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Validation of the SISRE-P Software for Teaching Reflection in Mathematical Didactics using the DELPHI Method

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Abstract

This research addresses the use of software in the mathematics education process, which has been growing in popularity and has proven to be a valuable tool to improve teaching and learning. The study aimed to validate the SISRE-P software in the teaching of mathematics, with the purpose of reducing the gap between theory and educational practice, and improving pedagogical practice. From the methodological point of view, a qualitative, cross-sectional and descriptive study was carried out, using the Delphi method for the validation of the instrument, which was applied to 36 teachers. For its development, a questionnaire was applied in the form of interviews, which were sent through Google Forms, through the process, they were analyzed to evaluate the effectiveness of SISRE-P. Within the results obtained, it is observed that the implementation of the SISRE-P software demonstrates its effectiveness to improve teaching practice in mathematics teaching. Recurrent participation in weekly reflective sessions, both in pedagogical pairs and with colleagues or individually, has strengthened the reflective process through methods such as class recording, collaborative conversations and records in field diaries. It is concluded that SISRE-P is an effective tool to enhance teaching practice in the teaching of mathematics. Its constant use in reflective sessions strengthens the process of teacher self-reflection and is fundamental within the constructivist pedagogical framework, focused on student autonomy and the active construction of knowledge.

Keywords: *SISRE-P software, mathematics teaching, teacher reflection, Delphi method.*

Introduction

The perception of professional tutors and pre-service teachers about the teaching and learning of mathematics is a complex and multidimensional area of research, influenced by diverse theoretical and methodological factors. Teachers face significant challenges when conveying abstract mathematical concepts, especially at higher educational levels where topics are more complex (Jaramillo and Puga, 2016). Beliefs about the nature of mathematics and its teaching deeply impact their pedagogical practices. While some opt for traditional approaches focused on memorization, others encourage critical thinking and problem solving (Cortés et al., 2024). Furthermore, although innovative methodologies such as the use of digital technologies and project-based learning are generally well received, their implementation is often limited by a lack of resources and adequate training (Mantilla, 2022).

In this way, perceptions towards mathematics learning are influenced by pedagogical, psychological and sociocultural factors. From a social perspective, teachers are aware that socioeconomic inequalities affect student performance and participation: perceptions of student demotivation are general in those from disadvantaged backgrounds (Favila et al., 2017). While those who receive greater family support and have access to educational materials tend to have more positive perceptions about mathematics (Bourdieu, 1998), cultural and social capital significantly influences the perception of participants. In addition, aspects such

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as gender and ethnicity are included in the perception and relationship with mathematics, where the presence of stereotypes fosters a negative perception towards mathematics (Simón et al., 2022).

From a pedagogical perspective, children's discouragement plus institutional pressure to obtain good results in standardized tests can lead teachers to prioritize compliance with standards over deep learning (Chiriboga 2021), which from a psychological perspective causes students to feel even more demotivated, increasing the problem.

Consequently, math anxiety is a common phenomenon that negatively impacts both academic performance and attitude towards the subject (Engle et al., 2020). For this reason, the analysis and applicability of mathematical concepts in real contexts is essential to foster a positive perception. This highlights the importance of implementing pedagogical strategies that connect mathematics with practical situations (Espinoza, 2017). Likewise, it is essential to foster self-efficacy in students, that is, the belief in their own ability to succeed in mathematics, which directly influences their motivation and performance (González et al., 2022).

Furthermore, the perception of professional tutors and pre-service teachers on the teaching and learning of mathematics is also marked by a significant gap between educational theory and practice. They often recognise the importance of innovative pedagogical approaches and educational theories that promote critical thinking, problem solving and the applicability of mathematical concepts in real-life contexts (Camino et al., 2024). However, in practice, they face numerous barriers that hinder the implementation of these theories. The lack of adequate resources, such as digital technologies and teaching materials, coupled with insufficient professional training, limits teachers' ability to implement effective pedagogical strategies.

For their part, participants perceive this disconnect between theory and practice in a tangible way. Although theoretical approaches suggest that mathematics can be relevant and applicable to their daily lives, traditional methodology focused on memorization and repetition generates disinterest and mathematical anxiety (Larracilla et al., 2019). This dissonance between educational theory and daily classroom practice contributes to a negative perception of mathematics learning, affecting student motivation (Calle et al., 2020). To reduce this gap, it is essential that educational policies and teacher training programs focus on providing the necessary resources and creating a teaching environment that facilitates the implementation of innovative and effective pedagogical theories.

Didactics is a science that arises as a response to the needs of educational environments, with the main objective of harmoniously integrating theory and practice. This balance, supported by science and research, effectively leads to meaningful learning. In this context, the current challenge of didactics is to guide, socialize, integrate and systematize knowledge and research to improve educational practice, promoting the integral development of personality and the capacity for continuous learning (Casasola, 2020).

In this sense, mathematics didactics has evolved in its epistemology. Initially, it focused on the student and his or her development during the learning process; later, its approach became more holistic, incorporating the dynamics between the student, the learning situation, and the institutional context. At first, special attention was paid to the student's prior ideas and their transformation during learning, but this resulted in an unbalanced analysis by leaving aside other important aspects. Later, theories such as the didactic situations theory highlighted the importance of the learning situation itself, examining how it influences the teaching and learning process. The didactic transposition theory and anthropological theory expanded this understanding by considering the institutional context as a determining factor, underlining that knowledge emerges from specific institutional practices, where expectations and roles are strongly influenced by positions within the institution (Laverde, 2020).

Thus, mathematics didactics studies mathematical epistemology and its processes of understanding and praxis in teaching-learning. It explores several concepts such as learning environments, which imply the means of assimilating knowledge or skills, and constructivist didactic practices, which define the circumstances in which an individual is motivated to participate in mathematical activities without the direct influence of the teacher, focusing on the creation and use of problems that stimulate the construction of

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mathematical concepts and theories. In addition, it examines the interaction between the student and the learning context, integrating pedagogical, psychological and sociocultural aspects (Lugo et al., 2019).

This research proposes the Systematization, Reflection and Proposal for Improvement (SISRE-P) model, designed to improve teaching practice in mathematics. This didactic model is presented as a tool for the development of logical-mathematical relationships, conceived as a software for the continuous training of teachers. To do so, it provides a timeline that allows analyzing and reflecting on the activities and strategies implemented in the educational field. It is based on theory and applied in pedagogical practice, its objective is to effectively transform educational work, promoting a culture of continuous improvement in the teaching of mathematics.

The SISRE-P teaching model represents a significant innovation in the continuing training of teachers in Early Childhood Education. This software, with its systemic and reflective approach, allows for the organized recording of activities and strategies implemented in the specific educational environment. This facilitates a deep reflection on teaching practices, allowing for rethinking and improving educational work.

In this way, the SISRE-P software is closely integrated into everyday educational reality, allowing teachers to play an active and transformative role in their educational work. Therefore, it seeks to strengthen the pedagogical skills of teachers and foster a culture of continuous improvement within educational institutions.

Some background information related to teaching practice in mathematics didactics and the use of software includes the development of educational software. For example, at the "Lidia Doce Sánchez" Medical Sciences Branch in Mayarí, Cuba, during the period from January 2018 to June 2019. This was designed to improve the teaching-learning process of the mathematics subject in the Surveillance and Anti-Vector Control course. The need for this resource was identified and it was created to cover the four topics of the subject, with methodological guidelines for its use in classes. This software motivated learning, improved the quality of the teaching process and stimulated student participation (Delgado et al., 2021).

Another relevant antecedent is the ProblemáTICas software, used to improve the mathematical skills of third-grade students in a rural school in Guaviare, Colombia. This study, developed in three stages (one initial and two subsequent ones, before and after the application of the software), used strategies such as checklists, interviews with teachers, surveys with parents and workshops with students, following a participatory action research approach. The results showed a notable improvement in the mathematical skills of the students, who were motivated and found a more fun way to learn. This qualitative and socially critical approach concluded that the use of the software contributed to raising academic performance, counteracting the lack of interest and demotivation towards mathematics (Bejarano, 2022).

In the project "The impact of GeoGebra in Ecuador", carried out at the Institute of Global Education (IEG) of the National University of Education (UNAE), a quantitative study was conducted that included the application of a 24-question questionnaire to 799 teachers from all over the country. A positive evaluation of the use of GeoGebra in the classroom was observed by respondents who already used it, as well as an interest in training in the software by those who had not used it. Among the benefits identified, the strengthening of skills to work collaboratively and the ability to verify assumptions stand out (Auccahuallpa, 2022).

These studies show that software applied to improve teaching practices is of vital importance in contemporary mathematics teaching. In this sense, the present research is justified from a pedagogical and curricular perspective in Ecuador, by addressing the widespread perception of the difficulty in teaching and learning mathematics, both for teachers and students, which represents a significant challenge in educational practice and in the gap between teaching theory and practice. The need to improve teaching and promote meaningful learning is a primary objective in the country's curricular field. Therefore, the SISRE-P research proposal is presented as a concrete response to these needs and challenges, offering a didactic model aimed at improving teaching practice in mathematics and contributing to educational quality.

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This study focuses on the validation of SISRE-P. Despite advanced pedagogical theories that promote meaningful learning and the practical application of mathematics, many teachers face significant difficulties in implementing these methodologies effectively in the classroom. Lack of adequate resources, insufficient training, and pressures to meet rigid assessment standards contribute to a palpable disconnect between educational intentions and the actual experience of students. SISRE-P is presented as an innovative tool designed to contribute to closing this gap through a structured approach of systematization, reflection, and proposal for improvement for teaching practice in mathematics. This approach not only aims to contribute to the improvement of mathematics teaching, but also to promote an educational environment that fosters critical thinking, problem solving, and the practical application of mathematical concepts in real contexts.

Therefore, it is imperative to develop SISRE-P in the Ecuadorian context, given the persistent challenges in teaching and learning mathematics. These challenges are exacerbated by the lack of effective tools that can support teaching. Therefore, improving educational quality and fostering more meaningful learning are the main objectives driving research on SISRE-P software.

Materials and Methods

A qualitative approach was used, characterized by a deep understanding of social, human and educational phenomena through observation and interpretation of non-numerical data, as defined by (Hernández et al., 2018). This design allowed capturing the complexity of participants' perceptions and experiences regarding the SISRE-P software in the specific context of their professional practices. The choice of this qualitative approach is based on the need to explore in depth the interactions between students, tutor teachers and the software within the practical environment of teacher training.

The sample of participants was selected by convenience (Hernández et al., 2018) and included 36 teachers from the Early Childhood Education program at the National University of Education (UNAE). This selection was based on the accessibility and relevance of the subjects for the study.

To validate the SISRE-P software, the Delphi method was used, which consists of collecting expert opinions through successive rounds of surveys or consultations. The instrument used to collect information corresponded to the questionnaire based on eight questions with open answers, through a structured interview. The experts review and adjust their answers based on the group's feedback until reaching a consensus or convergence in the answers (López, 2018). The Delphi method was chosen for its ability to obtain reliable and validated information on the effectiveness of the software in educational practice.

Table 1.

Phase 1: Proposal development

Processes	Characterization
Selection of experts	Experts who met the established inclusion criteria were included, i.e., experience in teaching and research work, teachers of the Early Childhood Education program at the National University of Education (UNAE). Teaching experience of at least five years.
Formulating questions	Eight questions were established: 1. How do you interpret the current pedagogical model in your PP institution in your practice? 2. How do you carry out self-reflection on your PP? And how often do you do it? 3. Would you use the SISRE-P teaching model for self-reflection on your practice in the field of logical-mathematical relations? Why? 4. Would you use the SISRE-P teaching model for self-reflection on your educational practice in other areas? Why? 5. What would you add to the SISRE-P teaching model to improve it? 6. What would you eliminate from the SISRE-P teaching model? 7. Would you recommend the model to other early childhood education teachers? Why? 8. Would you recommend the model to other teachers in general? Why?

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Application of questions	The questions were created in Google Forms and sent to the emails of the teachers included in the study. Once the process was completed, an analysis of each of them was carried out.
Feedback and convergence	The analysis was sent via institutional email to each of the teachers, and they were asked to complete the questionnaire again.
Final report	It was carried out based on the characteristics of the categorization and coding processes, which culminated in the development of the final report.

Table 2.

Phase 2: Analysis process

Development of the validation process	Characterization
Transcript of interviews	The answers were transcribed in Microsoft Word
Data Encoding	Labels or codes were assigned to pieces of information collected during the research.
Content analysis	The codes identified were analyzed based on each question.
Interpretation of results	The findings obtained from the experts' responses were analyzed.
Final report	A final report of the entire process was prepared

To ensure ethical integrity and evaluate the proposed SISRE-P software, a user manual for the software was provided and a download link was sent to participants. Subsequently, an interview was administered via Google Forms to collect data on participants' experience and perception regarding the use of the software. This methodological approach allowed for a detailed evaluation of the software and the collection of nuanced qualitative data on its impact on teaching practice and mathematics learning.

Results

Transcript of interviews

The interview responses from the professionals were transcribed using Google Forms and Word. The transcription process converted the written responses into a more structured and readable format. In this research context, the interviews were answered by the professionals through Google Forms and then transcribed to facilitate their analysis. The transcription was done verbatim, including every word written by the participants, with the aim of faithfully capturing their responses. Considering the amount of information, the information was not placed in this article.

Data Encoding

In the following table, the data is coded according to each of the questions:

Table 3. *Coding*

Questions	Coding
Practice of the pedagogical model	Differences in the conception of the student, the role of the teacher, the use of spaces and materials, and the promotion of autonomous learning.
Self-reflection	Use of field diaries, conversation with fellow interns, lesson study methodology, weekly reports.
Use of SISRE-P teaching model in logical-mathematical relationships	Positive responses, negative responses, neutral responses.
Use of SISRE teaching model in other areas	Positive responses, negative responses, neutral responses.

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Improving the SISRE-P teaching model	Structure of the model, attaching evidence (photos and videos), clarity and specificity of questions, inclusion of music for self-reflection, inclusion of audios or music in questions, applicability of activities for face-to-face classes, use of short questions, suggestions to improve educational practice. Inclusion of animations, use of images and audios in questions, accessibility and ease of use, space in questions for understanding, reflection of strengths and weaknesses, software without the need to download, comments on the development process, detail on pre-professional practices, full screen and improved visualization, interactivity and fun in videos or activities. Conformation and systematization of experiences, Additional knowledge about pedagogy.
	Elimination of long questions, elimination of specific elements, such as the reflective puzzle, improvements in presentation, such as font size of the questions. Elimination of download processes or distracting elements, consideration that the model covers everything necessary, therefore, nothing would be eliminated.
Recommendation of the model in early education	Innovation and dynamism of the model, ease of use and usefulness as a tool for reflection. Improvement of educational practice and teaching, help in the evaluation and analysis of results, importance of self-reflection and self-knowledge, stimulation of children's development and knowledge, contribution to educational training, dynamism and usefulness as a digital tool, potential to generate educational changes and strategies.
Model recommendation in other areas	Early childhood education, teachers from other courses, classroom application, reflection and continuous improvement, and educational innovation.

Note. The coding was developed from the analysis of the interviews.

Content analysis

A variety of pedagogical approaches are observed that impact the educational experience of students, influencing their cognitive, social and emotional development in a differentiated way. Likewise, a combination of methods used for self-reflection is observed, with field diaries being the most common, followed by conversation with fellow practitioners.

Most responses are positive, highlighting the perceived usefulness and benefits of using the SISRE-P model for self-reflection in the area of logical-mathematical relationships. Some negative responses mention technical or accessibility difficulties as reasons for not using the program. A variety of opinions are observed regarding the suitability and usefulness of the SISRE-P model for self-reflection.

On the other hand, participants expressed varied opinions, from acceptance and enthusiasm for the model to negative opinions due to perceived difficulties in its use. Likewise, the positive evaluation of the existing model is highlighted, in addition, suggestions for improvement are observed focused on the inclusion of multimedia, clarity in the questions, interactivity, accessibility and personal reflection. In some cases, some responses express total satisfaction with the current model. Finally, aspects such as the structure, the visualization of complete questions and the inclusion of interactive elements are mentioned as areas of opportunity.

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In this case, most participants consider the model as a whole to be adequate and would not remove any elements. Some suggest removing long questions or specific elements that they perceive as distracting, such as the reflection puzzle. Improvements in presentation, such as the size of the letters in the questions, are mentioned, but not necessarily the removal of elements.

Most participants would recommend the model to other early childhood education teachers due to its innovation, usefulness for reflection and improvement of educational practice. In addition, the importance of self-reflection, the stimulation of children's development and the contribution to educational training are highlighted as reasons for recommending the model. Finally, some participants mention ease of use, assistance in assessment and the importance of digital dynamics as positive aspects for the recommendation.

It is observed that there are consistent patterns in the perceptions and opinions expressed. The identified codes reflect recurring themes such as the benefits of the model, its applicability in various educational areas, the impact on teacher reflection, ease of use and recommendations for its implementation. Teachers' responses highlight the usefulness of the model to encourage reflection and innovation in educational practice, as well as its ability to improve the quality of learning. In addition, the importance of teacher training and ongoing monitoring to maximize the benefits of the model in the educational environment is emphasized.

Interpretation of Results

It is concluded that the diversity of pedagogical models present in internship institutions offers opportunities to enrich the educational experience of students, fostering their integral development and their ability to learn autonomously and meaningfully. Likewise, it seems that field diaries are an effective and popular tool for self-reflection. Collaboration with fellow interns also plays an important role in the process of continuous improvement.

On the other hand, it is observed that there is a widespread interest in using the SISRE-P model for self-reflection in the field of logical-mathematical relations, mainly due to its potential to improve educational practices and generate significant reflections on the teaching process. Concerns about technical or accessibility difficulties can be considered as areas of improvement to increase the adoption and effectiveness of the model.

Furthermore, it can be inferred that the SISRE-P model is perceived as a valuable tool for self-reflection in educational practice, as long as it is adequately adapted to each context. Participants value positive aspects of the current model, but also identify specific areas for improvement focused on interactivity, clarity and enrichment of the pedagogical experience. The inclusion of multimedia elements, clarity in the questions and ease of use are key aspects to improve the effectiveness and experience of the didactic model.

Most participants value the existing model positively and do not identify specific elements to eliminate. Some suggest minor adjustments, such as eliminating long questions or elements that they consider distracting. In addition, the general perception that the model covers all the elements necessary for its effective application is highlighted. In this order of ideas, they positively value the innovation, the usefulness for reflection and the educational improvement that the model offers, which motivates its recommendation to other Early Childhood Education teachers. They even highlight the importance of self-reflection, innovation in teaching and the positive impact on children's development as key reasons to recommend the model.

This model is therefore highly recommended to other teachers, given its potential to promote reflection, innovation and continuous improvement in educational practice. Its versatility and ease of use make it a valuable tool to enrich teaching.

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Final Report

The findings suggest the importance of reflecting on the implementation of different pedagogical models in the educational context, considering their impacts on student learning and development, as well as the need to promote pedagogical practices that favor autonomy, creativity, and meaningful learning. Furthermore, most professionals use field diaries for self-reflection. Therefore, it is suggested that collaboration between teachers and students be encouraged as a beneficial practice for learning and professional development. Therefore, the implementation of structured group reflection sessions is necessary to enrich the self-reflection process of teachers' professional development.

On the other hand, it is recommended to consider the implementation of the SISRE-P model for self-reflection in the field of logical-mathematical relations, given the positive receptivity by the participants. Likewise, it is suggested to address possible technical or accessibility barriers to guarantee a broader and more effective adoption of the model, highlighting trends and potential areas of improvement in relation to the implementation of the SISRE-P model for self-reflection in the field of logical-mathematical relations.

In this context, it can be inferred that the SISRE-P model is perceived as a valuable tool for self-reflection in educational practice, as long as it is adequately adapted to each context, that is, it highlights its potential to generate significant learning, foster innovation and improve educational practice in various areas. Therefore, it is recommended to highlight both the positive aspects of the current model and the specific suggestions for improvement raised by the participants and a summary of the identified categories, the observed patterns and the conclusions derived from the content analysis could be included.

On the contrary, it can be concluded that the majority of participants do not identify specific elements to be eliminated from the SISRE-P teaching model, considering that it covers what is necessary for its application. However, suggestions for improvement related to minor adjustments in the presentation or in the structure of the questions can be highlighted, rather than complete elimination of elements.

Furthermore, it can be concluded that the majority of participants would recommend the model to other Early Childhood Education teachers due to its innovation, usefulness for reflection and educational improvement. It is important to highlight the importance of self-reflection, the contribution to children's development and the facilitation of educational training as key aspects mentioned by the participants. After analyzing the participants' responses, a general consensus was found regarding the benefits of the model, highlighting its ability to encourage teacher reflection, innovation in the classroom and continuous improvement of educational practice. Teachers expressed their appreciation for the model's ease of use and its applicability in various educational areas.

Discussion of the Results

The study ofDelgado et al. (2021) mention that the software motivated learning, improved the quality of the teaching process, and stimulated student participation in reference to the software used to improve students' mathematics skills in a rural school in Guaviare, Colombia. In relation to this background, the results of the study indicate that most of the responses are positive, highlighting the perceived usefulness and benefits of using the SISRE-P model for self-reflection in the field of logical-mathematical relations. This suggests that, as in the case of the software in Colombia, the SISRE-P model has also been perceived positively by the participants in terms of its usefulness and benefits for self-reflection in the field of logical-mathematical relations.

Furthermore, the background mentions that in practice, they face numerous barriers that hinder the implementation of these theories. Lack of adequate resources, such as digital technologies and teaching materials, coupled with insufficient professional training, limits teachers' ability to implement effective pedagogical strategies (Camino et al., 2024). Relating this to the results of the study, where it is mentioned that participants express varied opinions, from acceptance and enthusiasm for the model to denial due to perceived difficulties in its use, the diversity of perspectives and the importance of taking into account the

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different opinions and experiences of teachers when implementing tools such as the SISRE-P model in the classroom are evident.

Similarly, the study ofBejarano (2022) determined that the use of software contributed to raising academic performance, counteracting the lack of interest and demotivation towards mathematics, which is related to the teachers' perspective on the use of software,highlighting their use in the educational process and the importance of self-reflection, innovation in teaching and the positive impact on children's development as key reasons for recommending this type of instrument.

In conclusion, the background highlights the positive impact that educational software can have on student learning, while the results of the study show the variety of opinions and perceptions of teachers about the usefulness and benefits of the SISRE-P model for self-reflection in the field of logical-mathematical relationships. Both sources of information underline the importance of considering different pedagogical approaches and the diversity of perspectives when implementing new tools and methodologies in the educational process.

Conclusions

The implementation of the SISRE-P software demonstrates its effectiveness in improving teaching practice in mathematics teaching. Recurrent participation in weekly reflective sessions, both in pedagogical pairs and with colleagues or individually, has strengthened the reflective process through methods such as class recording, collaborative conversations and field diary records. This approach is relevant within the constructivist pedagogical framework, which encourages student autonomy and the active construction of knowledge.

SISRE-P significantly facilitates teacher self-reflection by providing a teaching tool that allows teachers to identify areas for improvement and assess the achievement of specific objectives in different areas of mathematics. Participants have found this software to be a valuable resource that supports individual and collaborative reflection, promoting ongoing professional development in mathematics teaching.

To maximize the impact of SISRE-P, it is recommended to establish regular training and refresher sessions for teachers. These sessions should be designed to promote the effective use of the software, providing practical examples of its implementation in various educational contexts. In addition, guidance should be offered on the interpretation of the results obtained and the implementation of pedagogical adjustments based on the feedback generated by the software.

Finally, SISRE-P is an effective tool to enhance teaching practice in mathematics teaching. Its constant use in reflective sessions strengthens the process of teacher self-reflection and is fundamental within the constructivist pedagogical framework, focused on student autonomy and the active construction of knowledge. To promote a greater impact on the continuous improvement of mathematics teaching, the development of complementary materials and the realization of longitudinal studies to evaluate the long-term impact of the software on teaching practice and children's learning are recommended.

Author contribution

Diana Rodríguez, data analysis, methodology, summary, conclusion, bibliographic review.

Patricia Curay, writing of the introduction, discussion, conclusions, bibliographic review.

Mónica Salto, draft review, style review, contribution to bibliography.

Daysi Chiqui, draft review, abstract, translation, style review.

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Conflict of interest

The authors declare that there is no conflict of interest

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