Effective use of Elaborative Interrogation to improve academic performance

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Study techniques most commonly used by students are usually the least effective for learning. Therefore, a sample of undergraduate students was trained in the use of Elaborative Interrogation (EI), a more powerful strategy. However, there are no clear guidelines on how to implement this technique, and there are contrasting results on its effectiveness. The present study aimed at analysing the effectiveness of EI in undergraduate students' performance. A pre-test post-test design was used with 3 within-participants conditions: control, self-generated EI and externally-generated EI. The effects that training and type and quality of EI implementation had on students' comprehension (at textbase and situation model levels) were investigated. Results suggest that the EI technique may be useful to improve undergraduates' learning, but only in very specific situations. Otherwise, it may even hinder performance compared to traditional study techniques. Some insights are offered to better understand how the EI strategy works.

Learning strategies have been a topic of interest for researchers and educators for decades. However, students still confront tertiary education using mostly very basic strategies, such as rereading or highlighting (Karpicke, et al., 2009; Hartwig & Dunlosky, 2012). These traditional strategies, despite their extensive use by students, are considered to have low utility because they do not consistently enhance performance (Dunlosky et al., 2013). Therefore, it is necessary to help students to implement new learning strategies. The present study will focus on implementing elaborative interrogation at university.

Literature review

Reading comprehension

Reading literacy is defined as "understanding, using, evaluating, reflecting on and engaging with texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2019, p.34). Therefore, it implies much more than decoding written text. You need to comprehend what you read, extracting and constructing meaning through interaction and involvement with the text (RAND Reading Study Group, 2002). One of the most recognized models of reading comprehension is the one proposed by Kintsch (2004). He suggests that there are two main levels of text comprehension: textbase comprehension, which represents the basic meaning of the text (the ideas expressed and how they are structured), and situation model comprehension, which integrates the information provided by the text with the reader's prior knowledge. According to this, two competent readers will comprehend more or less the same at a textbase level, but their situation model comprehension can be very different, as it depends on their background knowledge, as well as on their goals and interests. At an educational level, textbase is related to a superficial comprehension where the student could reproduce the text in a more or less literal way. However, in order for students to acquire a deep comprehension (situation model level) it is necessary to integrate the information with prior knowledge: this way, they will be able not only to reproduce the text, but to apply the learnt information to different contexts and in a creative manner.

Elaborative Interrogation

In educational contexts, many strategies and interventions have been proposed to

promote a situation model comprehension of the learning materials. One of these interventions is called Elaborative Interrogation (EI). EI is a technique consisting on inserting "Why...?" questions in the text that has to be learnt. These questions are aimed at facilitating the learner to create explanatory answers using their background knowledge or to connect several pieces of information rather than asking for information that is explicitly stated in the text (McCrudden & Schraw, 2007). These elaboration processes, therefore, are related to a situation model comprehension and they improve academic achievement and promote learners' engagement and independent learning (Sperling et al., 2016; Endres et al., 2017; Donoghue & Hattie, 2021).

In the late 80s and during the 90s, authors started paying attention to EI, reporting benefits for learners in a wide variety of conditions: EI is useful for adults (Pressley et al., 1987), for children (Wood et al., 1990), in cooperative learning settings (Kahl & Woloshyn, 1994), and even controlling for prior knowledge effects (Woloshyn et al., 1992). More recent research still supports the effectiveness of EI. For example, Ozgungor and Guthrie (2004) report how EI is especially useful for low prior knowledge readers and those who show less interest in the reading topic. Other studies report that inserting "why?" questions is more beneficial than inserting other types of questions or offering other general purpose reading instructions (Roelle et al., 2015). This strategy is also found to facilitate strategic reading when combined with relevance instructions (Moreno et al., 2021).

However, there is not total agreement on the positive impact of EI. Previous research has also shown how EI is not more beneficial than other strategies (Ramsay et al., 2010). Moreover, some authors report a complete lack of effect of the EI strategy (Dornisch & Sperling, 2006; Callender & McDaniel, 2013; Khül & Bertrams, 2019). And not only that, there is data suggesting that EI hinders performance (Bartoszewski & Gurung, 2015; Clinton et al., 2016). These contrasting results have raised some doubts and concerns about the EI technique, and some authors (e.g. Sumeracki et al., 2018) suggest that more research in real classroom contexts is needed to understand the specific situations in which it is useful. In fact, in a very thorough review, Dunlosky et al. (2013) highlighted some questions that future research on EI should address: (a) effects of EI depending on the quality of the elaborations generated: research usually

focus on the application or not of EI, but do not consider if the application was done correctly. The EI questions, as well as the answers given to them, should be analysed; (b) EI effects have been widely supported for associative memory of explicitly stated information, but not enough data is available to suggest that these effects hold true on recall or comprehension of information that is more complex than fact lists; (c) few studies have been conducted outside the laboratory, more research is needed on representative educational contexts; (d) pre-training differences, since some studies assume that a brief instruction is enough for the student to apply EI and others do not give any instruction or example of how to use it.

Other authors (Weinstein et al., 2018) raise further questions, wondering (e) if the time spent answering the EI questions is efficient (considering that they could be using that time to keep reading and making sense of the materials instead of answering a question), or (f) if students should answer questions provided by other people or questions generated by themselves. It might be easier to answer questions that are already created by an expert on the topic which makes sure that the question is correct and appropriate to reflect upon; however, if the student has to also create the question even more time is needed to apply the EI technique, time that could be spent reading the contents, and students might choose to create an easy textbase question that would not be helpful to facilitate a deep learning of those contents, therefore, wasting time. On the other hand, forcing them to create the questions might be helpful to elaborate on the contents in their own way, rather than trying to understand the rationale or the intention of the question posed by another person.

Research questions

The present study is an attempt to answer some of the questions reviewed in the previous section, aiming at shedding some light on the workings of EI. The research questions for the study are:

1. Is it important to offer specific training on how to use the EI strategy or is it enough with a basic instruction eliciting its use?

EI is normally considered to require minimal training (Dunlosky et al., 2013). Many studies apply EI without prior training of students, just instructing them to answer why questions (*e. g.* Woloshyn et al., 1992) and they still find benefits from using the

strategy. However, other studies do not find these beneficial effects of EI, and suggest that training students on how to effectively use the strategy might be of key importance (Dornisch et al., 2011; Clinton et al., 2016). We expect to find higher performance of students using the EI strategy, but only after some training has been offered on how to effectively implement it.

2. Is EI more effective if students create their own questions or if they answer questions that are already created by a professor?

There is data suggesting that creating your own answers to EI questions is more effective than reading explanatory elaborations provided by others (*e. g.* Wood et al., 1990). However, other studies report that instructor-generated questions lead to better performance than student-generated questions, even when a revision phase is included so students can compare their own questions with those provided by the instructor (Byun et al., 2014). King (1992) suggests that student-generated questions may be superior to provided questions if they are guided on the process of creating those questions. Considering these data, we expect to find that questions generated by the professor would be more effective prior to EI training, and student generated questions would be more beneficial after EI training.

3. Is the quality of the answers to why questions an important factor, or is it enough just to answer them?

Previous data suggests that EI effects are really strong, and they hold when inadequate answers are given to EI questions, and even when no answers are given at all (Woloshyn et al., 1990). Authors assume that EI questions facilitate elaboration processing and prior knowledge activation, even when no explanations are found by students to answer the questions. However, other studies state that the quality of the answers is evident: correct explanations are related to better recall (Wood et al., 1990) and poor answers can hurt learning (Clinton et al., 2016). Higher quality answers to EI are also positively associated with transfer knowledge (Navratil & Kühl, 2019). We expect to replicate these results: higher performance for students that answer EI questions correctly.

4. Is the time devoted to answering why questions efficient or would it be better to spend that time using traditional strategies (i. e. rereading)?

Answering EI questions is time consuming, and it may take significantly longer than using traditional strategies like re-reading (Ozgungor & Guthrie, 2004). This may explain, in part, the potential benefits of the EI strategy, since it requires students to spend more time on task. However, studies where time differences between groups (EI and re-reading) were minimal still report a beneficial impact of the EI strategy (Smith et al., 2010). In general, greater use of active strategies (like elaboration) is associated with performance even when study time is controlled (Rowell et al., 2021). Therefore, controlling for time on task, we expect that using the EI strategy would obtain better performance than using traditional strategies, despite the time requirements of creating and/or answering why questions that could be spent on reading and learning the text more directly.

Materials and methods

Participants

Twenty undergraduate students participated in the study (45% males, 55% females). None of the participants had previously used elaborative interrogation, and they did not know about the strategy. Students were given course credit for their participation. All participants offered informed consent to participate, the guidelines of the Declaration of Helsinki were followed and the university committee approved the research study.

Research design

A pre-test post-test design was performed, with three different conditions:

Control: this is a control condition. Students read a text without any questions, and were instructed to learn the contents as they usually do.

Self-generated EI: students read a text that included prompts to create a "why…?" question, with a blank space to answer the generated question afterwards. Prompts were inserted every about 300 words. Participants were prompted to create questions that would help them to reflect on the contents and facilitate their learning, with answers that are not explicitly stated in the text.

Externally-generated EI: students read a text that had "why…?" questions inserted every about 300 words. These questions were created by their professor, and

were destined to help students reflect on the contents asking for answers that were not explicitly stated in the text. Students were instructed to answer all questions while reading, using them to reflect on the contents and check their understanding.

At pre-test, all participants read one text in each condition (therefore, each participant read a total of three texts). Using this within-participants design (very uncommon in previous EI research) we expect to obtain more reliable results than those obtained using between-participants designs. Students were given 20 minutes to read each text (or read and create/answer "why…?" questions). Students were tested right after each reading (10 minutes were given to complete each test). After pre-test, training was offered in which students were taught what elaborative interrogation is and how to use it in learning situations. They practiced creating and answering "why…?" questions during their lessons once a week for 4 weeks. At post-test, they were assessed in the same fashion as in the pre-test, using different materials. This means that on pre-test they only applied EI when prompted to do so, without explicit knowledge on the EI technique, whilst on post-test they had learnt and practiced how to use the EI technique.

Materials

Texts

Three texts were created of about 1,300 words each. All texts were extracted from their handbooks or lesson materials. Three versions of each text were created: one with plain text for the control, one with prompts and a blank space to create and answer why questions for the self-generated EI condition, and another one with inserted why questions and a blank space to answer for the external-generated EI condition (prompts and why questions were inserted in the exact same spots in the texts in both EI conditions). This way, all participants read the three texts in the same order, each text in a different fashion (self-generated EI, external-generated EI or control), counterbalancing the conditions in order to control for potential order effects and differences in the difficulty of the texts and/or the tests associated to them.

Three different texts were created for the post-test, with the same characteristics as before.

Recall Tests

A test was created for each text. All tests included 3 short answer questions that asked for textbase information stated in the text, and 2 short answer questions aimed at the situation model comprehension, asking for information not explicitly stated in the text. All questions were different from those inserted in the texts of the external-generated EI condition.

A rubric was created for each test and two researchers rated all of them with high inter-rater reliability (*ICC* = 0.92). Scores were transformed to a 0-10 scale to facilitate interpretation.

Self-report questionnaire

A simple self-report questionnaire was used to know the learning strategies that participants used during the task. This way it could be confirmed that they actually used EI in the EI conditions and which strategies were implemented in the control conditions (these strategies should be different from EI).

Data analyses

Results obtained did not meet the normality assumption, so non-parametric tests were used.

Results

Pre-Test

Friedman's ANOVA for repeated measures was performed. There were no significant differences across conditions in textbase comprehension (χ^2 (2) = 2.986, p > .05) or situation model comprehension (χ^2 (2) = 0.438, p > .05). Therefore, neither answering questions created by the professor nor creating and answering their own questions had any apparent benefits on recall.

Next, the quality of the answers given by students to the inserted questions (externally-generated EI) as well as the quality of the questions created and answers offered in the self-generated EI condition were analysed and categorized as appropriate use of the EI strategy (if questions and/or answers focused on elaborating the contents) or inappropriate use of it (if they focused on explicit literal information or were actually

wrong answers). Two researchers rated the quality of the EI implementation in these conditions with high inter-rater reliability (ICC = .91). Then each experimental condition was compared to the control. Wilcoxon signed-rank tests showed that performance on situation model questions was significantly hindered in both self-generated EI (Z = -2.705, p = .007) and externally generated EI (Z = -1.988, p = .047) when the EI strategy was not properly applied (see Figures 1 and 2, respectively). To make sure results can be generalized despite the small sample, post-hoc power analyses were performed using G*Power. Results showed high statistical power for results of self-generated EI (.98), which indicates that these results can be extended to a general population. However, statistical power for externally generated EI was lower (.62), so they must be interpreted with caution. Performance on textbase comprehension showed no significant differences across conditions. It is worth noting that correctly applying the EI strategy did not show any significant benefits compared to the control condition.

Figure 1

Mean comprehension scores (0-10 scale) of students on the self-generated EI condition (before training), compared to their own performance in the control condition. Results are divided between appropriate implementation (good questions were created and answered correctly during reading) and inappropriate

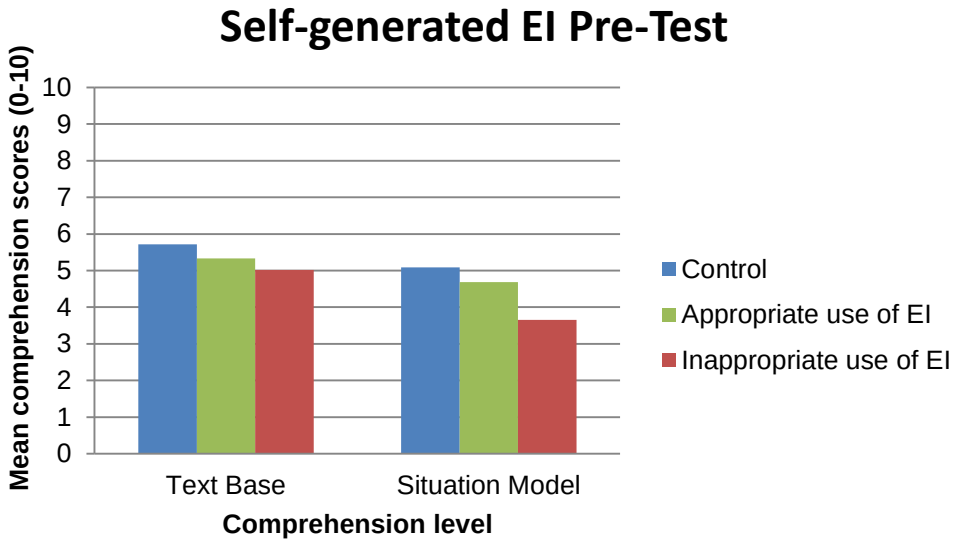
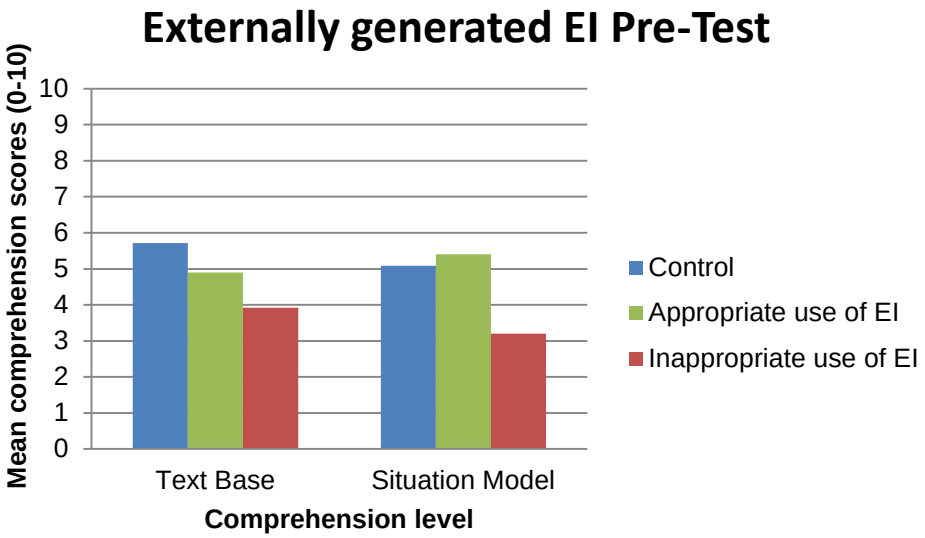


Figure 2

Mean comprehension scores (0-10 scale) of students on the externally generated EI condition (before training), compared to their own performance in the control condition. Results are divided between appropriate implementation (correct answers to EI questions during reading) and inappropriate.



Post-test

After the training on how to implement the EI strategy, students were tested again. Friedman's ANOVA for repeated measures was used. Similarly to the pre-test, no significant differences were found across conditions in textbase comprehension (χ^2 (2) = 1.000, p > .05) or situation model comprehension ($\chi^2(2) = 0.113$, $p > .05$). Again, the quality of the questions and answers offered to inserted questions was assessed and they were categorized as appropriate or inappropriate. This time, Wilcoxon signed-rank tests showed how students who made an appropriate use of the strategy in self-generated EI showed enhanced performance in overall recall ($Z = -2.201$, $p = .028$). Statistical power for this test was high (.84). This enhanced performance was mainly caused by an increment in the situation model comprehension scores ($Z = -1.951$, $p = .051$), since the improved performance in textbase comprehension did not reach significance (see Figure 3). However, externally generated EI still showed no significant benefits from correctly applying the EI strategy, although their performance was superior to the control condition. This time, inappropriate use of the strategy did not hinder performance (at least significantly) compared to the control condition (see Figure 4).

Figure 3

Mean comprehension scores (0-10 scale) of students on the self-generated EI condition (after training), compared to their own performance in the control condition. Results are divided between appropriate implementation (good questions were created and answered correctly during reading) and inappropriate.

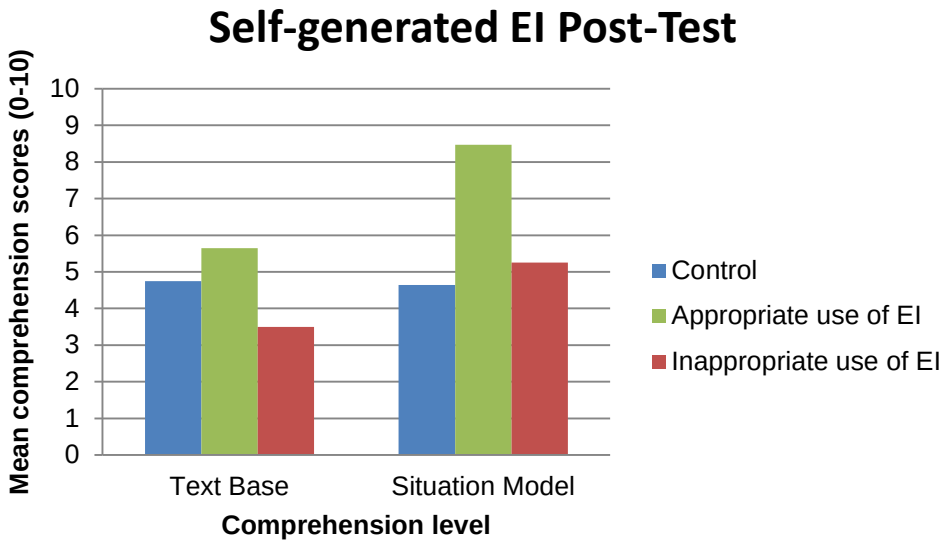
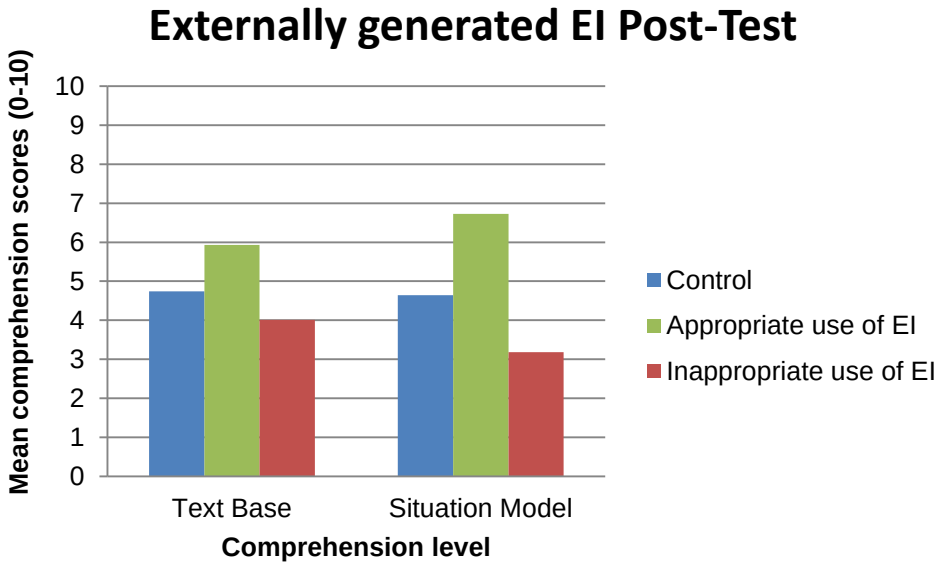


Figure 4

Mean comprehension scores (0-10 scale) of students on the externally generated EI condition (after training), compared to their own performance in the control condition. Results are divided between appropriate implementation (correct answers to EI questions during reading) and inappropriate.



Self-report questionnaires

All participants reported to use either rereading or underlining/highlighting (or both) unless they were explicitly asked to do otherwise (as in the EI conditions). Therefore, all participants used traditional learning techniques in the control condition so contamination effects from EI training seem to have no effect on strategy implementation with control texts.

Discussion

The research questions for the study will be now discussed in light of the results obtained:

1. Is it important to offer specific training on how to use the EI strategy or is it enough with a basic instruction eliciting its use?

We expected to find better performance using the EI strategy after some training was offered on how to implement it. This turned out to be correct. At pre-test, when students were just prompted to use the strategy without prior training, no significant improvements were found over the control condition, even when the strategy was correctly implemented. However, after the training, recall was significantly improved in students who created and answered their own why questions correctly (self-generated EI). It is worth noting that simply answering the given why questions (externally generated EI) did not show to have a positive impact.

This result suggests that some training is actually necessary to benefit from EI. This might have to do with the materials used. Research on EI has usually focused on the learning of discrete facts (Dunlosky et al., 2013). However, when using more complex materials, it is more difficult to decide on which contents you should focus the why questions or how to elaborate to answer them (Hamilton, 1997). Therefore, training might be necessary depending on the type of contents that must be learnt: learning factual statements might be facilitated by just prompting the use of EI, but learning more complex materials might require prior training on EI for it to be useful.

2. Is EI more effective if students create their own questions or if they answer questions that are already created by a professor?

Considering previous research, we expected externally generated EI to be more effective than self-generated EI prior to training, and the reverse results after the training. This hypothesis was only partially correct. Prior to training, none of the two implementations of EI facilitated performance compared to the control condition. After some training, it seems that creating and answering your own questions adequately is more effective than answering the questions given by a professor, supporting King's (1992) argument. This result contrasts with the ones reported by Byun et al. (2014), in which instructor generated prompts were more effective than student-generated ones. One potential explanation is that they used these prompts in a problem-solving context, not with expository texts for learning as we did. Also, although the prompts they used are also destined to promote elaboration, they are not specifically using elaborative interrogation (why questions), which may have had some influence too.

The possibility of different implementations of EI having different impacts depending on the specific contents they are applied to is worth investigating in the future.

3. Is the quality of the answers to EI questions an important factor, or is it enough just to answer them?

We expected to find better performance when the quality of the answers given to EI questions was appropriate. This hypothesis was correct, but differences were found depending on the training. Prior to receiving EI training, low quality answers significantly hindered performance, irrespective of the why questions being created by a professor or by the students, supporting the hypothesis posted by Clinton et al. (2016) as a potential explanation for the negative effects of EI that they found. After receiving the training, high quality answers enhanced performance significantly, but only for student-generated questions. Again, the strong effects found in previous research even when wrong answers or no answers were given by students (*e. g.* Woloshyn et al., 1990) might have to do with the contents. EI might have stronger effects irrespective of the quality of the answers to learn facts, but quality of the answers might be more important for more complex learning. In fact, it is very interesting to highlight how performance on textbase comprehension did not vary. The quality of the answers only had an impact on the more complex level of situation model comprehension, supporting the argument of EI having different impacts depending on the complexity of the knowledge to be

acquired. Results obtained by Farooq (2019) are in line with this claim, since EI prompts (teacher-generated) showed no effect in the complex learning situation tested in the experiment (writing a synthesis paragraph from multiple documents). It also supports the results by Navratil and Kühl (2019), in which higher quality answers related to better performance. Therefore, previous contrasting results that can be found in the literature on the effects of EI might be explained not only by the different type of contents used, but also by how performance is measured and the quality of answers given to why questions.

It is also important to highlight the relationship between the quality of the answers and the training received. Giving quality answers having no prior training on how to use the EI strategy seems to be necessary just to achieve a similar performance than using traditional strategies. Therefore, EI should not be recommended without prior training on how to use the strategy, at least if using more complex materials than fact lists, because implementing it poorly might hinder performance, and using it appropriately may not be more beneficial than traditional strategies (re-reading and/or highlighting).

4. Is the time devoted to answering EI questions efficient or would it be better to spend that time using traditional strategies (e.g. rereading)?

We expected to find time invested on answering why questions to be efficient, leading to better performance than devoting that time to traditional strategies. This hypothesis is only correct in a very specific situation: if students generate their own questions and the answers they give to those questions are appropriate, also assuming they have received some training on how to use the EI strategy and that we are assessing situation model comprehension. If any of these elements is missing, time devoted to answering EI questions might not only be inefficient, but it can even be counterproductive, leading to poorer performance. However, this result must be interpreted with caution. It is true that time on task was controlled and the same for all participants, but we can't know how much time they spent on reading and how much on creating and answering the questions. It is true that if you are creating or/answering questions you cannot devote that time to re-read or highlight, so higher performance in EI conditions implies that time devoted to EI is more efficient than devoting it to re-read or highlight. However, it is very possible that time spent answering the why questions is

efficient up to a breaking point, where any extra time devoted to it hinders performance. Also, in order to control time on task, students were given a fixed limited time to work on the texts. Results might have been different if no time restrictions were imposed.

Conclusions

The present study aimed at contributing to the Elaborative Interrogation field, offering new data that can be useful to help answer some of the questions that the implementation of this strategy raises. To increase the validity of the results, a within-participants design was used: the traditional between-participants design commonly employed on EI research raises concerns about the results obtained, since the reported effects might be caused by individual differences rather than the strategy itself. Also, as suggested by Sumeracki et al. (2018), the study was carried out in a real learning context, including the learning sessions and assessments as part of the students' learning materials for their subjects.

Results reported here suggest that EI can be useful in real learning contexts, and for more complex learning than fact lists. However, significantly improving situation model comprehension was only achieved in a very specific situation: students had received training, they created and answered their own questions and those questions and answers were appropriate. This result raises further issues. Since students' performance was only enhanced (significantly) when creating and answering their own questions, it may be possible, on the one hand, that these effects have to do with the extra effort of creating a suitable question rather than to the elaborations performed to give an answer. On the other hand, considering the fact that students that only answered EI questions (externally generated EI) did perform better than in the control condition, but not as good as when they created and answered their own questions (self-generated EI) might mean that both answering EI questions and creating them have a beneficial impact, but only the combination of both tasks reaches a significant level.

Regarding training, it seems essential to train students to obtain benefits from applying EI to more complex materials than fact lists. However, it is worth highlighting that this training may not necessary improve performance, it would just avoid hindering students' achievement, which really makes us wonder if training on EI is worth the effort, considering it may lead to the same outcomes than easier strategies, such as re-

reading or highlighting (or even to lower achievement if it is not correctly implemented).

As a final conclusion, and based on these results, we cannot be optimistic enough to recommend the EI strategy for undergraduate students learning from expository texts. Re-reading and highlighting may be inefficient strategies, but a bad implementation of EI can reduce learning outcomes (situation model comprehension) compared to them, and a proper implementation does not assure a beneficial impact.

Limitations of the present study are related to time on task. Students reported to use re-reading and highlighting in control conditions and focusing on EI in experimental conditions, but how much time they spent on the first reading and how much on the use of the strategies cannot be analysed with the present experimental design. It is true that results were obtained suggesting beneficial effects for specific strategies and situations, but more information could be obtained with more control on this variable. Another limitation has to do with sample size. It is true that statistical power analyses showed very high scores, suggesting that the effects reported here will hold with larger samples. However, there might be other effects that did not reach significance due to the small sample, so larger samples could offer extra information. The novelty of the results obtained is an important addition to the field, and can offer some clues to explanation the contrasting results found on previous studies.

More research is needed to fully assess the utility of the EI strategy. Future studies might be able to assess the impact of time (discerning time devoted to answer why questions and time devoted to reading) to better interpret how much time would be efficient to spend on elaborating. Also, different levels of comprehension (textbase and situation model) should be addresses, since EI might be useful just for some of them.

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Declaration of interest statement

The authors report there are no competing interests to declare.

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