the Likert scale can capture the intensity of the students' feelings for a given item, indicating their level of agree-disagree scale (Barua, 2013), we consider that this assessment method is not appropriate for determining an improvement in the CT capacity of the students. This leads to another limitation of our study, related to the limited number of papers analysed which describe good practices for thinking critically, based on e-learning.

The second challenge refers to the low number of studies that analyse CT dispositions. Only two papers out of 19 focused on some of the dispositions such as open-mindedness, self-confidence, and systematicity, which were also found in a recent literature review on CT in HE developed within the CRITHINKEDU_O2 (2018) European Project. We consider this as an important concern, suggesting that educators and HE teachers should put more emphasis on CT dispositions.

The third challenge deals with one difficulty reported, regarding other variables that might influence CT, apart from those included in the analysis. We must keep in mind that social presence may limit the development of CT in students, as Costley and Lange (2016) point out. Further research is needed in order to deeply understand how social factors, such as personal interactions or mainstreams, could affect the development of critical thinkers.

This review presents some limitations due to the representativeness of the selected articles to answer the first research question, since the search was limited to empirical papers, which implement CT interventions in e-learning environments.

In conclusion, this review seeks to contribute to a better understanding of how e-learning might promote CT in HE, despite the challenges mentioned above. There is a need to develop more experimental research on CT through e-learning in order to improve the knowledge about the daily-work basis that may help to identify which learning strategies and activities better promote CT, ultimately turning it into a better educational practice.

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