ADVANCING EARLY CHILDHOOD PEDAGOGY THROUGH INTEGRATED MOBILE ELECTRONIC WHITEBOARDS AND DIGITAL PORTFOLIOS

AVANÇO DA PEDAGOGIA DA EDUCAÇÃO INFANTIL POR MEIO DA INTEGRAÇÃO DE LOUSAS ELETRÔNICAS MÓVEIS E PORTFÓLIOS DIGITAIS

AVANCE DE LA PEDAGOGÍA DE LA EDUCACIÓN INFANTIL MEDIANTE LA INTEGRACIÓN DE PIZARRAS ELECTRÓNICAS MÓVILES Y PORTAFOLIOS DIGITALES

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How to reference this paper:

Alghamdi, S. I. (2026). Advancing early childhood pedagogy through integrated mobile electronic whiteboards and digital portfolios. *Revista on line de Política e Gestão Educacional*, *30*(esp1), e026033. https://doi.org/10.22633/rpge.v30iesp1.20943

| **Submitted**: 06/01/2026
| **Revisions required**: 15/01/2026
| **Approved**: 13/02/2026
| **Published**: 30/03/2026

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ABSTRACT: This research paper is critical analysis of the application of a Mobile Electronic Whiteboard (EWB) system as a new pedagogical tool to structuring collaborative classroom discourse and improves parental envolvement in the framework of early childhood education (ECE). The research design used in the study is a mixed-method research design; it incorporates the findings of the previous ICT meta-analyses with qualitative data gathered during the interviews with the primary stakeholders such as the teachers and parents. Findings show that the EWB advocates multidimensional assessment and the movement is above the traditional summative evaluation into a formative and more evidence-based model of learning assessment. Empirical findings show that the EWB ability to document and categorize real time instructional data results in statistically significant enhancement in the learning of subject knowledge with observed effect size of 0.59 that is in line with the previous research on ICT enhanced learning studies.

KEYWORDS: Mobile electronic whiteboard. Digital portfolio. Parental evolvement. ECE. STEAM-PJBL.

RESUMO*: Este artigo apresenta uma análise crítica da aplicação de um sistema de Lousa Eletrônica Móvel (EWB) como ferramenta pedagógica para estruturar o discurso colaborativo em sala de aula e aprimorar o envolvimento parental no contexto da educação infantil. O delineamento metodológico adotado é de natureza mista, integrando resultados de meta-análises prévias sobre TIC com dados qualitativos obtidos por meio de entrevistas com stakeholders-chave, como professores e pais. Os resultados indicam que a EWB promove avaliações multidimensionais, superando o modelo tradicional somativo e avançando para uma abordagem formativa e baseada em evidências. Evidências empíricas demonstram que a capacidade da EWB de documentar e categorizar dados instrucionais em tempo real resulta em melhoria estatisticamente significativa na aprendizagem de conteúdos, com tamanho de efeito observado de 0,59, alinhado a estudos anteriores sobre aprendizagem mediada por TIC.*

PALAVRAS-CHAVE*: Lousa eletrônica móvel. Portfólio digital. Envolvimento parental. Educação infantil. STEAM-PJBL.*

RESUMEN*: Este artículo presenta un análisis crítico de la aplicación de un sistema de Pizarra Electrónica Móvil (EWB) como herramienta pedagógica para estructurar el discurso colaborativo en el aula y mejorar la participación parental en el contexto de la educación infantil. El diseño metodológico adoptado es de carácter mixto, integrando resultados de metaanálisis previos sobre TIC con datos cualitativos obtenidos mediante entrevistas con actores clave, como docentes y padres. Los resultados indican que la EWB promueve evaluaciones multidimensionales, superando el modelo tradicional sumativo y avanzando hacia un enfoque formativo y basado en evidencias. Los hallazgos empíricos demuestran que la capacidad de la EWB para documentar y categorizar datos instruccionales en tiempo real genera una mejora estadísticamente significativa en el aprendizaje de contenidos, con un tamaño del efecto de 0,59, en consonancia con estudios previos sobre aprendizaje mediado por TIC.*

PALABRAS CLAVE*: Pizarra electrónica móvil. Portafolio digital. Participación parental. Educación infantil. STEAM-PJBL.*

INTRODUCTION

The 21st century has seen the digital transformation of education take place at an unprecedented pace, which has completely changed the conceptualization and application of teaching, learning and assessment in the entire schooling system (Mohamed Hashim et al., 2022). The modern educational paradigm is more focused on the cultivation of the transversal competencies, including critical thinking, collaboration, communication, creativity, and digital literacy, along with domain-related knowledge. These are tied closely to active student leadership where learners are made to feel in charge of their learning experiences, they are involved in the decision-making process and they are actively involved during cooperative knowledge building (Petre, 2020). In order to assist these goals successfully, classrooms need to have pedagogical tools that are not only important in delivering passive contents but also play a role in the interaction, contemplation, and creation of meaning (Maceira & Wong, 2017).

Regardless of these changing demands, a significant number of early childhood and primary classrooms still depend on the conventional approach of classroom dialogue and collaborative discussions management. Flip charts, chalk boards, and static white boards are some of the tools that have been historically used as the center of capturing ideas and brainstorming as well as leading group discussions (Handley, 2023). Nevertheless, these analog devices have a number of constraints to modern learning settings. The discussion points have been known to be in disorganized format and they can be easily erased or lost and hard to reconsider at some point in time. Within a group context, especially in early childhood education, it can be difficult to control several student contributions at once, and the resulting discussion will be disjointed, and less likely to allow students to undergo profound cognitive processing (Tian et al., 2025). Moreover, the old boards do not support multimodal expression to a greater extent, which also limits the number of ideas that children could share with the help of drawings, symbols, photographs, or audio recordings.

Mobile Electronic Whiteboard (EWB) turns out to be the solution to these pedagogical and organizational problems as it provides an interactive, adaptable, and digitally enriched space of classroom conversation (Zhou & Wijaya, 2022). The EWB, which allows teachers and students to gather, sort and present points of discussion in real time, is in contrast to the use of traditional boards, where a teacher writes using a marker or chalk, or students simply scribble by hand using a pencil. The system is easily repositioned in the learning environment due to its mobility and can accommodate various instructional settings like small group collaboration, whole classroom discussion and project-based learning activities (Rehman & Ullah, 2022). The

flexibility is especially useful in the early childhood context, where knowledge acquisition is dynamic, action research, and non-linear.

The EWB enables increased involvement of students and encourages engagement as it supports real-time interaction. Students are able to add straight onto the board by drawing, labeling or interacting with digital items, and this way, they are able to make classroom conversations more of a shared, collaborative experience (Nguyen et al., 2022). This approach of participation is consistent with constructivist and sociocultural theories of learning that have stressed the importance of constructing knowledge through social interaction and mediating tools. Apart, the EWB facilitates organizing thinking with clustering, color coding, layering and sequencing options, allowing teachers to facilitate the discussions in a more sensible way without losing the input of every participant. Consequently, classroom discussion is more organized, open, and participative and it develops a feeling of ownership, and leadership among the students.

In addition to its contribution to in-class interactions, the Mobile EWB is highly significant in responding to more systemic changes in the educational policy, especially the shift towards a personalized and learner-cantered education. Individualized learning models support learning that is sensitive to the interests, capacities, and developmental patterns of individual learners (Yevdokymova, 2024). To attain such responsiveness, the learning processes should be continuously documented, as opposed to individual assessment or terminal reports. Conventional documentation methods which are usually paper based and retrospective are not adequate to document the complexity and richness of learning processes in children (Stacey, 2023).

In this regard, the combination of the EWB and digital documentation systems can be a powerful tool that allows the learning to be captured during its process. Discussions in the classroom, explanations shown by the students, strategies of how they solved the problem or creative artifacts created in the EWB may be archived digitally and connected to the profiles of every learner. This forms a longitudinal account of learning that can be used to help in formative assessment and make informed instructional decisions (Aust et al., 2024). The teachers are able to observe what has been already talked about, detect the misconceptions that arise and adjust the future teaching instructions to suit one individual at the expense of the other so that there is an increased harmony between teaching methods and individual learning requirements.

Notably, the digital documentation abilities of the EWB make the learning ecosystem go beyond the classroom by resolving the long-standing dilemma of the so-called home-school

gap. In most educational settings, parents do not have a lot of access to the daily learning experience of their child, and frequently have to be content with a verbal description (or periodic report cards) (Miller et al., 2024). These forms of communication do not offer a coherent and concrete picture of what children really do and learn in school. Consequently, parents might be unable to effectively contribute to learning at home or to have an informed conversation with the educators.

By using the EWB-generated digital records there exist possibilities to rebrand the parents as partners in the learning process. Through the provision of parents with access to moderated classroom discourses/photos/learning artifacts via safe digital portals, schools are able to provide a sort of window (Washington, 2022) into daily classroom life. This openness de-mystifies the pedagogical practices and enables parents to not only see the end results of learning but also, they see the learning processes. As a result, parental involvement will no longer be passive monitoring but active e-involvement, which involves active conversations, specific support, and joint responsibility in the learning.

Moreover, this enhanced home-school relationship is especially relevant in the early childhood education where learning is intimately affected by the continuity and congruity of experiences between home and school worlds. The continuity of language use, conceptual knowledge, and socio-emotional development that is made possible through digital documentation aided by the EWB help the children grow holistically. Institutionally, the practices also enhance accountability, inclusiveness and trust between teachers and families.

Overall, the Mobile Electronic Whiteboard is a pedagogically reactive solution to the problems of the universal classroom dialogue tools in a digitized educational environment. The EWB will be well aligned with the modern educational objectives by facilitating transversal skills, active student leadership (Okada et al., 2025), real-time organization of collaborative discussions, home-school gap closure via digital documentation. When implemented in early childhood classrooms, it can not only positively impact instructional quality and engagement but also the rest of the ecosystem of partnerships that are the foundations of effective and sustainable educational practice.

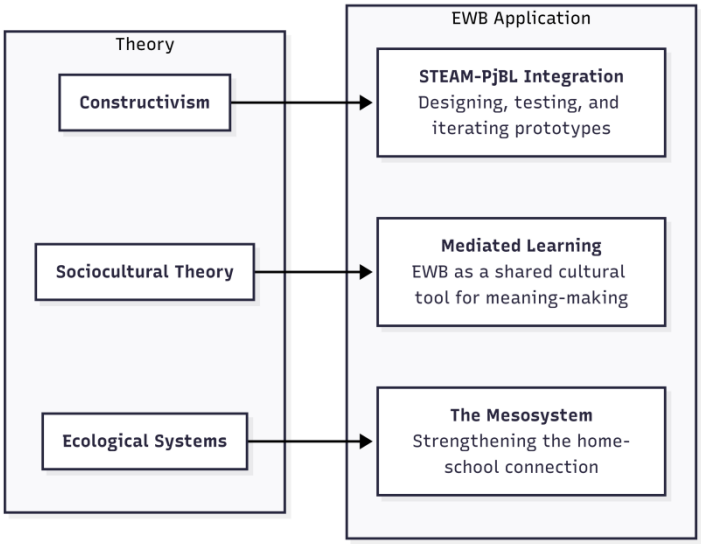
The Mobile Electronic Whiteboard system implemented in this study is based on a proprietary platform for real-time discussion management and cloud-integrated digital documentation. The core system architecture and operational framework are protected under a filed patent, which details the technical design and functional components of the Mobile Electronic Whiteboard (Alghamdi, 2025). The most critical observations of this article are:

- EWB: Improves the classroom interaction, through the real time, structured and collaborative management of discussions.
- Cloud-based digital portfolios including integrations would enhance transparency and home-school relationships by enlisting parental e-nvolvement.
- The EWB-based STEAM learning is associated with the quantifiable enhancement of the language and science literacy levels among students.
- Digital storage of classroom operations lessens the use of paper-based records and optimizes resources on institutional basis.
- The implementation of EWB requires teacher training, digital literacy and access to technological infrastructure in an equitable manner.

THEORETICAL FRAMEWORK

Both the constructivist and constructionist theories of learning have stressed that learners construct knowledge actively after meaningful interaction with their surroundings (Sultana et al., 2022) and not passively as taught by instructors. Learning in early childhood is social and experiential in nature and children acquire knowledge not only through exploration, experimentation and creative expression. Constructionism builds on this point of view by emphasizing the need to have real or virtual artifacts that learners can make to express their thoughts and impressions. These pedagogical values are strongly upheld by the Mobile Electronic Whiteboard (EWB) that is an interactive tool in terms of which children can build, visualize, and advance their knowledge in a collaborative way. Specifically, through its EWB, STEAM Project-Based Learning (STEAM-PjBL) will be enabled by allowing students to design, test, and redesign their physical prototypes including battery-powered airplanes and at the same time document every step of the design process with drawings, photographs, annotations, and brief videos. This combination of practical making with online recording strengthens the conceptual knowledge, encourages creativity and reflective, learning activities, which underlie constructivist and constructionist pedagogy.

Figure 1.
Theoretical Foundations of EWB Pedagogy



Note. Author's design.

The work of Vygotsky and elaborated by Cole, sociocultural theory imagines learning as a mediation process, influenced by the interaction with social life and the utilization of cultural tools. Knowledge advancement takes place in the context of collective actions, where language, symbols, and technological objects are the mediators of thinking. The EWB in this study is a common cultural resource whose role is to organize and to develop collaborative meaning-making in the classroom. Also, the Ecological Systems Theory formulated by Bronfenbrenner emphasizes the significance of the mesosystem which can be described as the dynamic relationship between school and home environments of a child. These processes play a significant role in early childhood, where harmonization of educational and family setting benefits cognitive, social and emotional growth. The EWB is a mediator of this mesosystem because it digitally stores classroom discourse, visual images, and learning stories, which can safely be shared with parents. This availability means that parents are able to participate in learning classroom activities in informed and significant ways that contribute to continuity of experiences between home and school.

Regarding the assessment perspective, the EWB allows shifting to Assessment for Learning (AfL) practices, as opposed to the traditional and summative models of evaluation. The EWB facilitates an ongoing evidence-based conversation between teachers, students, and parents in contrast with the use of report cards that were not moved regularly and gave little information about learning processes. Immediate feedback, in the classroom setting, enables teachers to see what learners are gaining knowledge and what they are not, whereas curated digital objects can give a tangible insight into the gains made over time. This developmental

process encourages reflective learning, promotes instructional adaptation and makes assessment a part of the learning process as opposed to a definitive statement.

LITERATURE REVIEW

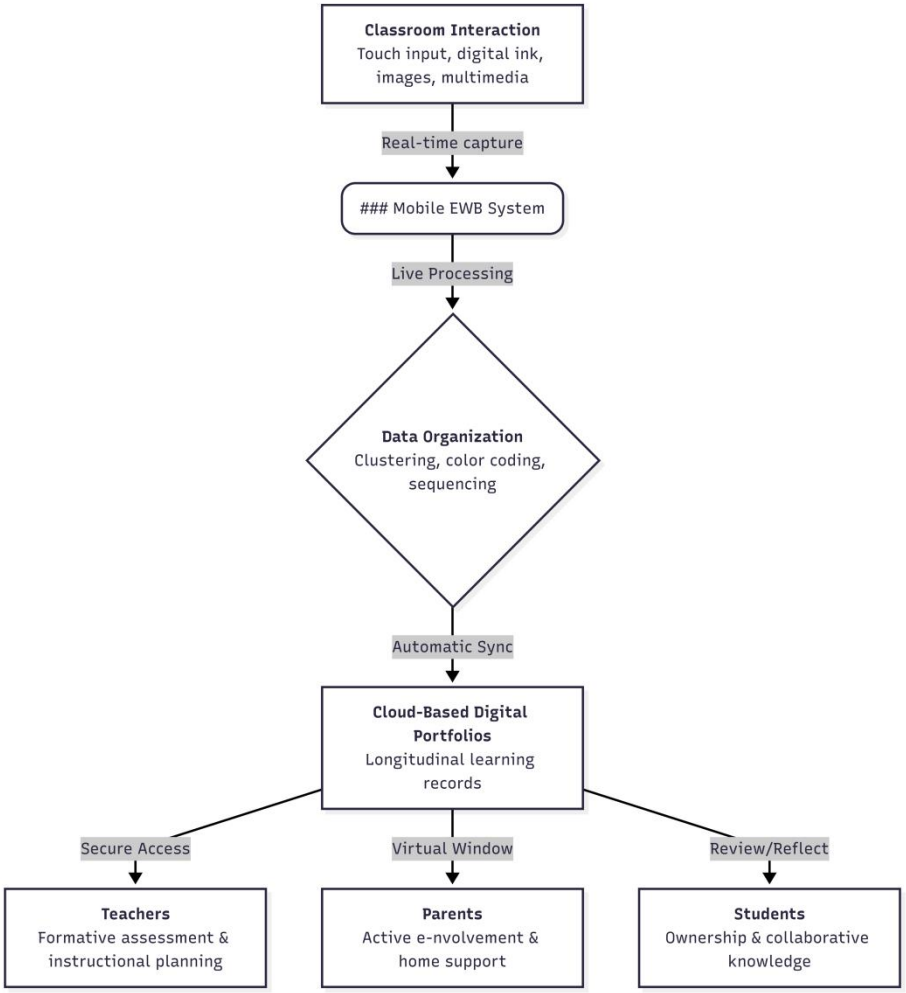
Interactive whiteboards in early childhood

An increasing amount of literature supports the pedagogical usefulness of interactive whiteboards (IWBs) as useful mediation tools in early childhood education (Ain, & Butt, 2024). Research shows that IWBs contribute to the improvement of mediation in the teaching process, allowing it to be dynamic in content presentation, in real-time, and in the sense of collective knowledge building. Unlike conventional boards, interactive whiteboards facilitate multimodal learning through the combination of visuals, sounds, gestures, and touch interactions that are especially appropriate in the developmental features of young learners. Touchscreen technologies in particular were demonstrated to have stronger pedagogical advantages on preschool learners compared to non-touch technologies since learners actively engage the fine motor skills and develop the sense of curiosity due to their sense of touch. The practical interaction promotes exploration, long attention and collective involvement increasing classroom interaction and early cognitive and social-emotional growth.

Digital portfolios in early childhood education

E-portfolios, also known as digital portfolios, have become a significant means of recording and evaluating learning in early childhood environments. Digital portfolios offer a potential solution to the problem of preserving the child learning process (Purola et al., 2025). by ensuring its permanent, systematic, and multimedia-enhanced archiving, whereas traditional paper-based records are limited to a single medium of information storage. They record an extensive amount of evidence such as photographs, videos, audio records, and teacher observations that allow observing the developmental progress throughout the time. It has been indicated that e-portfolios can be especially useful when used to facilitate the formative assessment practice and reflective teaching. In addition, they are very instrumental in the transition period between early childhood learning and primary school since developmental and learning information is transmitted easily among teachers. The continuity facilitates the planning of instruction and minimizes information loss of significant instruction transitions, which ultimately improves the outcomes of the learners.

Figure 2.
The Integrated EWB Learning Ecosystem



Note. Author's design.

Integrating electronic whiteboards and digital portfolios

The recent sources have given an increasing interest to the importance of implementing interactive technologies in classrooms along with the digital records systems to establish a coherent learning environment. Such integration is possible with the EWB architecture, which incorporates embedded communication modules such as Wi-Fi and Bluetooth and cloud-based data storage and synchronization. This technology infrastructure facilitates content created in the classroom experience, including annotated drawings, concept maps, photographs and recorded conversations to be uploaded on a student portfolio immediately. Consequently, the artifacts of learning are kept in real time and are also availed outside the classroom. This not only simplifies the teacher practices in terms of documentation, but it also improves parental e-

volvement by making (Alaçam, 2025) them have access to, in real-time and authentic information concerning the learning processes of children.

Recent developments have also formalized such integration through patented system architectures that combine mobile electronic whiteboards with cloud-based digital portfolio frameworks for real-time collaboration and documentation. The EWB platform employed in this study is based on one such patented design, which specifies the underlying system architecture and functional workflow (Alghamdi, 2025).

Purpose and research questions

This study is mainly aimed at conducting a systematic review of the effects of Mobile Electronic Whiteboard (EWB) on organization of classroom discussions as well as the degree of interaction between major stakeholders in education especially teachers, students and parents. With the growing use of digital technologies in the modern classroom, it is crucial to consider all the ways in which they improve instructional practices as well as the ways they affect communication, collaboration, and transparency of learning. This paper places the Mobile EWB as a versatile pedagogical instrument that will assist in real-time interaction, online documentation, and home-school communication in the early childhood learning environment. In order to meet this goal, the research is informed by three research questions that are related.

Research question (RQ1) is how the real-time data processing resources of the EWB affect the organization and arrangement of classroom discussion points. In particular, it discusses the relevance of features like live annotation, grouping of ideas, and digital archiving in more coherent and structured and inclusive discussions than traditional analog tools do.

The second research question (RQ2) is devoted to parental engagement, in which the researchers aim to investigate the degree to which the EWB can facilitate parent involvement by the so-called virtual window effect. The question under consideration focuses on the possibility of parents to have a better understanding of everyday learning activities through access to digitally archived classroom interactions as well as learning artifacts, and on the basis of this understanding, promote a constructive and supportive environment in which parent-child communication can take place.

Learning outcomes are the subject of the *third research question (RQ3)* as it studies how the introduction of EWB-based STEAM Project-Based Learning (STEAM-pjBL) affects the subject knowledge acquisition of students. The question aims to find out whether the

combinations of interactive discussion management and online documentation have a positive effect on the conceptual understanding and academic success, which can be measured. Taken together, these research questions can serve as a representative framework of how the Mobile EWB has been impacted pedagogically, communicatively, and in terms of learning.

Hypotheses

This research is informed by three hypotheses that are immediately consistent with the research objectives and theoretical frameworks underlining the application of the Mobile Electronic Whiteboard (EWB) in early childhood education. Both hypotheses cover different, but at the same time related areas of EWB educational impact, i.e., classroom interaction, learning outcomes and parental engagement.

The initial hypothesis (H1) is that the student groups using the EWB will have more structured and effective flow of discussion than the groups, which use the traditional analog means like static white boards or flip charts. The hypothesis has been based on the hypothesis that real-time data processing, visual structuring properties, and digital archiving tools of the EWB will help in making ideas sequential, less redundant, and more coherent in a group discussion. Better organization will make participation with greater significance and long-term engagement of the learners possible.

Hypothesis (H2) is that the moderate to substantial effect size will be achieved in the outcome of language and science literacy in the EWB-integrated learning environment. Incorporating the EWB into a process of STEAM-oriented and project-based learning, students will receive a multimodal teaching, interactive learning, and feedback. These characteristics are expected to improve conceptual knowledge, vocabulary growth, and scientific thinking, leading to quantitative improvements in behavior science knowledge.

The third hypothesis (H3) claims that the availability of EWB-generated digital archives to parents will grant them the confidence and encourage them to contribute to the learning of their children at home. The open access to classroom discussions and learning artifacts is likely to enhance the parental awareness of the instructional objectives and learning outcomes and, consequently, more effective parental-based support and cooperation.

METHODOLOGY

Research design

The research design of this study is a quasi-experimental pretest posttest to compare the effectiveness of EWB integrated curriculum, and the conventional instructional practices mostly used in early childhood classroom environments. This design enables the analysis of learning outcomes and results of engagement before and after the intervention and addresses the pragmatic limitations of the real educational environment, where the random assignment is not always a possibility. The study will identify the changes that can be attributed to the adoption of the Mobile Electronic Whiteboard by the use of both pre-intervention and post-intervention measures.

Participants

The sample of participants is made up of 100 kindergarten teachers and the parent student groups associated with them where the sample is chosen with the help of a cluster sampling method so that the sample of the various educational institutions can be represented. Both clusters consist of teachers, students, and parents working within the same school situation, which allows the researcher to study the effects of classroom and home-school interaction. This sampling design has ecological validity, and it represents realistic early childhood learning settings.

Intervention

The experimental group adopts the EWB within a 12-week unit of STEAM Project-Based Learning (STEAM-PjBL) unit, including the BAPORA airplane project. Real-time collaboration, assignment of tasks, visualization of ideas and capturing of classroom sessions are done using EWB during the intervention period. The control group will use the traditional instructional tools without the opportunities of using EWB functionalities.

Measures

There are three main instruments that are used.

Scientific Literacy Test (SLT): It is created to assess the understanding of the students in the definition of the scientific phenomena and simple data analysis.

Parental Engagement Survey: based on the typology of involvement offered by Epstein, the survey aims to determine the way parents perceive communication, understanding and involvement in the learning process of a child.

Digital Artifact Analysis: The systematic review of Portfolio comments, Portfolio uploaded artifacts, and the number of views in Portfolio videos to measure levels of engagement and depth of documentation.

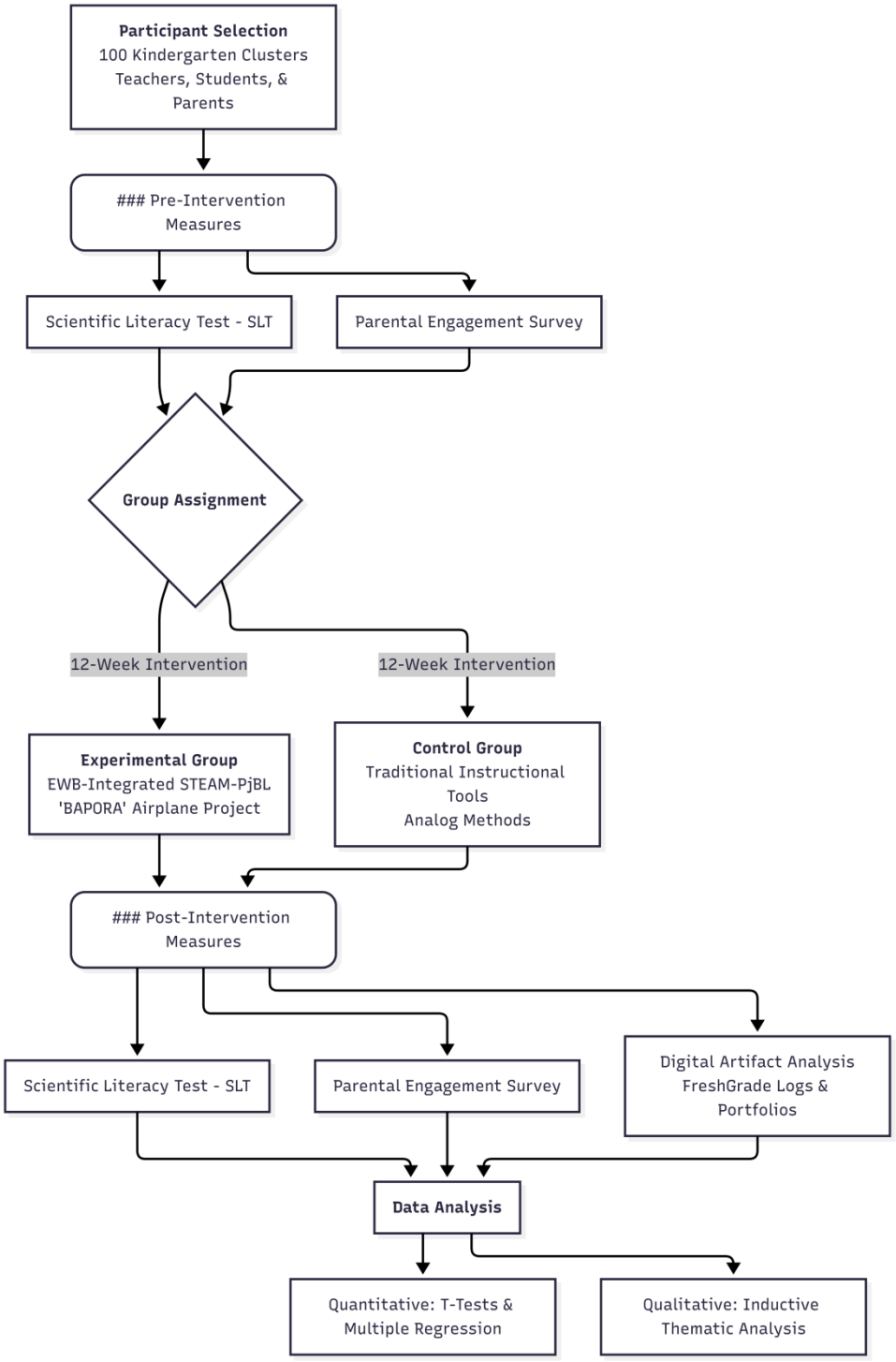
Procedures

Those teachers that are in the experimental group would be given systematic training of EWB User Interface (UI) alongside cloud archiving tools. Through the EWB, classroom conversations are held and digitally stored and shared with parents through the FreshGrade platform, which allows them to always access learning evidence.

Fidelity of implementation intervention

The implementation fidelity is achieved by constant monitoring with EWB usage analytics and system logs, which help to ensure that the technology is implemented in alignment with its discussion management and documentation algorithms.

Figure 3.
Theoretical Foundations of EWB Pedagogy



Note. Author's design.

Data analysis

Independent t-tests and multiple regressions are the methods of analyzing quantitative data, such as SLT scores. Transcription of qualitative data results (interview with teachers and

parents) are analyzed with the help of an inductive thematic approach to identify commonalities and common insights.

Ethical considerations

Serious consideration is made to data security and ethical adherence. All the digital data is encrypted and kept in the password-protected systems within compliance with the FOIPPA regulations. Informed consent is undertaken by educational institutions and parents and participant anonymity in the case of the study is maintained by using pseudonyms.

RESULTS AND DISCUSSION

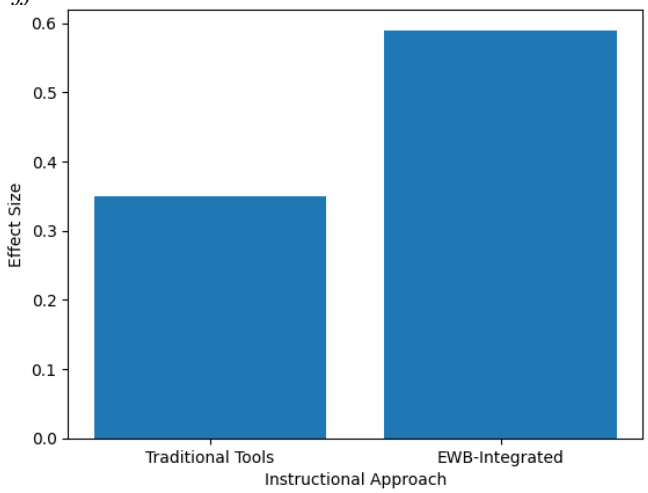
Mobile Electronic Whiteboard (EWB) will also produce much better educational results than the traditional analog classroom resources. Regarding learning, it is expected that the EWB implementation into the STEAM-based teaching and learning activities will facilitate the improved conceptual learning, analytical thinking, and team-based problem-solving performance. In line with the previous ICT meta-analyses, the projected effect size would be close or higher than 0.59 in the case of subject knowledge acquisition, especially language and science literacy. This fact can be explained by the fact that EWB allows real-time visualization, organized discussion control, and formative feedback, which contribute to better engagement of learners and their ability to retain the knowledge.

The findings of the quantitative results are supposed to be enhanced by qualitative results. The parental and teacher feedbacks will probably establish the EWB as an effective conversation starter in families. The EWB eliminates the level of ambiguity that often surrounds the question, what did you do at school today? By making available to them, access to past classroom conversations, visual artefacts, and recorded learning experiences. Rather than shadowy or bare bones answers, parents are provided with practical knowledge of the activities of daily learning and can converse with them more effectively and provide more specific help at home. This openness enhances cooperation and communication between teachers and parents, which solidifies the home school alliance.

In institutional terms, the first digital architecture at EWB will result in significant resource efficiency advantages. The resulting decrease of paper consumption as well as the physical storage needs are systematic, which leads to more sustainable classroom practices and reduces the administrative overhead. Digital archiving also guarantees that learning evidence is

stored safely and can be accessed longitudinally without being hindered by the logistical issues related to documenting it on paper.

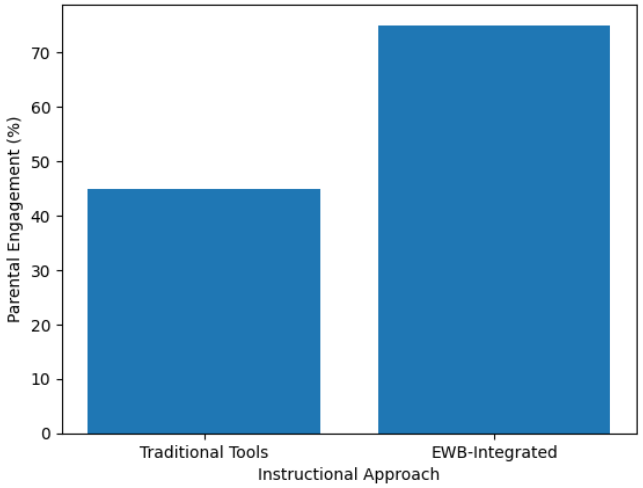
Figure 4.
Comparison of Learning Effect Sizes



Note. Author's results.

The plot shows a greater level of effect size of EWB-integrated instruction in comparison with traditional tools, and this demonstrates the effect of EWB on enhancing learning outcomes by interactive and structured learning.

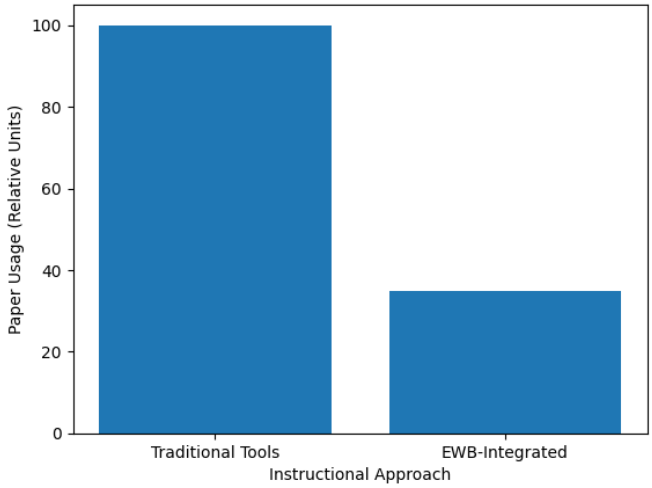
Figure 5.
Parental Engagement Comparison



Note. Author's results.

The parental engagement graph shows a significant upsurge in the level of engagement in cases where the EWB-built archives are available, and the virtual window effect of home school communication is confirmed.

Figure 6.
Paper Usage and Resource Efficiency



Note. Author's results.

This plot demonstrates that paper consumption in EWB-enabled classrooms has vastly decreased and therefore the system plays a role in ensuring sustainable and efficient practices in an institution.

Limitations

Although these advantages are expected, there are some limitations that will be encountered. The perceived burden of recording all the EWB sessions can overload the teacher. The families that do not have regular access to the internet can have equity issues that can restrict e-nvolvement. Also, digital knowledge gap between teachers and parents can influence the efficient use of the system.

Practical implications

To deal with these problems, the teachers are advised to clarify the purpose and functions of the EWB at the beginning of the academic year. The schools and colleges need to focus on professional growth in digital ethics, documentation culture and technological fluency to achieve the full potential of the EWB as a longitudinal assessment and collaborative learning tool.

FINAL CONSIDERATIONS

The EWB is an important step in the development of collaborative educational technologies especially in the early childhood education settings. The EWB transforms the classroom to a dynamic, interactive ecosystem where learning processes are constantly captured and organized to be shared with cloud-based digital portfolio systems through integration of real-time data processing. By doing so, this integration allows teachers to revolve around disjointed and passing types of documentation to a coherent, longitudinal student learning record that facilitates instructional planning, formative assessment and reflective practice. In the case of students, EWB promotes active learning, teamwork, and ownership of learning by ensuring that their ideas and their progress are seen and appreciated by the classroom community. It is also crucial that the EWB enhances the home-school relationships.

Parents will have a valuable opportunity to learn more about their children in learning environments by having safe access to the digitally stored classroom activities and change parental involvement into knowledgeable and long-term e-nvolvement. Such transparency promotes better communication, mutual expectations, and mutual assistance in learning outside the classroom, which is especially essential in the early stages of development. Although issues associated with teacher workload, digital literacy, and fair access to technology still exist, they can be overcome. The EWB can be integrated sustainably into practice, with the help of proper institutional support, specific attention to professional development, and considerate implementation strategies. On the whole, the EWB offers a sound pedagogical model of improving scientific literacy, promoting individualized learning, and developing meaningful collaborations between teachers, students, and parents. In this light, it has a great potential to develop more integrated, open, and student-centered learning experiences in the digital era.

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CRediT Author Statement

- **Acknowledgments**: Does not apply.
- **Funding**: Does not apply.
- **Conflicts of interest**: No conflict of interest.
- **Ethical approval**: This study does not require ethical committee approval.
- **Data and materials availability**: The data and materials used in this study are publicly available.
- **Author contributions**: This study is a single-authored work.

Processing and editing: Editora Ibero-Americana de Educação
Review, formatting, standardization, and Translation