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IMPACT OF A DIGITAL TOOL TO IMPROVE METACOGNITIVE STRATEGIES FOR SELF-REGULATION DURING TEXT READING IN ONLINE TEACHER EDUCATION

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ABSTRACT

Aim/Purpose	The aim of the study is to test whether the perception of self-regulated learning during text reading in online teacher education is improved by using a digital tool for the use of metacognitive strategies for planning, monitoring, and self-assessment.
Background	The use of self-regulated learning is important in reading skills, and for students to develop self-regulated learning, their teachers must master it. Therefore, teaching strategies for self-regulated learning in teacher education is essential.
Methodology	The sample size was 252 participants with the tool used by 42% or the participants. A quasi-experimental design was used in a pre-post study. ARATEX-R, a text-based scale, was used to evaluate self-regulated learning. The 5-point Likert scale includes the evaluation of five dimensions: planning strategies, cognition management, motivation management, comprehension assessment and context management. A Generalized Linear Model was used to analyse the results.
Contribution	Using the tool to self-regulate learning has led to an improvement during text reading, especially in the dimensions of motivation management, planning management and comprehension assessment, key dimensions for text comprehension and learning.

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Findings	Participants who use the app perceive greater improvement, especially in the dimensions of motivation management (22,3%), planning management (19.9%) and comprehension assessment (24,6%), which are fundamental dimensions for self-regulation in text reading.
Recommendations for Practitioners	This tool should be included in teacher training to enable reflection during the reading of texts, because it helps to improve three key types of strategies in self-regulation: (1) planning through planning management, (2) monitoring through motivation management and comprehension assessment, and (3) self-assessment through comprehension assessment.
Recommendations for Researchers	The success of the tool suggests further study for its application in other use cases: other student profiles in higher education, other teaching modalities, and other educational stages. These studies will help to identify adaptations that will extend the tool's use in education.
Impact on Society	The use of Metadig facilitates reflection during the reading of texts in order to improve comprehension and thus self-regulate the learning of content. This reflection is crucial for students' knowledge construction.
Future Research	Future research will focus on enhancing the digital tool by adding features to support the development of cognition and context management. It will also focus on how on adapting the tool to help other types of learners.

Keywords	self-regulated learning, metacognition, reading, teacher education, digital tool

INTRODUCTION

A high level of text reading is one of the basic elements for learning and academic performance at all educational levels. From elementary school onwards, studies have shown a significant correlation between reading comprehension and academic performance (Pascual-Gómez & Carril-Martínez, 2017; Viramontes et al., 2019). Moreover, as the academic year increases, the correlation becomes stronger (Dias et al., 2015; Elosua et al., 2012). This relationship is maintained throughout life, evidenced in a study by Galiza (2022) showing that university students with a proficient reading competency level obtained a significantly higher academic average.

Reading literacy directly affects knowledge acquisition. For example, content literacy facilitates the acquisition of science domain knowledge and, in turn, reading comprehension (Kim et al., 2021). The influence has also been seen in mathematics where students are unable to extract the facts of a problem due to a lack of understanding of the words (Verschaffel et al., 2020). In fact, these results are in line with predictors of reading difficulties, as these children often show problems reading easy words and problems with vocabulary (Psyridou et al., 2021).

Moreover, according to the results of the Programme for International Student Assessment (PISA) in 2018, one of the most important variables in explaining reading proficiency results is the use of metacognitive strategies (Vázquez-López & Huerta-Manzanilla, 2021). This is consistent with the findings of other studies, such as Villanueva (2022), that found a significant relationship between metacognitive reading strategies and performance. Metacognition plays an indisputable role in domain-specific contexts, such as in language skills (Krieger et al., 2022). When metacognitive knowledge in reading strategies is improved, reading comprehension is improved (Soodla et al., 2016; Urban et al., 2023), which leads to improved learning of any content. In fact, Carretti et al. (2014) found that the largest effects of intervention programmes focused on metacognition, are obtained in reading comprehension.

Another study carried out to check the difficulties of trainee teachers in an online master's degree program, found that the most affected areas of self-regulation in reading texts were comprehension assessment, motivation management, and planning management (Ortega-Ruipérez & Castellanos-Sánchez, 2023). This has allowed us to advance the design and development of a digital tool focused on metacognitive strategies, as most of the tools to improve self-regulated learning are based on the training of cognitive strategies (Hooshyar et al., 2020).

LITERATURE REVIEW

Metacognitive strategies are an essential part of self-regulated learning (SRL), together with cognitive and socioemotional strategies, as described by different SRL models (Panadero, 2017). If we work on metacognitive strategies during learning, the use of cognitive and socioemotional strategies is also enhanced (Akamatsu et al., 2019), as metacognitive strategies help to reflect on the use of the rest of the strategies. Therefore, it is important to focus especially on metacognitive strategies if we want to develop self-regulated learning. Winne's (1996) model was the first relevant model to highlight metacognition as the key to self-regulated learning, and since then many authors have contributed on which metacognitive strategies facilitate self-regulated learning.

Thus, most research agrees, according to Muijs and Bokhove (2020), on three types of strategies: planning strategies, which allow selecting goals and creating a plan to achieve them; monitoring strategies, which allow monitoring whether goals are being achieved through reflection; and evaluation strategies, which allow self-assessment and analysis of performance. Planning, including time management, has a strong positive effect on performance (Colthorpe et al., 2018; Fokkens-Bruinsma et al., 2020). Supervision improves understanding of the learning process (Pardo et al., 2016) and the ability to judge one's own work (Panadero et al., 2018; Tai et al., 2018). Self-assessment is more effective than teacher feedback and is able to reduce maladaptive behaviour (Vasu et al., 2020), especially if it is carried out on specific criteria (Carroll, 2020) and after the detection of errors (Zamora et al., 2018).

Primarily, when metacognitive strategies are applied to self-regulate learning during text reading, they are based on planning strategies, cognition management, motivation management, comprehension assessment and context management (Núñez et al., 2015). Therefore, to use digital tools to enhance instruction for self-regulated learning, the design must include issues related to the five strategies that occur during text reading. Bull and Kay (2010), propose the Open Learner Model (OLM), which is based on learners questioning what they know, how well they know a topic, what they want to know, and how they can learn it (Kay et al., 1997). This model facilitates goal setting, strategy implementation, and strategy monitoring, which has a positive impact on performance (Chou & Zou, 2020).

On the other hand, for students at any educational stage to be able to develop metacognitive strategies in reading texts, it is undoubtedly essential that their teachers master them, that is, that they know how to apply them in order to be able to teach them properly (Panadero, 2017). Teachers must explicitly include metacognitive strategies during their instruction so that students can integrate them into their learning process (Dignath & Veenman, 2021), as it is essential that teachers act as metacognitive role models (Wall & Hall, 2016). Therefore, it is vital to include specific tools and strategies that facilitate self-regulated learning during teacher education (Perry et al., 2019).

So far, most of the tools used by both teachers and students for self-regulated learning are based on self-reporting only, with which it is very difficult to measure metacognition in action (Perry et al., 2019). A tool based on OLM design ensures that students have to question their own learning, i.e. it ensures the use of metacognition, as they have to reflect on their learning process based on the "wh" questions: What, Who, When, Where, Which, Why, Whose, and How (Kay et al., 1997). Therefore, according to Chou and Zou (2020), this model facilitates the implementation and monitoring of self-

regulation strategies. The need to use a digital tool is especially accentuated in online and blended environments, as the mastery of technological tools becomes essential to be able to make the most of the knowledge acquisition process.

One variable that has been positively influenced by the use of self-regulated learning in teacher education is self-efficacy. As the introduction of metacognitive strategies improves so will a teacher's self-efficacy to introduce self-regulated learning in their teaching (Dignath, 2021). In addition, a clear relationship has been found between self-efficacy and self-regulated learning. Training programmes in metacognitive skills lead to an increase in self-efficacy, which in turn has a positive impact on performance (Joie-La Marle et al., 2023). These results have been tested around different aspects of second language proficiency. Examples include Teng and Yang's (2022) findings on the relationship between self-efficacy and performance, which in turn is mediated by the role of metacognition and studies on writing achievement (Arroyo et al., 2021; Chen et al., 2022; Djatmika et al., 2022). Perceived self-efficacy and resilience are fundamental coping mechanisms, and engagement is one of the key factors in resilience (Sagone et al., 2020). Therefore, using metacognitive strategies for self-regulated learning acts as a compensatory mechanism for students who are at academic risk due to reading problems.

Another variable that clearly influences a good reading comprehension outcome is reading engagement, measured as situational interest in and motivation for reading (Kim et al., 2021). Reading engagement can significantly predict reading comprehension (Hamedi et al., 2020). The relationships between reading comprehension and reading engagement are strong in all cases, except for low achievement readers (Wantchekon & Kim, 2019).

Based on the literature, the aim of this research is to test if the use of a digital tool, developed by the authors as part of a research project, and based on OLM design to facilitate metacognitive strategies, improves the perception of the use of these strategies during text reading in trainee teachers. Thus, the following sections of the manuscript will discuss the method used to answer this research question, the results obtained, the discussion of the results and the conclusions reached after analysing the study.

METHOD

This is an intervention study, specifically to test whether a digital tool for self-regulated learning has a positive impact on text reading. The independent variable is the use of the tool, while the dependent variable is the perception of the use of SRL strategies in text reading.

A quasi-experimental design was used as study participants decided whether they wanted to use the tool or not on a voluntary basis and could not be randomly assigned to research groups (Creswell & Creswell, 2017). Thus, to have greater control over the independent variable, a control group was used in addition to the experimental group. Also, it has been possible to compare the improvement results of both groups to find out if there are differences in terms of improvement in both groups, and to be able to confirm if this improvement is due to the use of the tool.

A pre-post study design was carried out in order to have more control over the independent variable. This means that data were taken on the five dimensions related to the dependent variable, self-regulation during text reading, both before and after the intervention, that is, the use of Metadig tool. In this way, it will be possible to confirm whether the improvement produced by the tool is significant with respect to the initial level shown by the participants in the application of metacognitive strategies, or whether, on the contrary, they showed a similar level of self-regulation before and after using Metadig.

PARTICIPANTS

The total population of a master's degree in educational technology for teachers, where this study was conducted at a Spanish online university, is 650 students. A total of 252 students participated in the research, that is, 38.7%. This percentage is considered adequate to be able to generalize the results, as for a confidence level of 95% and a population of 650, a sample size of at least 242 participants is recommended (Dupont & Plummer, 1990). The sampling was carried out in a non-probabilistic manner, since the students decided voluntarily if they wanted to participate in the study, so it is a convenience sample.

Regarding the distribution of the participants in the research groups, 42% used the app regularly (105 participants), while 58% hardly used it beyond the first few days (147 participants). The students decided if they wanted to continue using the application for the whole course. This resulted in the two study groups, which were used to contrast the benefit of using the app (experimental group) versus not using it regularly (control group). In this way, the groups were formed according to the students' choice of whether to use the tool or not. To study the differences between groups, a box was added to the self-regulated learning questionnaire to mark whether they had used it throughout the entire course.

INSTRUMENTS

Intervention tool: Metadig

A four-hour training course on the importance of self-regulated learning was conducted in a master's degree in educational technology. Students were offered the voluntary use of the digital tool Metadig so that they could self-regulate their learning in the master's degree. Metadig is a digital tool designed to improve student learning through metacognitive self-regulation. Therefore, the tool is divided into three sections: planning, monitoring, and self-assessment of learning. The tool has gone through several versions, which have been improved based on previous studies on learners' needs, usability studies and expert validation studies. Metadig has been shown to have a positive impact on the assessment of comprehension and planning management in relation to self-regulation during text reading, and information seeking in terms of improving study habits (Ortega-Ruipérez, 2022). Also, to a lesser extent, the dialogical dimension of critical thinking (Pereles et al., 2024a).

Research instrument for pre-test and post-test

To assess the improvement in self-regulated learning during text reading, a pre-post study was conducted. An assessment scale for self-regulated learning from texts (ARATEX-R), developed and validated by Núñez et al. (2015), was implemented. This assessment included 23 items for the assessment over five dimensions: cognition management (1), motivation management (2), comprehension assessment (3), planning (4), and context management (5). The items of the questionnaire and the dimension to which each item belongs can be found in the Appendix.

The reliability analysis for the test with our sample was a Cronbach's alpha of 0.95. For each dimension this shows very positive values: in the planning scale (6 items) we obtained a Cronbach's alpha of .91; in the management of cognition scale (5 items) the Cronbach's alpha is .87; in the management of motivation (5 items) an alpha of .84; in the evaluation of comprehension (5 items) an alpha of .86; and in the management of context (2 items) an alpha of .63. Although the latter is not as good as the previous ones, it is considered sufficient.

PROCEDURE

The week before the start of classes in the second term of the master's degree, when the intervention was implemented, students were contacted through the platform's notification menu, via email, and through telephone calls made by the tutor of each group. The tutors phoned students to remind them that there would be some sessions on self-regulated learning that could help them to improve their study strategies. The first training session was held the week of the start of classes, and covered

the topics of what self-regulated learning is, focusing on metacognitive strategies, and why it is important to use self-regulated learning, explaining the main benefits known from research. After this, the app developed for the intervention was explained, emphasising the metacognitive strategies focused on at each stage. First, they had to select the objectives and plan how to study them. Then, each week, they checked to see if they were following the plan. Finally, the last week they were able to do a self-assessment of their learning and guide the study of the exams. Finally, the study in which this instructional innovation is framed was explained to them, and they were kindly asked to collaborate in the study, explaining that all they had to do was fill in a questionnaire in Google forms. This session was recorded in Adobe Connect, which is the videoconferencing tool used at the university. Thus, the students could review the recording during the following week, so the questionnaire was left open for a week. The questionnaire contained the items of the ARATEX-R scale (Appendix). No personal data was collected, so the questionnaires did not have to be anonymised.

During the four-month period, which lasts 15 weeks, the students used the app autonomously, whenever they saw fit, as the aim was for them to organise their own learning process in the different subjects of the master's degree: programming and robotics, entrepreneurship and innovation, and applied neuroscience. Students who chose to use Metadig were given basic instructions on when to use each section. Thus, in the first week, they had to plan their objectives and decide how they were going to tackle them. For the next 15 weeks, the duration of the term, the app allows them to manage and monitor their weekly progress. In weeks 5 and 10, they were reminded to use the app in their own class sessions and through the class forums. In addition, before week 15, a quick review was given on how they could use the self-assessment part of the app to make the most of it. For the last week, the app includes a self-assessment function and identifies weaknesses to dedicate more time to study.

Finally, after the exams, during week 16, they were called for the second training session. The notice was issued to the students a week before, and they were reminded of the call the day before. This time, the training also lasted two hours, but it was about why it is important for them to work on metacognitive strategies with their students for them to develop self-regulated learning. To do this, the idea was to start with a reflection by each student on how the app had helped them to study. At the end of the session, they were asked to fill in the same questionnaire as in the first session, but this time a question had been included at the beginning of the questionnaire about whether they had used the app regularly or not, specifying that regularly meant at least once a week. As in the first session, the recording of the session was accessible for one week, so the collection of questionnaire responses was also closed one week after the session.

Data Analysis

Firstly, the reliability of the test on the study sample was checked by analysing Cronbach's alpha, both at a general level with all the items and for the items of each dimension. In this way, it has been possible to affirm that the measuring instrument used is suitable for measuring reading comprehension in this case, i.e., for this sample. Secondly, two variables have been created for each dimension, one with the pretest items and the other with the post-test items. As this is a standardised instrument, whose validation tests can be found in Núñez et al. (2015), the variables have been calculated from the average value of the items corresponding to each dimension of the study. Thirdly, it was found whether the sample distribution corresponds to a normal distribution for each dimension.

In cases where the dimension follows a normal distribution, a Generalized Linear Model with Gaussian distribution has been applied. In cases where the dimension does not follow a normal distribution, a Generalized Linear Model has also been used, but adjusting the distribution with Gamma distribution for non-symmetric distributions. In both cases, the impact of belonging to one group or another is analysed, i.e., whether they have used the Metadig tool to employ metacognitive self-regulation strategies, placing this variable as a factor in the test. This impact is measured, depending on the

group, on each dimension of the study, i.e., on the post-test variable of each dimension as the dependent variable, since the aim is to check its impact after the intervention. Finally, to know the real impact, free of the effect of the pretest, the pretest variable of the dimension is placed as a covariate.

The statistical software Jamovi, version 2.3.26, was used to carry out the analysis. These results are explained below according to the study design, using the tables provided by Jamovi. In the generalised linear model, several statistics are considered. First, the correlation coefficient, i.e., the R2, is used to find out the amount of variability explained by the model. This data is mainly used to compare it with the rest of the dimensions and to find out which dimension explains a greater proportion of the total variance. Second, the regression coefficients of the model, the value of the intercept estimator is interpreted as the average in the dimension (postest) once the initial level (pretest) is controlled. If it is significant ($p < 0.05$), this data allows us to know the effect, i.e. the regression coefficient. This data tells us the average score that a person who belongs to the group that does not use the Metadig tool would have. Third, in the estimator of the effect variable, the groups variable, we first check whether the change is significant, to confirm whether there are significant differences between groups, after controlling for the initial variable (pretest). Using the Bonferroni correction, which is a more robust adjustment for the sample size, it is possible to know whether the difference between the groups is significant. If it is significant, the estimator of the variable will be used to predict how much the Metadig-using group improves with respect to the mean score of a person belonging to the non-Metadig-using group. Finally, a plot of marginal means is used to visually check the influence of the group on the dimension, free of the pretest effect.

RESULTS

We start from very poor results in terms of the different dimensions studied in the pre-test of the study (Pereles et al., 2024b). These results are particularly low in planning, motivation management and evaluation of understanding. All three were around 1.5 points below on a 5-point Likert scale. After the intervention, there were clear differences between the two groups. Below, the dimension-to-dimension differences are analysed to better understand how the use of metacognitive strategies for self-regulated learning through the Metadig tool has influenced self-regulation during text reading.

COGNITION MANAGEMENT

With the Shapiro-Wilk test, it is observed that it does not follow a normal distribution ($p = 0.004$), so the Generalized Linear Models test is used with the Gamma distribution for non-symmetric distributions. In this case, the proportion of the total variance of the cognition management dimension explained by the regression is 17.5%, although not a very high value, the predictors (group and pretest) are statistically significant ($p < 0.001$). The model suggests that 17.5% of cognition management is explained by the regular use of metacognitive strategies.

From the parameter estimation (Table 1) the mean estimated value for someone belonging to the group that does not regularly use metacognitive strategies is 3.93 points. A person who regularly uses these strategies could have 0.34 points more, that is, 4.27 points out of 5. Therefore, Bonferroni test (Table 2), confirms that the difference between groups, after controlling for the pretest effect, is significant. This difference can be seen graphically in Figure 1.

Table 1. Parameter estimates for cognition management.

				95% Confidence Interval				
Names	Effect	Estimate	SE	Lower	Upper	exp(B)	z	p
(Intercept)	(Intercept)	3.926	0.0501	3.829	4.025	50.69	78.28	< .001
Groups1	1 - 0	0.340	0.0813	0.181	0.500	1.40	4.18	< .001
Cognition_pre	Cognition_pre	0.379	0.0539	0.268	0.488	1.46	7.02	< .001

Table 2. Post-Hoc comparisons – groups for cognition management.

Comparison						
Groups		Groups	Difference	SE	z	$p_{bonferroni}$
0	-	1	-0.340	0.0813	-4.18	< .001

Note: Intercept computed for Groups = 0

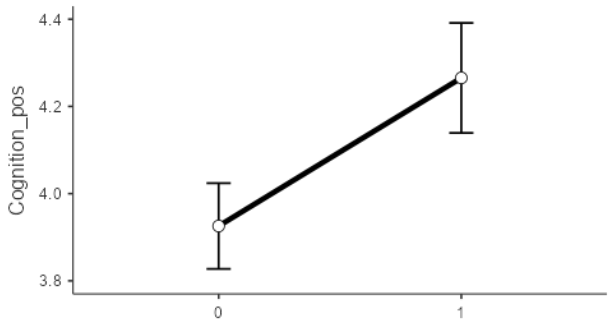

Figure 1. Plots - estimated marginal means by group for cognition management.

MOTIVATION MANAGEMENT

With the Shapiro-Wilk test, a normal distribution is observed (p = 0.631), so the Generalized Linear Models test with the Gaussian distribution is used. First, the model fit measure is observed with R2. In this case, the model suggests that 22.3% of motivation management is explained using metacognitive strategies through the tool used.

If we look at the estimated parameters of the model (Table 3), we see that the predictors (group and pretest) are statistically significant (p < 0.001). Controlling for the effect of the pretest, the average value of a person who does not use metacognitive strategies is 3.52 points out of 5 for motivation management. Someone who does use these strategies regularly can score 0.59 points more on motivation management, i.e., 4.11 points. These differences are confirmed to be significant by the Bonferroni test (Table 4) and can be seen graphically in Figure 2.

Table 3. Parameter estimates for motivation management.

				95% Confidence Interval				
Names	Effect	Estimate	SE	Lower	Upper	exp(B)	z	p
(Intercept)	(Intercept)	3.517	0.0570	3.405	3.628	33.67	61.73	< .001
Groups1	1 - 0	0.593	0.0883	0.420	0.766	1.81	6.71	< .001
Motivation_pre	Motivation_pre	0.266	0.0534	0.162	0.371	1.31	4.99	< .001

Table 4. Post-Hoc comparisons – groups for motivation management.

Comparison						
Groups		Groups	Difference	SE	z	$p_{bonferroni}$
0	-	1	-0.593	0.0883	-6.71	< .001

Note: Intercept computed for Groups=0

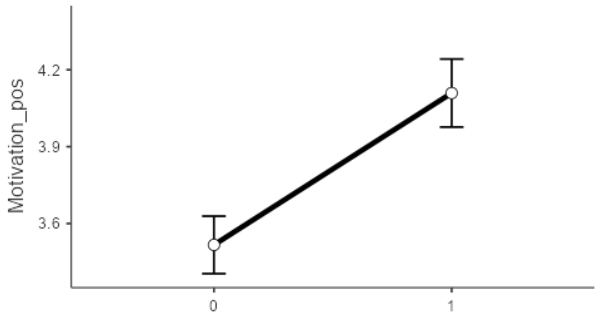

Figure 2. Plots - estimated marginal means by group for motivation management.

EVALUATION OF COMPREHENSION

With the Shapiro-Wilk test, a normal distribution is observed (p = 0.648), so the Generalized Linear Models test with the Gaussian distribution is used. First, we observe the model fit measure with R2, which suggests that 24.6% of the comprehension assessment is explained by the regular use of metacognitive strategies through Metadig.

The predictors also turn out to be statistically significant (p < 0.001). According to the estimated parameters (Table 5), controlling for the effect of the pretest on the sample, people who do not use Metadig to employ metacognitive strategies would obtain a mean value of 3.62 out of 5 when evaluating the comprehension of a text; while people who use Metadig would obtain 4.11 points, that is, 0.49 points more than those who do not use it. According to the Bonferroni test (Table 6), this difference between groups is significant, as shown in Figure 3.

Table 5. Parameter estimates for evaluation of comprehension.

				95% Confidence Interval				
Names	Effect	Estimate	SE	Lower	Upper	exp(B)	z	p
(Intercept)	(Intercept)	3.619	0.0541	3.513	3.725	37.30	66.89	< .001
Groups1	1 - 0	0.493	0.0838	0.329	0.658	1.64	5.88	< .001
Comprehension_pre	Comprehension_pre	0.373	0.0546	0.266	0.480	1.45	6.83	< .001

Table 6. Post-Hoc comparisons – groups for evaluation of comprehension

Comparison						
Groups		Groups	Difference	SE	z	$p_{bonferroni}$
0	-	1	-0.493	0.0838	-5.88	< .001

Note: Intercept computed for Groups=0

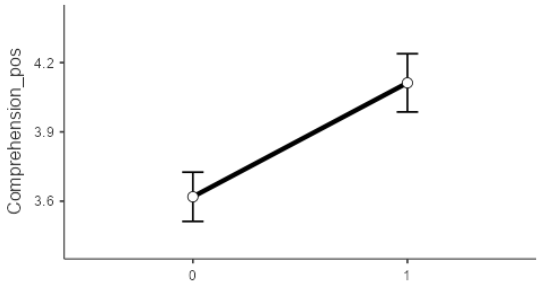

Figure 3. Plots - estimated marginal means by group for evaluation of comprehension.

PLANNING MANAGEMENT

With the Shapiro-Wilk test, a normal distribution is observed (p = 0.340), so the Generalized Linear Models test with the Gaussian distribution is used. In this case, the model fit measure with R2, suggests that 19.9% of planning management is explained by the regular use of Metadig to use metacognitive strategies during text reading.

When analysing the estimated parameters (Table 7); whose statistics are significant (p < 0.001), a person with a medium level in the pretest, and who does not use the Metadig tool for the regular use of metacognitive strategies, would obtain 3.57 points in planning management. Meanwhile, a person who does use Metadig to regularly employ metacognition would score 4.09 points in planning management, that is, 0.52 points more. The Bonferroni test shows that the differences between groups are also significant (Table 8), as shown in Figure 4.

Table 7. Parameter estimates for planning management.

				95% Confidence Interval				
Names	Effect	Estimate	SE	Lower	Upper	exp(B)	z	p
(Intercept)	(Intercept)	3.573	0.0609	3.453	3.692	35.62	58.63	< .001
Groups1	1 - 0	0.519	0.0944	0.333	0.704	1.68	5.49	< .001
Planification_pre	Planification_pre	0.332	0.0572	0.220	0.444	1.39	5.80	< .001

Table 8. Post-Hoc comparisons – groups for planning management.

Comparison						
Groups		Groups	Difference	SE	z	$p_{bonferroni}$
0	-	1	-0.519	0.0944	-5.49	< .001

Note: intercept computed for Groups=0

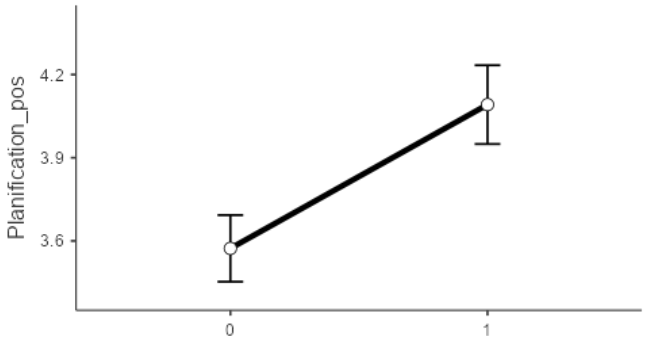

Figure 4. Plots - estimated marginal means by group for planning management.

CONTEXT MANAGEMENT

With the Shapiro-Wilk test, it is observed that it does not follow a normal distribution ($p = 0.004$), so the Generalized Linear Models test is used with the Gamma distribution for non-symmetric distributions. In this case, the proportion of the total variance of the context management dimension explained using Metadig is 16.1%.

Moreover, the predictors are statistically significant ($p < 0.001$). In the estimation of the parameters (Table 9), the mean estimated value for someone belonging to the group that does not regularly use metacognitive strategies is 4.22 points. A person who regularly uses these strategies could have 0.28 points more, that is, 4.50 points out of 5. The corrected Bonferroni test (Table 10) confirms that the difference between groups is significant. This difference between groups, after controlling for the pretest effect, can be seen graphically in Figure 5.

Table 9. Parameter estimates for context management.

				95% Confidence Interval				
Names	Effect	Estimate	SE	Lower	Upper	exp(B)	z	p
(Intercept)	(Intercept)	4.219	0.0552	4.112	4.329	67.93	76.42	< .001
Groups1	1 - 0	0.286	0.0883	0.111	0.463	1.33	3.24	0.001
Context_pre	Context_pre	0.423	0.0506	0.312	0.530	1.53	8.36	< .001

Table 10. Post-Hoc comparisons – groups for context management.

Comparison						
Groups		Groups	Difference	SE	z	$p_{bonferroni}$
0	-	1	-0.286	0.0883	-3.24	0.001

Note: Intercept computed for Groups=0

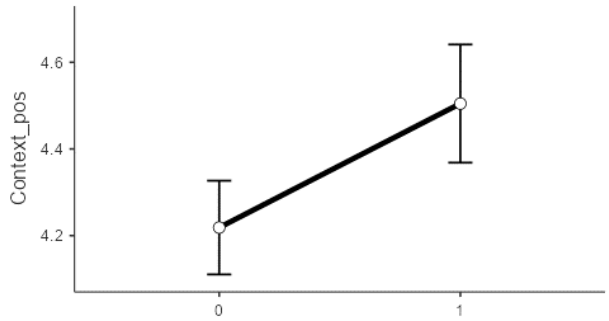

Figure 5. Plots - estimated marginal means by group for context management.

SUMMARY OF RESULTS

After verifying that the differences between groups were significant in all dimensions, Table 11 summarizes, the weight of variance explained using Metadig in each of the dimensions and the difference in mean scores between those who regularly use metacognitive strategies thanks to Metadig and those who do not use them. Although, the results show that all the differences are significant, this will help to determine in which dimensions the use of Metadig can be more useful to improve self-regulation during text reading.

Table 11. Results by dimensions

Dimension	R2	Mean G-0	Mean G-1	Difference
Cognition management	0.175	3.93	4.14	0.34
Motivation management	0.223	3.52	4.11	0.59
Evaluation of comprehension	0.246	3.62	4.11	0.49
Planning management	0.199	3.57	4.09	0.51
Context management	0.161	4.22	4.50	0.28

According to the results in Table 11, the regular use of metacognitive strategies through the Metadig tool explains almost 25% of the improvement in the evaluation of comprehension, followed by 22% of the improvement in the management of motivation, and 20% of the improvement in the management of planning. The tool does not explain in the same way the improvement in the management of cognition (17.5%) and context (16.1%). However, considering that after controlling for the pretest

effect, which are assumed to be equal, significant differences were found between the groups in all cases.

If we look at the difference in means between groups in each dimension, free of the pretest effect, the greatest difference is found in the management of motivation, followed by the management of planning and the evaluation of understanding. Each difference was equal to or greater than half a point on the five items on which the measures were taken. Again, in the management of cognition and in the management of context, the effects of the application do not seem to have had such an influence, although they were also significant, but the difference between the groups is around 0.3 points.

DISCUSSION

Following Vázquez-López and Huerta-Manzanilla (2021) and Soodla, et al. (2016), the premise that the development of metacognitive strategies linked to reading is a key variable for students to improve their reading competence was considered throughout the study. Núñez et al. (2015) warned that, to self-regulate learning during text reading, strategies for planning, cognition management, context management, comprehension assessment and motivation management must be developed. For this purpose, in this study the student was invited to work with the digital tool Metadig and was motivated through the development of a training session on the importance of developing metacognitive strategies to improve text reading.

The first dimension addressed in this study is the influence of Metadig on the ability to manage motivation. This is initially necessary to encourage the use of metacognitive strategies because, if students do not perceive that through their use there is an improvement in performance, they will not use them (Teng & Yang, 2022). Also, as stated by Kim et al. (2021), motivation management influences reading comprehension. To motivate students to use the tool, a 2-hour training was conducted beforehand to explain the importance of self-regulating their learning. 42% of the participants decided to use the Metadig tool regularly. The results obtained after the intervention show that the percentage of students who used the tool improved their motivation management compared to those who did not use it (22.3% can be explained by the use of Metadig). This suggests the importance of teachers being aware of the potential of metacognitive strategies and integrating them into their instruction. This will improve students' ability to better manage their motivation and therefore improve their reading comprehension (Dignath & Veenman, 2021).

This study has also addressed the importance of developing metacognitive planning strategies. In this case and after the intervention, it is observed that the group that used Metadig improved in the management of their planning more than the group that did not use Metadig (19.9% can be explained by the use of Metadig). Thus, following Colthorpe, et al. (2018), this improvement in metacognitive planning strategies can lead to an improvement in performance. This in turn can lead, according to Urban, et al. (2023), to a greater development of reading proficiency. In this sense, the university where the study was conducted provides students with planning, which, together with the use of Metadig, helps them to develop planning strategies and to understand the importance of planning (Fokkens-Bruinsma et al., 2020). The development of these planning strategies has a positive impact on the development of text reading, becoming more noticeable as higher levels of education are reached (Dias et al., 2015; Elosua et al., 2012; Viramontes et al., 2019).

The results obtained in the reading comprehension assessment dimension show that students who used Metadig improved their ability to comprehend a text compared to students who did not used the tool (24.6% can be explained by the use of Metadig). This may be because, as stated by Muijs and Bokhove (2020), it is not only planning strategies that influence performance and the improvement of reading comprehension. According to Pardo et al. (2016) metacognitive strategies linked to monitoring, which are developed with Metadig, help students to understand their learning process. In turn, the self-assessment strategies that are also developed with Metadig allow students to judge their own

work and detect errors in the learning process (Panadero et al., 2018; Tai et al., 2018). Therefore, it can be affirmed that the use of Metadig improves evaluation of comprehension during reading in conjunction with the development of metacognitive strategies for self-regulation of learning (Soodla et al., 2016; Urban et al., 2023).

Therefore, as it has been observed, the planning, monitoring and self-evaluation strategies promoted by Metadig improved self-regulation during text reading, especially related to the dimensions of motivation management, comprehension assessment and planning management (Núñez et al., 2015). It should be noted that the results also show an improvement in the dimensions of cognition management and context management (17.5% and 16.1% respectively, can be explained by the use of Metadig), although slightly lower than those obtained in the three strategies described above. This may be because the Metadig design focuses on the metacognitive strategies of planning, monitoring, and self-evaluation. Cognitive strategies and context management are not metacognitive strategies as such. Despite this, the existing improvement allows us to affirm that the use of intervention programs focused on metacognition, such as the one carried out through the Metadig tool, favours the self-regulation of learning during the reading of texts, and contributes to improvement in reading comprehension (Carretti et al., 2014).

This study reflects the need to include metacognitive strategies in teacher training (Perry et al., 2019) and to promote the values of the self-regulated learning (Duffy et al., 2009). Digital tools such as Metadig help in this effort. This will influence future teachers to teach these strategies to improve text reading to their students at any educational stage (Panadero, 2017).

CONCLUSIONS

It is claimed that the objective of this research has been satisfied: to check if the use of a digital tool based on OLM design to facilitate metacognitive strategies improves the perception of the use of these strategies during text reading in trainee teachers. Participants who use the app perceive greater improvement, especially in the dimensions of motivation management (22,3%), planning management (19.9%) and comprehension assessment (24,6%), which are fundamental dimensions for self-regulation in text reading.

Using a quasi-experimental design in a pre-post study with 252 participants, the ARATEX-R tool made it possible to evaluate the five dimensions considered fundamental in text reading. With the methodology used, it can be concluded, therefore, that the application developed to enable the regular use of metacognitive strategies, related to planning, monitoring and self-evaluation of the learning process, has proven to be a very positive tool in teacher training. Thus, the use of Metadig facilitates the necessary reflection during the reading of texts to improve comprehension and thus self-regulate the learning of content.

Therefore, the teaching and use of self-regulated learning in teacher training, based mainly on metacognitive strategies, is proposed as a mechanism to improve teachers' reading of texts and the teaching of these strategies to their future students. Consequently, Metadig should be included in teacher training to enable reflection during the reading of texts.

Among the limitations of the study are that the first session may have influenced the self-regulation strategies of the control group, since they all participated in this session on what self-regulation is, which could favor the use of metacognitive strategies by participants even without using the tool. It might also be considered a limitation that the evaluation instruments evaluate perception and not the actual use of these strategies. It is difficult to verify if the participants in the experimental group really use more self-regulation strategies during text reading, or if it is a simply perception.

Finally, limitations derived from the research approach should be noted, since the participants' choice of whether to use the tool may be an external influence related to motivation. All these fac-

tors, which were not considered or could not be included in the research design, may affect the generalizability of the results. With respect to the design, it should be noted that although the original design of the tool included the recording of data on the use of the app, budgetary limitations prevented it from being included in the development of the tool. Therefore, some analysis procedures related to the use of each participant had to be discarded.

The presented research is a first approach and underscores the necessity for rigorous empirical validation in subsequent phases of the research. More studies should be carried out to validate anticipated benefits. Also, it should be noted that two avenues for future research have been identified. More in-depth investigation into which functionalities of the Metadig tool are more useful in improving the use of strategies during text reading can aid in further development of the tool. Additionally, studies the expand beyond teacher training programs can investigate the tool's usefulness by students enrolled in other university programs. It tool can also be applied to other modalities in addition to online training, since the lack of use of metacognitive strategies during reading may also affect students in blended and face-to-face modalities. Finally, it would be interesting to adapt this tool to the needs of students in other educational stages, believing that it could be especially useful in secondary education.

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APPENDIX

Table A1. ARATEX-R test items and dimensions

ID	D	Item
T1	2	Before I start working on a text, if I think the task is going to be boring, I encourage myself by telling myself that I will be able to do something I enjoy when I am done.
T2	5	Before I start studying, I make sure I have all the material I might need (dictionary, pencil, and paper, etc.) at hand.
T3	2	While I am studying, I encourage myself by reminding myself that understanding and learning the text depends on me trying hard enough.
T4	3	When I finish the text, I check whether I have understood everything correctly.
T5	3	If I have not managed to understand and learn the text well, I try to look for the causes to avoid the same thing happening to me next time.
T6	4	After working on a text, I use the experience of how I organized my time and the changes I had to make in my planning to decide in the future how to allocate time for a similar task (whether I was able to estimate how long it would take, whether it took longer than I had thought, etc.).

ID	D	Item
T7	4	Before I start studying, I stop to decide what activities and strategies I am going to use, planning how I am going to read and study.
T8	2	Before I start studying a text, if it seems useless or uninteresting, I try to motivate myself by reminding myself how important it is to learn it in order to pass the exam and the subject, and thus finish the course and the degree.
T9	4	Before I start studying, I plan how much time I may need to spend on understanding and learning the text, and how much time I am going to allocate to working on the different activities I must do.
T10	3	As I read, I notice if I have any problems understanding the text and I ask myself what I can do to solve them.
T11	2	While studying, when faced with difficulties that discourage me, I try to do something to make myself feel better, such as reminding myself how good I will feel when I manage to learn the text.
T12	4	While I am studying, I consider whether my time planning was correct, or whether I need to modify it (because I will need more time, because I will have more time to spare, etc.).
T13	3	When I finish the text, if I have not understood it well, I stop to think about what I did and what I could improve in order to understand it better next time.
T14	4	After attempting to study a text, I reflect on the effort I had to put into it and use this experience to plan my activities in future similar tasks.
T15	2	Before I start studying, if I find it difficult, I encourage myself by reminding myself that when I try I usually do well in understanding and learning written texts.
T16	5	Before I start studying, if there is too much noise or other aspects that prevent me from concentrating, I do something to provide a quiet environment without distractions.
T17	1	While I am trying to understand, if I cannot extract the idea from an important sentence, I do different activities to clarify its meaning.
T18	1	As I read, I try to relate the different ideas I get from the text.
T19	1	In order to understand the text, I am reading, I try to discover the main ideas of the text.
T20	1	As I read, I try to relate the most important ideas to find the general organization of the text.
T21	1	To understand a text well, I try to link the new information it gives me with what I already know about the subject.
T22	3	When I am faced with a text, I ask myself whether I have the necessary background knowledge to be able to learn something from it.
T23	4	When I finish trying to study a text, I notice the things I have done that have worked for me and consider possible changes in the way I will do the task next time.

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