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<https://doi.org/10.1057/s41599-023-01537-w>

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Training future primary teachers in historical thinking through error-based learning and learning analytics

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Current pedagogical trends move towards the implementation of active methodologies; however, little research has been conducted in the field of history teaching. Purely memorised learning no longer has a place in today's age of information and technology. Simulating the role of historians in the classroom, what is known as promoting historical thinking, makes more sense. Thus, training teachers on how to develop historical thinking by active methodologies such as error-based learning (EBL) becomes necessary. Moreover, the traditional summative test does not demonstrate the assessment of the level of historical thinking. Nevertheless, technology enables formative assessment by different techniques and tools such as learning analytics (LA). Then, to analyse the potential of combining EBL and LA to foster and evaluate historical thinking can be interesting. To this end, in the present quantitative quasi-experimental study, the impact of EBL and LA to encourage and assess historical thinking skills have been analysed with 107 pre-service teachers. To this end, while 66 students worked with EBL with sources where errors were introduced in a controlled way, the other 41 students worked with the same unmodified sources. At the end of each session, LA was used to analyse the students' level of knowledge in the six dimensions of historical thinking through interactive questionnaires. The results obtained show an improvement in the historical thinking of future teachers due to the use of EBL. Furthermore, it has been proven that the data obtained from the LA enables predicting the results obtained by the students in a later test. In this way, the usefulness of active methodologies such as EBL combined with LA in the training of future teachers in our area of knowledge contrasts with the methods currently used.

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Introduction

For a long time, classroom knowledge has been obtained through the conventional teaching approach of lectures (Khalaf and Zin, 2018). This teaching approach consists of the teacher, as the main character of the teaching-learning process, explaining the theoretical contents while the students become the recipients of the information. Then, contrary to the contemporary pedagogical principles, the instructor still plays a central role in the teaching-learning process while the students, who only have a passive part in these sessions, are expected to memorise theoretical knowledge for a final summative evaluation (e.g., exam) (Miralles-Martínez et al., 2014; Gómez-Carrasco and Miralles-Martínez, 2017). In the area of social sciences in general and history in particular, the teaching process has traditionally been focused on the transmission and memorisation of theoretical contents, such as dates or events (Licerias and Romero, 2016; Gómez-Carrasco and Miralles-Martínez, 2017; Martínez-Hita and Gómez-Carrasco, 2018). Thus, the traditional lecture-based methodology continues to be excessively used, so that procedural knowledge is pushed into the background (Martínez-Hita and Gómez-Carrasco, 2018) and hardly given any attention. Moreover, this classical perspective of history has produced unfavourable opinions of and a lack of interest in studying history among students (Burenheide, 2007; Licerias and Romero, 2016) since they consider these memorised contents useless. However, this perception can be changed through new educational approaches (Fuentes, 2002; Martínez-Hita and Gómez-Carrasco, 2018).

Consequently, a change in history teaching from the foundations becomes necessary. Given that in current educational contexts students should be the focus of the teaching-learning process (Muntaner et al., 2020), it is important to introduce alternative pedagogical approaches that allow this change. Then, the history teaching process should move away from mere memorisation to a competency-based approach (Domínguez, 2015) in which discipline skills, such as reflection or source interpretation, are fostering (Sáiz and Domínguez, 2017); that is, to develop historical thinking (VanSledright, 2014; Gómez-Carrasco and Miralles-Martínez, 2017). In such a manner, students become the protagonists of their own learning and play an active role in the teaching-learning process. For this reason, it is difficult for students to develop historical thinking if they are mere recipients of information. Then, it is essential to boost it with active methodologies (Gómez-Carrasco et al., 2018). Among pedagogical alternatives we find error-based learning (EBL), which is gaining popularity (Darabi et al., 2018). EBL is an active methodology that aims to improve students' learning by detecting, correcting and reflecting on deliberated errors (Ericsson et al., 1993). Although its potential has been proven in areas such as mathematics and science (Darabi et al., 2018), there is a paucity of evidence in the history literature.

Consequently, researching its effects in our area takes on great importance. This new educational perspective is also justified in the current society, thanks to emerging technologies, that what is important is no longer just the content, but the way of accessing the information, particularly when, nowadays, it is possible to find false information about present and past events (fake news) or information that is not entirely true (post-truth), or that is disseminated for a specific purpose (Moreno-Vera, 2020; Wineburg, 2018). The important thing becomes not to know the information, but how to obtain and interpret it. Then, it is necessary to provide students with tools that enable them to question the knowledge and compare the information presented to them. This is, in short, improving one of the most needed skills today: their critical digital literacy (Santisteban et al., 2020).

In addition, if the teaching-learning process should change its pedagogical approach, its associated evaluation process should be

modified too. Technology not only enables new information sources and methodological approaches, but also new ways of evaluating which can be put into practise concurrently with them (Pelletier et al., 2021). As different authors such as Miralles-Martínez et al. (2014) or Tirado-Olivares et al. (2021) point out, the summative evaluation instruments such as exams, typically used in areas such as history, must be changed to other continuous or formative assessment processes. However, to achieve a real impact through the integration of technology in the educational context, the teacher must feel sufficiently empowered and comfortable with the technologies to do so. On the contrary, authors such as Gutiérrez-Martín et al. (2022) emphasise the lack of training and the corresponding lack of teachers' perceived self-efficacy to integrate technologies into their teaching practice autonomously. It is especially relevant in the history teaching practice as technology is still not widely used in the classroom (Monteagudo Fernández et al., 2020). Therefore, extending this training will lead to a better predisposition of teachers to use technologies during their teaching practice to formatively assess their students among others.

In addition, focusing on history teaching in particular, the capability of this formative assessment based on technology could help to identify not only theoretical misconceptions, but also to gather information about how both students' history skills and learning process are being carried out (Miralles-Martínez et al., 2014). In this line, as the EDUCAUSE 2021 horizon report points out, the new technological instruments enable the collection of large amounts of information in any educational context almost automatically (Pelletier et al., 2021), something difficult and arduous to do by teachers manually. This form of gathering, analysing and decision-making based on the information through technology is known as Learning Analytics, hereinafter LA Long et al. (2011). However, few studies have introduced LA in our area of knowledge (Li and Wong, 2020b).

Hence, the current study presents an active methodological approach as it is EBL focused on training future teachers to work with sources with and without errors in order to demonstrate the potential of using this methodology in history for the promotion of historical thinking. In addition, in order to analyse the development of the historical thinking in tertiary students, LA has been applied too.

Theoretical framework

Historical thinking: from a lecture-based methodology to an active one. The history teaching process is frequently characterised by rote, repetitive, and conceptual learning, as well as by the use of a textbook as the primary resource (Gómez et al. (2014) Gómez-Carrasco and Miralles-Martínez, 2017). In this pedagogical approach, students are mere recipients of information as they only memorise the contents explained by the teacher, which are normally those that are included in the textbook. Consequently, students play a passive role in the teaching-learning process. Some authors, such as Sáiz and Gómez (2016) outline that this way of teaching is meaningless at the present time, since knowing history is not simply accumulating facts and data (VanSledright, 2014) that we can easily access thanks to emerging technologies. As Miralles-Martínez et al. (2014) state, the classical perspective of history does not provide students a strong knowledge foundation and is outdated in today's society, since we have access to any information in a few seconds. Therefore, history should be expanded to include procedural content in a way that helps to improve students' understanding of the present and the future (Levstik and Barton, 2015), that is, to promote higher cognitive skills that go beyond mere memorisation of content, such as critical thinking.

In addition, the obsolete way of teaching (Gómez-Carrasco, 2023; Moreno-Vera and Alvén, 2020) contributes to students developing a negative perception of and disinterest in history since they consider history contents as monotonous and useless (Zhao and Hoge, 2005; Licerias and Romero, 2016; Sanz et al., 2017). Nevertheless, this perception can be altered by changing the way of teaching (Fuentes, 2002; Martínez-Hita and Gómez-Carrasco, 2018). In this way, a renewal of the history teaching towards a reflexive and open approach, in which students develop cognitive skills such as critical thinking and reflection actively, becomes crucial. Thus, the history teaching should expand to include discipline-specific skills (Lévesque, 2008; Sáiz, 2013; Seixas 2010), such as critical reflection, source interpretation or evidence-based argumentation. As an alternative to traditional history teaching, an approach that seeks the learning of historical methods in addition to the knowledge of purely theoretical contents emerged (Martínez-Hita, 2021). This alternative approach is widely known under the name of historical thinking (Domínguez, 2015; Drie and Boxtel, 2008; Seixas and Morton, 2013; VanSledright, 2011; Wineburg, 2001).

Historical thinking can be defined as the imaginative process that historians develop in order to interpret the evidence and produce the historical narrative (Seixas and Morton, 2013). It is translated into the educational field as a pedagogical strategy that encourages the learning of the techniques for historical research (Martínez-Hita, 2021). The beginnings of historical thinking as an educational approach can be found in a discussion that began in England in the 1970s (Martínez-Hita, 2021) when a new didactic approach (*New History*) based on the techniques and skills used by historians was born (Domínguez, 2015). The *New History* purpose was to integrate the use of more complex cognitive skills in the teaching of history. It was implemented for the first time in 1972 thanks to the *History Project*, renamed as *School History Project*. The results showed that students had a better understanding of history at the end of the project (Domínguez, 2015). Later, the project *Concepts of History and Teaching Approaches* aimed to include conceptual and procedural contents in the teaching-learning process of history to the same extent (Lee and Ashby, 2000).

The historical thinking model allows students to represent the past and develop their own knowledge of history, as well as reasoning and understanding social reality (Lévesque, 2011). Historical thinking is also linked to critical thinking (Gómez-Carrasco and Miralles-Martínez, 2014) as students learn to give opinions supported by evidence, to identify false and consistent arguments and to reflect (VanSledright, 2004; Gómez-Carrasco and Miralles-Martínez, 2017). Critical thinking skills are essential to face the society in which we live, characterised by continuous change. Thus, the current educational laws emphasise the need to train active, critical and responsible citizens, capable of acting autonomously (VanSledright, 2004; Gómez-Carrasco and Miralles-Martínez, 2017).

In this context, some countries have already included research's contributions on historical thinking in their curricula, including England, Canada or Australia (Zarmati, 2019). For instance, in the English textbooks there is a predominance of procedural contents (Martínez-Hita and Gómez-Carrasco, 2018) and the activities included promote critical thinking (Caparrós Ruipérez et al., 2021). Students must therefore use sources to deduce facts, comprehend that history is not a closed subject but rather that there are several ways to interpret the past, and simultaneously cultivate critical thinking (Cooper, 2014). However, this approach is not common as research suggestions have not been completely implemented into teaching practice (Lévesque and Clark, 2018). Thus, it is still necessary to promote the renewal of history

teaching so that teachers are able to fully integrate the contributions of historical research in their didactics.

To reduce this gap and promote historical thinking development, Seixas and Morton (2013) proposed certain activities focused on six particular concepts: cause and consequence, relevance, change and continuity, ethical dimension, historical perspective and sources. Additionally, they assert that these ideas will empower students to create original interpretations of history and that they are the first step in reflecting on the manner in which history is taught. Hence, they provide the foundation for developing a new approach to teaching history. These factors have already been incorporated into the curriculum in British Columbia (Canada), which intends to cultivate these six historical ideas so that students can apply them to solve problems, make decisions, and effectively communicate their thoughts (Zarmati, 2019).

Additionally, the use of active methodologies that emphasise higher-order cognitive abilities like analysis, interpretation, and explanation lead to students having a more favourable perception of the subject and foster historical thinking and its understanding (VanSledright and Maggioni, 2016). In this line, there are several educational experiences that show the effectiveness of applying active methodologies in the teaching of history. For instance, gamification (López-Fernández et al., 2022), a hybrid technique that blends student response systems and enquiry-based learning (Tirado-Olivares et al., 2021), problem-based learning (Gómez-Carrasco and Sobrino López, 2018), virtual reality Villena-Taranilla et al. (2022) or flipped classroom (Monteagudo Fernández et al., 2017) also in combination with previously mentioned methodologies such as gamification (Gómez-Carrasco et al., 2020). In addition, some of the proposals have been developed with prospective teachers. As an example, Gómez-Carrasco et al. (2019) developed a gamification and flipped-classroom programme with pre-service teachers. The results revealed positive improvements in motivation and perception of learning.

Thus, the use of active methodologies in this subject improves both learning, which becomes deeper, and the perception that students have of history as a discipline, as argued by different authors (Fuentes, 2006; VanSledright and Maggioni, 2016) and demonstrated by several investigations, including those cited above (Rodríguez-Medina et al., 2020). However, if we analyse the previous studies, the focus of innovation lies in the external elements included in the teaching-learning process and not in modifying the contents themselves in order to promote historical thinking. For this reason, in the present study, we used the EBL methodology. Even though this is still an active methodology, it allows an easy way of fostering historical and critical thinking in class while working with historical sources. Nevertheless, EBL is rarely used in history teaching.

Error-based learning (EBL): active approach to renewing the teaching-learning process. Routinely, error has been punished in the educational field (Fajardo Ariza and Corredor Montagut, 2006), as it is seen as an obstacle to learning and a failure indicator that saps motivation in students De la Torre (2004). This traditional approach focuses on students' failures rather than on their achievements (Álvarez-Herrero, 2019). Consequently, students pay more attention to the outcome than to learning (Pantziara and Philippou, 2015), avoid exposing themselves to situations in which they may fail (Fajardo Ariza and Corredor Montagut, 2006) and may develop negative feelings towards the contents (Álvarez-Herrero, 2019). Likewise, the fear of failure affects the self-esteem of the student, who will try not to face new

learning for fear of not achieving a correct performance (Briceño, 2009).

Contrarily, from a constructivist viewpoint, errors are considered as natural elements of learning (Briceño 2009, 2015) that result from a stage of cognitive disequilibrium (Piaget, 1977). From this perspective, errors are seen as the outward indicator of learners' struggles comprehending and completing mental tasks (Astolfi, 2003; Fernández et al., 2018). This conception of errors might help learners gain more self-confidence and self-esteem so they can succeed again rather than fail again Rong and Choi (2019). In other words, students may understand failure as unavoidable and non-conditioning. As a result, they will improve their learning, as positive responses to failure among students are associated with success later on. (Jackson et al., 2021).

Moreover, this approach contributes to the student becoming an active subject of the learning process at the same time as the teacher becomes a guide who focuses on the process and not on the outcome De la Torre (2004). To this end, the teacher needs to help students feel less anxious and prevent frustration by treating errors as a vehicle for relearning rather than something to be embarrassed of (Briceño, 2015). This optimistic attitude on errors seems to be becoming more prevalent across a variety of contexts, including university. As a result, more research studies have been conducted in recent years that focus on mistakes as an inherent aspect of the instruction. This translates into a methodology already known as "Error-Based Learning", with already proven positive results (Kapur, 2014; Loibl and Leuders, 2019).

The origin of EBL can be traced back to Morgan (1894), when introduced the concept of "trial and error" as a learning strategy. In this line, some experts such as Brown et al. (1989) proposed methods in which students learned from ill-structured problems and challenges in real contexts. Later, Ericsson et al. (1993) integrated the concept of "deliberated practice", stating that it allows turning "novice" students into experts through the detection and correction of errors, as well as the reflection to learn from them. Nowadays, more and more authors are taking positions in favour of EBL (Darabi et al., 2018). One of its benefits is that it enables attention to be directed toward the process rather than the finished result De la Torre (2004). Also, errors have a significant capacity for learning since they encourage reflection and self-criticism, leading to the creation of new knowledge (Briceño, 2009). This author also points out that when students make errors, their mechanisms to analyse what has happened and then solve the problem are activated. Furthermore, it has been proved that when students try to answer issues, even if they are unable to do so, they increase their comprehension because they are using prior information and are better equipped to apply what they have learned (Kapur, 2008; Loibl and Rummel, 2014). For that purpose, it is necessary to create a trusting climate where students can communicate and learn and errors are acknowledged (Jackson et al., 2021).

The implementation of EBL has been addressed in different ways in the educational field. Most of them emphasise that error should be understood as a challenge that students must overcome through reflection and metacognition (Briceño, 2015). Therefore, the pedagogical possibilities of error in the instructional design of learning experiences should be considered. Although the majority of approaches are focused on preventing failure, very few of them include failure into the teaching-learning process (Tawfik et al., 2015). Moreover, learning from failure encourages the acquisition of more in-depth knowledge (Tawfik and Jonassen, 2013; Jackson et al., 2021). For instance, Kapur (2014) developed a study whose results showed that students who encountered failure significantly improved their understanding of ideas and knowledge transfer. In the university field, Álvarez-Herrero (2019) developed a study with pre-service teachers where the results revealed that the use of

errors in the teaching-learning process decreases the likelihood of making the same mistakes again in the future.

Thus, EBL has strong educational value as it enhances learning. For this reason and given the negative effects of punishing errors in education, it is important to benefit from the use of errors as an educational tool. Therefore, it is time to benefit from errors so that students can improve their learning (Álvarez-Herrero, 2019) as they are inherent elements of the teaching-learning process. Owing to the fact that the majority of the current literature focuses on the use of EBL in scientific and technological fields (Darabi et al., 2018), investigating its effects in the area of history takes on greater importance.

Furthermore, focusing on how to apply EBL in history and given that this methodology emphasises the importance for students to pay attention to the process not only the outcome De la Torre (2004) students should detect errors both effectively and quickly. In this way, we avoid the possibility of the errors' assimilation as true information by students. To this aim, it is vitally important to include formative assessment techniques, which could detect whether or not the student has detected the error, without waiting for a subsequent exam. This is possible thanks to technology, and specifically to LA, as we have already mentioned.

From summative perspectives to formative ones thanks to technology: integrating LA to assess historical thinking.

Although it is true that there is a need to renew assessment processes in order to be able to offer more effective and continuous feedback to students, the feedback process is still generally developed under classical summative paradigms through tests such as exams, which are focused only on what students have memorised (Moreno-Vera et al., 2020). In fact, as Barthakur et al. (2022) point out, the use of these summative tests assigns students a score, but they do not provide diagnostic information on students' strengths and weaknesses. Furthermore, this lack of evaluative renewal is justified due to the time required, and the amount of work involved, in the continuous manual collection of information on each student's performance (Pardo et al., 2019). However, thanks to technology, the inclusion of LA during the teaching-learning process can solve it.

Despite the fact that there are many definitions about what LA is, one of the most commonly known is the one proposed by Long et al. (2011). These authors define LA as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" (p.1). Such is its potential that the Horizon report 2021 describes LA as one of the higher technological trends in educational context in the short-medium term (Pelletier et al., 2021). Nevertheless, as Dubé and Wen (2022) state this expected impact always is shown as future interesting perspectives, but they are not translated into realities in the classroom. In addition, Gašević et al. (2022) emphasise that, although its great potential to predict student's performance, there are a limited number of studies in which LA is used to develop new ways of assessment. Therefore, more research in which LA is put into practice is needed.

In this line, even though LA studies are increasing currently, most of them are carried out in scientific-technological areas, with little evidence in other areas such as History (Li and Wong, 2020b). The study conducted by Cózar-Gutiérrez, Caparrós (2020) is one of the few examples of the positive effects of integrating LA in history teaching. However, taking into account what has been summarised before, it will be interesting to analyse if LA could fill the gap of the summative tests about assessing competencies such as students' historical thinking (Miralles-Martinez et al., 2014;

Tirado-Olivares et al., 2021). To do this, the first thing that is necessary is to reverse the aversion that many teachers feel towards the use of technology, due, among others, to the lack of university training they receive on how to use them effectively (Gutiérrez-Martín et al., 2022). This also makes them feel insecure and incapable of using technology by themselves, as they perceive them as difficult to use. On the contrary, as Li and Wong (2020a) states, the integration of LA can be done through easy technological instruments such as student response systems (hereinafter SRS), which are defined as “a wireless response system that provides faculty the means to actively engage students in lecture classes” (Kaleta and Joosten, 2007; p. 2).

As can be seen from the definition, not only the use of SRS is a solution to easily implement LA, but their integration in the teaching-learning process has an interesting positive effect on students too. In the same vein, most recently, Carrasco-Hernández et al. (2020) showed that students who used SRS, scored better in the final exam than those who did not. Authors focusing in our area of knowledge, such as Tóth et al. (2019) observed that university students who participated in Kahoot quizzes in a social science degree weekly achieved better overall results versus the normal group. These results were also obtained in three more social science bachelor's degrees (Ruíz Giménez et al., 2019) in which it was found that students improved not only their learning, but also their engagement in class, especially intriguing in our field of study because of the previously reported low levels of students' interest and motivation related to history contents (Liceras and Romero, 2016). The formative assessment aspect was also interpreted positively using LA through SRS since many students valued the immediately received positive feedback, because they considered that this helped them to be aware of both their correct answers and mistakes (Ruíz Giménez et al., 2019). Then, its implementation in EBL can provide interesting results to analyse.

Therefore, given the limitations within the educational field of teacher training in active history methodologies such as EBL, and considering the current necessity of combined ICT and these new pedagogical approaches, this research is aimed to examine the effect of its implementation on pre-service primary teachers' academic achievement. To this end, a quantitative analysis was conducted to analyse the effectiveness of the intervention in terms of participants' learning gain in historical thinking. In addition, we also evaluated the effect of LA techniques as a formative assessment tool by analysing the association between participants' scores gathered during the intervention and their scores after the intervention. All this seeks to offer relevant evidence to the educational community about the implications for teaching practices that this instructional approach may have in future years in history teaching with two specific objectives:

1. Evaluate possible differences in the academic performance reached by pre-service teachers in relation to historical thinking according to the type of learning methodology used: working with historical source evidence vs EBL
2. Analyse the predictive potential of LA-based formative assessment on the academic achievement of university students in history.

Methods

Participants. This study was conducted with university students. In particular, 107 pre-service Primary Education teachers from a Spanish university participated in the study. All the students were enrolled in the subject entitled “Social Science II. History and its didactics”. Then, all students belonged to the same Faculty of Education of Albacete (University of Castilla-La Mancha) and

they were studying in the same academic year, and they were taught by the same lecturer. This research was done in the compulsory practical section in which students learn about new methodological processes to work with historical sources actively.

These participants were divided into two different groups. The first group was encompassed by 66 students. This group was randomly assigned as the control group (hereinafter, CG). In this group sources without the introduction of deliberate errors were used. The second group which had 41 students were considered the intervention groups (hereinafter, IG). In this group as it will be detailed later, the procedure was similar to the CG condition, but the sources presented contain deliberate and controlled errors.

The ethical standards established by APA were always complied with and at all times, participation in this study was completely voluntary and anonymous. To make this clearly specified, all participants in this study were required to read and sign an informed consent.

Design. To analyse the pre-established objectives mentioned before, a quasi-experimental study using a quantitative methodology was carried out. Therefore, through this study, we aim to know how the implementation of an active error-based learning methodology and the use of learning analytics affects pre-service teachers' academic performance and how we can predict this performance taking into account variables such as their gender.

Procedure. The experimental phase consisted of six sixty-minute sessions. In the first and last session, a test was conducted to evaluate eventual differences before and after the intervention in terms of academic performance. Then, in the remaining sessions, students worked with different sources such as maps, historical text or research reports. An example of these sources can be seen in Fig. 1. These sources were of all historical eras: from prehistory to the contemporary age. In each session, a central theme was used as the main focus of the sources, for example, wars during history or illnesses. Alongside these sources, different open-ended questions on the topics were presented to students with each related to one of the dimensions of historical thinking. Thus, as it was mentioned before, the only difference between the experimental and control conditions was inside these sources, since in the IG sources, errors were included intentionally.

These errors should be noticed by students to answer the questions presented correctly. However, to make sure that students do not assimilate them as real historical information, at the end of each session, an interactive multiple-choice activity was done by using the Quizizz platform. Each Quizizz question was developed considering the six historical thinking dimensions proposed by Seixas and Morton (2013). Then, each questionnaire complied with two conditions: the ability to verify that errors have been corrected and that all the historical dimensions have been developed. These questions were the same in two groups. The procedure followed during the research is shown in Fig. 2.

Instruments and measurements. As previously mentioned, a pre-test and post-test was carried out to analyse students' previous knowledge about these contents (pre-test) and what knowledge level students achieved at the end of the study (post-test). In particular, these ad hoc. tests were composed of closed and open-ended questions. All of them focus on one of the historical thinking dimensions following the recommendations of Seixas and Morton (2013). In addition, the construction of the questionnaire was reviewed by four university lecturers of history and its didactic before their implementation. At the end of the intervention, data obtained from both

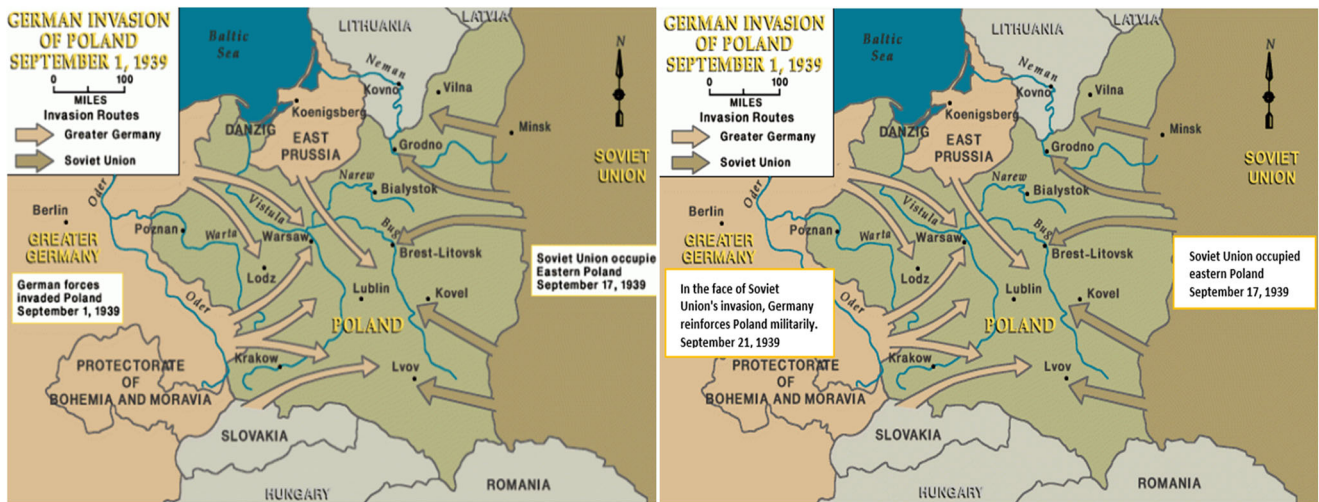


Fig. 1 Example of source used in both conditions: on the left, map of German Invasion in 1939 extracted from United States Holocaust Memorial Museum. Copyright of United States Holocaust Memorial Museum: <https://encyclopedia.ushmm.org/>. On the right, the same map with the modification of which country invaded Poland and its consequences.

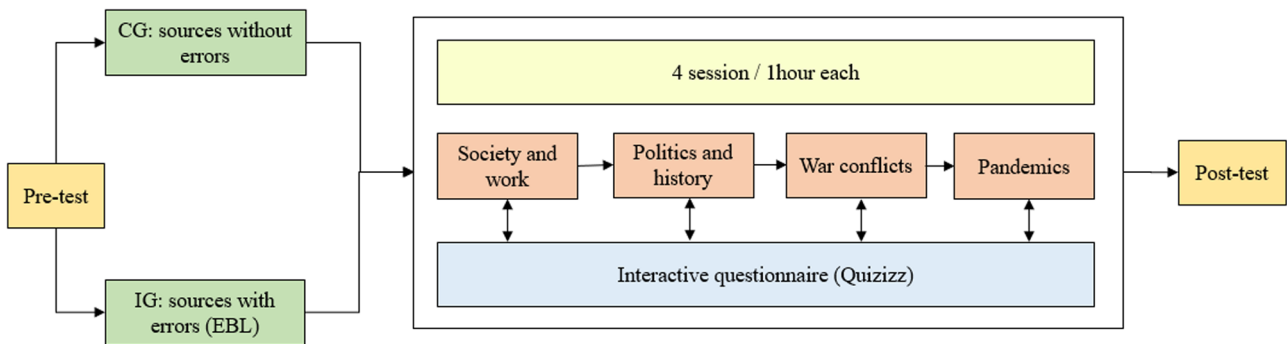


Fig. 2 Pedagogical dynamic implemented during each session in both groups. CG control group, IG intervention group and EBL error-based learning.

closed and open-ended questions were coded. To this aim, the open questions were reviewed by the researchers participating in the study following the assessment scale validated by Sáiz and Gómez (2016) for the analysis of each of the dimensions of historical thinking. Furthermore, in relation to the second objective of the research, to provide continuous feedback of the students' historical thinking, the LA data obtained by the SRS-based formative assessments of all the participants in the different sessions were used too.

Data collected were exported to a database and analysed using the SPSS software (vs.24) and R software. The descriptive analysis was conducted to evaluate the average score obtained by each student taking into account the study conditions. Then, inferential analyses were done to assess significant differences with regard to the research objectives. In particular, the analysis of covariance (ANCOVA) test was used to analyse the post-test results, since this test could be used to analyse the effect of the different methodologies used on the final level of knowledge, adjusted for the initial level of knowledge. Finally, a multiple linear regression was used to verify the predicted potential of the SRS-based scores obtained by the Quizizz questionnaires performed. The resulting effect size of the individual predictors was determined by calculating Cohen's f^2 with the semipartial correlation coefficients of the predictors as determined using R. Values of Cohen's f^2 of 0.02, 0.15, and 0.35 indicate small, medium, and large effect sizes, respectively (Cohen, 1922). A confidence interval of 95% was used for all the analyses.

Results

The results obtained are organised according to the objectives previously mentioned. In this regard, the first analysis was done to contrast the use of the EBL methodology and the use of the same sources without errors based on the academic achievement attained by the students. Then, the second analysis intended to evaluate the association between LA-based scores and post-test scores within both methodologies used.

How the inclusion of errors enables differences in academic performance.

According to academic performance the descriptive data obtained both in the pre-test and post-test are shown in Table 1. Those students who did not attempt one of these tests were not considered. As can be seen, before the intervention students had a similar low knowledge base with regard to the contents asked. On the contrary, after the intervention a higher knowledge was demonstrated by students from both groups. However, this academic performance was not equal at the end of the intervention. Students who took part of the IG demonstrated a higher level of knowledge in contrast to CG students, even though they have a slightly lower level before the intervention in contrast to CG students.

To check if these differences were statistically significant, an inferential analysis was performed. In particular, for this purpose, after checking the assumption of normality, homogeneity of variance and homogeneity of regression slopes, we opted to

perform a one-factor ANCOVA. The results obtained by this test can be seen in Table 2.

After adjustment for pre-test scores, there was a statistically significant difference in post-test scores between the groups, $F(1, 100) = 13.80; p < 0.001$. In addition, to verify the effect size of the EBL methodology, the partial eta-squared (η^2) was used $\eta^2 = 0.12$. According to Cohen (1988), this value corresponds to a medium-large effect. Therefore, after controlling that pre-test scores were not statistically significant ($p = 173$), the ANCOVA test revealed that the academic achievement of pre-service teachers in the IG is significantly greater compared to the academic results obtained in the CG after the intervention. This higher academic performance by the use of EBL methodology can be seen in Fig. 3.

Potential of using learning analytics in historical thinking evaluation. To analyse the feasibility of using LA as a formative assessment tool, a multiple linear regression was calculated to predict post-test scores based on the methodology used and SRS scores. To this purpose, only those students who attended at least

three quarters of the intervention sessions conducted were considered ($n = 104$, being 66 students from the IG and the rest from the CG).

In particular, a significant regression equation was found ($F(1,101) = 4.72; p = 0.03; f^2 = 0.12$). According to Cohen (1992), this value of Cohen's f^2 would be classified as a small-medium effect size. Concerning the local effect of each predictor, an almost high effect size was found in relation to group variable ($f^2 = 0.31$) and a medium-high effect size to LA variable ($f^2 = 0.22$) was obtained respectively (Cohen, 1922). As can be seen in Table 3, participants' predicted post-test scores are equal to $3.96 + 0.63$ (methodology) + 0.22 (LA scores) where methodology is coded as $0 = CG$ and $1 = IG$, and LA scores are measured in a 10-point scale. Therefore, participants' post-test scores in which EBL was used scored .63 more than CG students. In addition, by the use of LA, students of both groups increased +0.22 points in the post-test scores regardless of the methodology used. Thus, taking everything previously noted, both LA scores and the methodology used were significant predictors of post-test scores.

All in all, we can appreciate that EBL not only has a significant effect in terms of academic performance, but it can be implemented in the classroom in combination with LA techniques too. Finally, these techniques, independently of the methodology used, have a predictive and performance-enhancing capacity on subsequent tests of historical thinking skills.

Discussion

Despite the existence of new pedagogical trends in which the learner plays an active role, the methodology most frequently used in the history teaching is still the master class or expository lesson (Miralles-Martínez et al., 2014). As these authors also pointed out, this methodology is out of date and does not offer a

Table 1 Descriptive statistical data according to the methodology used.

Condition	N	Pre-test		Post-test	
		M	SD	M	SD
IG	61	3.95	1.20	6.03	1.11
CG	42	4.16	0.59	5.27	0.99

Table 2 One-way ANCOVA results using pre-test scores and methodology to examine the effect on academic performance.

Predictor	Sum of squares	df	Mean square	F	p	η^2
Methodology	15.49	1	15.49	13.80	<0.001	0.12
Pre-test scores	2.12	1	2.12	1.88	0.173	
Error	112.28	100	1.12			
Total	128.899	103				

Table 3 Multilinear regression analysis summary for LA and methodology predicting academic achievement in historical thinking.

	B	SD	Beta	t	p	f^2
Constant	3.96	0.66		6.01	<0.001	
Methodology	0.63	0.21	0.27	2.93	<0.001	0.31
Average LA scores	0.22	0.09	0.20	2.17	0.003	0.22

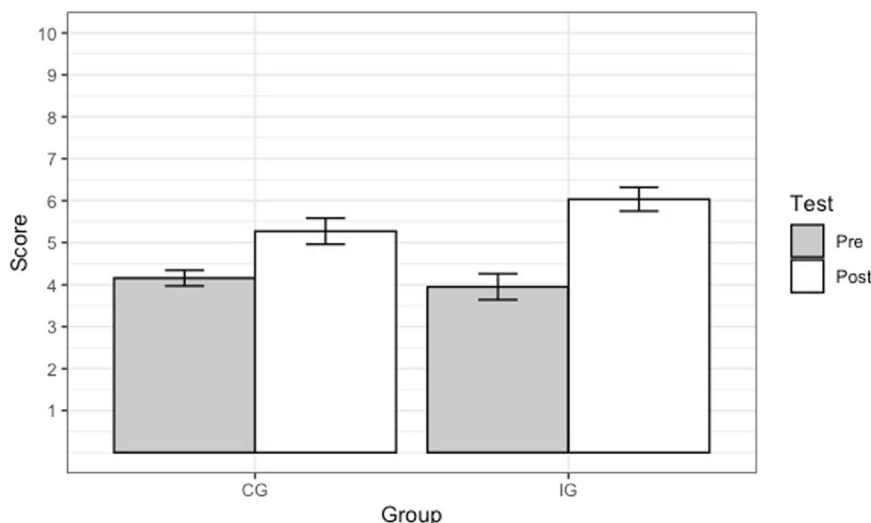


Fig. 3 Pre-test and post-test scores obtained by groups. The bar chart shows the means and confidence intervals for both the control group (CG) and the intervention group (IG) before and after the intervention.

solid foundation for student instruction. Furthermore, this classical perspective of history contradicts current pedagogical principles since it contributes to the perpetuation of the passive role of the students, as they receive a closed set of knowledge that the teacher explains to them (Gómez-Carrasco and Miralles-Martínez, 2017). As a consequence, students perceive historical contents as closed, tedious and with no practical application (Zhao and Hoge, 2005; Licerias and Romero, 2016), so that they may become bored and unmotivated, losing interest in the discipline. A change in the history teaching at all levels is necessary. In this line, several authors pointed out that history teaching should also include some higher cognitive skills specific to the discipline as historical thinking is (Seixas, 2010; Sáiz and Domínguez, 2017), which include, for instance, source-based argumentation, interpretation, and critical thinking. To this end, implementing innovative and engaging techniques in history training becomes necessary (Tirado-Olivares et al., 2021).

Thus, to follow current pedagogical principles and to introduce active educational approaches in history teaching where students are at the centre of the learning process are both necessary (Muntaner et al., 2020). For this aim, in the present study, a possible way of an active methodology such as EBL at university level has been tested. The interest in using this methodology was due to the fact that despite the effectiveness of EBL has been proved in other fields of knowledge, such as mathematics or science (Darabi et al., 2018), there is a scarcity of evidence in the area of history. It was interesting to prove whether EBL works on history or not, since working with errors also allows students to have an active role and focus on the process rather than on the result De la Torre (2004). Methodologies such as EBL can be the solution to renew how to teach history, and, especially, to enable students to foster their historical thinking, something impossible to achieve with methodologies in which students have a passive role (Gómez-Carrasco et al., 2018).

To check the interest of integrating EBL in history teaching, two experimental conditions were contrasted. While the CG students worked with sources without errors, the IG students worked with these same sources with errors. The results obtained show not only the possible use of EBL in history, but its effectiveness too. Thus, pre-service teachers' historical thinking is considerably improved by the didactic use of mistakes during the teaching-learning process of history. In this way, the positive effects of EBL in terms of academic performance found in the literature (e.g., Darabi et al., 2018; Jackson et al., 2021) have also been verified in our study area. In this regard, this study upholds that EBL not only allows students to acquire knowledge at a greater level of depth (Tawfik and Jonassen, 2013), but also facilitates the acquisition of higher cognitive skills such as interpretation and critical reflection while working with sources.

Then, the use of EBL methodology helps to reduce the likelihood of future teachers making such errors in the future, as has also been seen in the research of Álvarez-Herrero (2019) in the natural science area. As a result, the use of errors in a controlled and deliberated way seems to be beneficial and worth implementing in the history teaching-learning process of pre-service teachers. Hence, these results show that EBL contributes to the historical thinking development of future teachers. This is particularly important, since it is necessary for pre-service teachers to be trained in historical thinking so that they can fully understand and integrate it into their teaching practice.

As discussed above, today's education should not focus on knowing information, but rather on how to work with the information that is so accessible today thanks to current technologies, aligning with what history teaching in general, and historical thinking in particular, should provide to students (VanSledright, 2014; Miralles-Martínez et al., 2014; Sáiz and

Gómez, 2016). This requires an increase in teachers' training of their use since authors such as Santisteban et al. (2020) pointed out prospective teachers have a low level of critical digital literacy. Owing to this current lack of training, they do not feel able to use technology autonomously in practice and, therefore, will not be predisposed to apply educational-technological approaches (Gutiérrez-Martín et al., 2022). On the contrary, their use not only allows for new high-value approaches in which students can be responsible of their learning process, identifying both the errors inside sources and their own errors within EBL approaches, but at the same time addresses one of the major drawbacks facing the renewal of history teaching: how to assess the development of historical thinking on an ongoing basis in the classroom (Miralles-Martínez et al., 2014). To find a solution was the second main objective of this paper.

This point could be made possible by the implementation of the LA, as they allow us to collect massive and continuous information almost immediately (Pelletier et al., 2021). This integration of LA can be done in the classroom in a simple way thanks to SRS systems (Li and Wong, 2020a) such as Quizizz, the digital interactive platform, which has been used in this study. The integration of these technologies into history learning has been tested before. In fact, positive results in terms of academic performance, immediate feedback and assessment using other SRS systems such as Kahoot! have been found before in previous studies (Tóth et al., 2019; Tirado-Olivares et al., 2021); however, these studies were focused on analysing theoretical contents and not how skills such as historical thinking have been fostered during the teaching-learning process.

While the potential of implementing LA in the learning process in the short to medium term is well known (Gašević et al., 2022; Pelletier et al., 2021), there is little evidence of its use in areas such as history (Li and Wong, 2020b). In spite of this, as this study has shown, the use of LA would overcome the disadvantage faced by new history teaching with a competency-based approach, and cover the deficiencies that summative tests such as exams have demonstrated in evaluation (Miralles-Martínez et al., 2014). The results obtained in this paper highlight the capacity of daily LA scores to predict what level of historical thinking a future teacher will demonstrate in a later test. Thus, this research emphasises the importance not only of implementing new educational approaches by means of active methodology and new contents to foster (historical thinking), but also the feasibility to analyse the learning process daily thanks to new technological possibilities such as LA. By means of LA, both students and teachers could daily know what learners have already understood and what they have not. Something that, as it has been pointed out before, is relevant when EBL is implemented, since students have to pay attention to the learning process and be concerned about their mistakes De la Torre (2004).

Conclusion

There are already many authors who emphasise the importance of renewing the teaching-learning process (Gómez-Carrasco and Miralles-Martínez, 2017). Nowadays, students must acquire both an active and leading role in their learning, in which the learning process is equally important to the final academic outcome (Muntaner et al., 2020). Thus, from our area of knowledge, it is essential to encourage future teachers to work with sources in a reflective way, generate their own arguments and, in short, encourage their critical thinking, which translates into encouraging historical thinking in class (VanSledright, 2004, 2014; Sáiz and Domínguez, 2017). The present study goes along these lines in order to train future primary teachers to implement EBL to foster this historical thinking, especially crucial since there exists no evidence of this approach in our area of knowledge (Darabi

et al., 2018). The results obtained by ANCOVA test show the positive medium-large effect (Cohen, 1988) of EBL in history, as those students who had worked with deliberately introduced errors in the sources acquired higher levels of historical thinking in a post-test after controlling pre-test scores.

In addition, the present study has also corroborated LA as a viable and effective alternative both to provide students with relevant information about their learning process and to formatively evaluate their historical thinking. This point is relevant because of the need to implement alternative and/or complementary evaluations to assess this competence (Miralles-Martínez et al., 2014). Thus, the present study shows a practical way of integrating LA in the classroom together with active methodologies such as EBL. One of the great shortcomings of educational research continues as we have already known the great potential of LA (Pelletier et al., 2021), but we currently need evidence on how to implement it in the real context (Dubé and Wen, 2022; Gašević et al., 2022). This is especially interesting in areas such as history due to the lack of research (Li and Wong, 2020b). As we have seen in this study, not only the use of EBL and LA can be feasible combined during the teaching-learning process, but both EBL has confirmed to greatly improve prospective teachers' historical thinking training, and LA enables an effective way to assess this competence continuously. These were the two objectives, and then the main contributions of this study.

Proposals for future research and improvement. During the research, new questions and hypotheses arose that could lead to interesting results in the field of teaching history. Firstly, the current study focused only on analysing the impact of using methodologies such EBL and LA in terms of learning gain and evaluation. Thus, future studies into the exploration of students' interest and motivation towards the use of these active methodologies and tools used could also be beneficial. This aspect could be especially relevant taking into account that our sample was composed by pre-service teachers who are likely to use them in the future. Thus, their satisfaction or not while using them may influence the possibility of employing this educational approach in their future professional practice.

Similarly, in line with the previous point, analysing the sample taking into account variables such as gender could yield interesting conclusions to analyse. To this end, replicating this same study by expanding the sample would be necessary. Furthermore, given the conclusions obtained on the positive impact of the use of EBL and LA for the promotion of historical thinking, continuing in this line of action with a greater number of sessions or at other educational levels, such as primary education, could provide interesting evidence to compare with the current results. These hypotheses, due to the lack of studies in this field, could be a starting point for new studies and lines of research.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Received: 23 November 2022; Accepted: 23 January 2023;

Published online: 03 February 2023

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Acknowledgements

This work was supported by the European Union through European Regional Development Funds (ERDF-FEDER) and the Castilla-La Mancha Regional Administration under grant SBPLY/19/180501/000278; by the Ministry of Education, Culture and Sports of Spain under grant FPU20/02375; and by the University of Castilla-La Mancha under grant 2021-GRIN-31060.

Author contributions

ST-O: investigation, methodology, conceptualisation, writing—original draft, writing—review and editing. RC-G: conceptualisation, investigation, funding acquisition, methodology, writing—review and editing, supervision. CL-F: writing—original draft, investi-

gation, writing—review and editing. JAG-C: investigation, funding acquisition, methodology, writing—review and editing, formal analysis, supervision.

Competing interests

The author(s) declare no competing interests.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the educational administration of the autonomous community of Castilla-La Mancha and the Ethics Committee of University of Castilla-La Mancha (Date 07.04.2022./No. CEIS-632710-Z1N4).

Informed consent

Informed consent was obtained from all participants. As part of the ethics approval process, the authors obtained informed consent from all the participants in the study. To this aim, before data collection, an information sheet and consent form were distributed to explain to participants what the study was about, what information will be collected, and how this information will be managed (anonymous and only for research purposes). All the participants were allowed to ask questions before agreeing to sign the consent form.

Additional information

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