University of Piraeus

Department of Digital Systems

PhD Dissertation

A Learning Experience Design Model for Whole-Child Development in Kindergarten: Based on Learning Trajectories and Universal Design for Learning Principles in Technology-Enhanced Environments

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PIRAEUS 2024

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Dr. Aloizou Valeria

“Τόδε έργον αέξεται, ω επιμίμνω”

- Όμηρος (περ. 800-750 π.Χ.)

– Οδύσσεια ξ’ 66

“The work that will progress is the one in which you will persist”

Homer (c. 800-750 BC)

- Odyssey, Rhapsody ξ, Line 66

Acknowledgments

As I reach the end of this journey, I find myself reflecting on the experiences that have shaped my research and personal growth over the years. This dissertation is not merely an academic endeavor; it is a testament to the invaluable support, encouragement, and guidance I have received from many important people along the way.

First and foremost, I would like to express my deepest gratitude to my Mentor and Professor, Dr. Symeon Retali, whose unwavering support has been a constant source of strength throughout this journey. Your experience, knowledge and insightful guidance have not only shaped the course of this dissertation but also profoundly influenced my intellectual growth. From the very beginning, you have believed in my abilities, and for that, I am deeply thankful. Your patience in guiding me through every challenge has truly elevated the quality of my work. You have been a constant pillar of encouragement, always available to offer advice and steer me in the right direction. Your mentorship has extended far beyond the academic sphere, influencing my personal and professional development in ways I could not have anticipated. The passion and dedication you exhibit in your research have been a source of inspiration for me. Your belief in my potential has fueled my determination to reach new heights, not only in this work but also in my future career. For all the time, energy, patience, and care you've invested in my progress, I will forever be grateful.

I extend my heartfelt thanks to the esteemed members of my dissertation committee, Dr. Demetrio Sampson and Dr. Foteini Paraskeva, for their invaluable guidance and support throughout my master's program and dissertation work. Your expertise and research have been a source of inspiration during this academic journey, motivating me to strive for excellence. I am deeply grateful for the time and effort you dedicated.

I would also like to acknowledge the school principals and teachers who participated in the case studies. Your willingness to embrace this research and collaborate with me made this journey all the more enriching. Thank you for your trust and the wonderful cooperation that made this study possible.

To the exceptional members of the CoSyLLab research unit, your insights, encouragement, and collaboration over the years have greatly enriched my experience, and I truly cherish the memories and friendships we have built.

To my life partner, Nikola, thank you for your unwavering love, patience, and encouragement all these years. You have been my rock, lifting me up during challenging times and celebrating my successes. I am forever grateful for your presence in my life.

To my supportive parents, Spyro and Elvira, your unconditional love and belief in me have been the foundation upon which I stand today. Thank you for your sacrifices and for always being there for me. To my cherished grandmother and my late grandfather, your wisdom, resilience, and love continue to inspire me every day. I hope this work would make you proud. To my caring sister, Samantha, thank you for being my confidant, my cheerleader, and my best friend. Your support and encouragement have been a constant source of strength in my life, and I am incredibly grateful for the special bond we share. To my dear friends, thank you for your laughter, your shoulders to lean on, and your willingness to listen. Your friendship has enriched my life in countless ways.

Each of you has played a vital role in bringing this study to fruition, and I am truly thankful for your contributions. I share this accomplishment with you, for without you, it would not have been possible. As I close this chapter, I look forward to carrying the lessons and memories we've shared into the next phase of my academic and professional journey.

With gratitude,
Valeria Aloizou

Abstract

This dissertation explores the integration of a new Learning Experience (LX) design model aimed at supporting holistic development in early childhood education, particularly in Kindergarten, drawing on the principles of Universal Design for Learning (UDL) and learning trajectories. While academic achievement is traditionally viewed through a cognitive lens, there is increasing recognition that social, emotional, and physical development are equally critical. The concept of whole child development is fundamental to creating inclusive and equitable education systems. The LX design proposed in this study responds to the growing need for multimodal teaching and learning approaches that cater to the whole child. It integrates technology in a way that is both purposeful and pedagogically sound, emphasizing that effective technology use in education depends on the tools, the learning context, and the educator's strategies. The dissertation highlights the importance of teacher guidance and instructional support in maximizing the potential of digital tools, while also addressing challenges related to alignment with state standards, resource creation, and the assessment of digital pedagogical value. The study is structured around three (3) empirical case studies conducted in authentic educational settings. The first case study evaluates the effectiveness of multimodal learning stations within the LX design, revealing that such stations create interactive and conducive learning environments. Key findings include the promotion of positive classroom behaviors, enhanced academic performance, increased student motivation, particularly for those with concentration difficulties, and the importance of clear instructions and well-defined activities. The study also highlights the role of innovative teaching approaches in fostering holistic growth and creating inclusive learning environments. The second case study explores the implementation of multimodal learning stations as a core curriculum tool, yielding significant improvements in academic achievement, cognitive development, and social-emotional skills. Students demonstrated higher proficiency in critical mathematical skills, and teachers reported positive attitudes toward the LX design, noting its effectiveness and ease of integration. The study underscores the LX design's ability to seamlessly facilitate multimodal learning, resulting in high levels of student engagement and improved classroom dynamics. The third case study investigates the potential of the LX design in special education and distance learning contexts. The findings show considerable improvements in student performance, attention, autonomy, and motivation. The use of both synchronous and asynchronous learning methods was identified as a critical factor for the success of online interventions. The LX design enabled children to exercise diverse skills, including academic, cognitive, motor, and socio-emotional areas, highlighting its adaptability and effectiveness in various educational settings. The conclusions drawn from these case studies demonstrate the LX design's ability to foster a holistic learning environment that supports comprehensive child development across cognitive, social-emotional, and physical domains. This dissertation makes two key contributions. First, it introduces a novel and well-structured LX design model tailored to support holistic development in kindergarten through the integration of multimodal educational technologies. Second, the dissertation presents a systematic mixed-methods evaluation approach, drawing on both qualitative and quantitative data to validate the effectiveness of the LX model. The findings of this dissertation offer a foundation for further research and practical application, guiding educators and learning designers in implementing holistic approaches within authentic classroom settings.

Key words: whole child development, learning experience design, universal design for learning, learning trajectories, multimodal learning stations, movement-based learning

Περίληψη

Η παρούσα διδακτορική διατριβή πραγματεύεται ένα νέο Μοντέλο Σχεδιασμού Μαθησιακής Εμπειρίας (Learning Experience Design-LX Design) για την υποστήριξη της ολόπλευρης ανάπτυξης στο Νηπιαγωγείο, η οποία αφορά στην καλλιέργεια των γνωστικών, κινητικών, συναισθηματικών και κοινωνικών δεξιοτήτων του παιδιού. Ενώ οι συγκεκριμένες δεξιότητες συχνά μελετώνται ξεχωριστά, στην πραγματικότητα είναι αλληλένδετες. Σύμφωνα με έρευνες, μια ολοκληρωμένη εκπαίδευση θα πρέπει να προάγει την ολιστική ανάπτυξη του παιδιού, κι έχει ιδιαίτερη σημασία στην προσχολική εκπαίδευση, καθώς σ' αυτό το στάδιο τίθενται τα θεμέλια για τη μελλοντική ανάπτυξη και πρόοδο του παιδιού. Το προτεινόμενο Μοντέλο Σχεδιασμού Μαθησιακής Εμπειρίας βασίζεται στις τροχιές μάθησης (learning trajectories), οι οποίες οργανώνουν τους διδακτικούς στόχους των αναλυτικών προγραμμάτων σπουδών σύμφωνα με τα αναπτυξιακά στάδια. Επιπλέον, δίνεται έμφαση στην ενσωμάτωση δραστηριοτήτων ενσώματης (movement-based) αλληλεπίδρασης. Παράλληλα, ακολουθώντας τις αρχές του Καθολικού Σχεδιασμού για τη Μάθηση (Universal Design for Learning – UDL), ενσωματώνονται πολλαπλές αναπαραστάσεις του περιεχομένου στους σταθμούς μάθησης και ψηφιακά εργαλεία όπως διαδραστικοί πολυμεσικοί πόροι και εκπαιδευτικές εφαρμογές. Πραγματοποιήθηκαν τρεις (3) μελέτες περίπτωσης σε αυθεντικά περιβάλλοντα μάθησης για την αξιολόγηση του προτεινόμενου Μοντέλου Σχεδιασμού Μαθησιακής Εμπειρίας. Η πρώτη μελέτη αξιολογεί την αποτελεσματικότητα των πολυτροπικών σταθμών μάθησης του μοντέλου. Κύρια ευρήματα περιλαμβάνουν την προώθηση θετικών συμπεριφορών στην τάξη, την ενισχυμένη ακαδημαϊκή επίδοση, τα αυξημένα κίνητρα των μαθητών, ιδιαίτερα για εκείνους που έχουν δυσκολίες συγκέντρωσης, και την ανάγκη παρουσίασης σαφών οδηγιών και καλά καθορισμένων δραστηριοτήτων. Η δεύτερη μελέτη ερευνά την εφαρμογή του μοντέλου για μία ολόκληρη σχολική χρονιά, αποφέροντας σημαντικές βελτιώσεις στην ακαδημαϊκή επίδοση, τη γνωστική ανάπτυξη και τις κοινωνικο-συναισθηματικές δεξιότητες. Οι μαθητές παρουσίασαν υψηλότερη επάρκεια στις μαθηματικές δεξιότητες, ενώ οι δάσκαλοι είχαν θετικές στάσεις απέναντι στο μοντέλο όσον αφορά την αποτελεσματικότητά του και την ευκολία ενσωμάτωσης του. Η τρίτη περίπτωση διερευνά τις δυνατότητες του μοντέλου σε πλαίσια ειδικής αγωγής και εξ αποστάσεως εκπαίδευσης. Τα ευρήματα δείχνουν σημαντικές βελτιώσεις στην ακαδημαϊκή επίδοση, την προσοχή, την αυτονομία και τα κίνητρα των μαθητών. Η χρήση τόσο σύγχρονων όσο και ασύγχρονων μεθόδων εξ αποστάσεως διδασκαλίας αναγνωρίστηκε ως κρίσιμος παράγοντας για την επιτυχία των διαδικτυακών παρεμβάσεων. Η παρούσα διατριβή πρωτοτυπεί σε δύο βασικά στοιχεία. Πρώτον, εισάγει ένα νέο και καλά δομημένο Μοντέλο Σχεδιασμού Μαθησιακής Εμπειρίας για ολόπλευρη ανάπτυξη στο Νηπιαγωγείο αξιοποιώντας εκπαιδευτικές τεχνολογίες πολλαπλής μορφής

(multimodal educational technologies) που έχουν αξιολογηθεί θετικά σε αυθεντικά περιβάλλοντα μάθησης. Το προτεινόμενο μοντέλο μπορεί να αξιοποιηθεί εύκολα – χωρίς χρονοβόρες διαδικασίες επιμόρφωσης - από εκπαιδευτικούς και σχεδιαστές μάθησης για τη σχεδίαση μαθησιακών εμπειριών. Δεύτερον, η μικτή μέθοδος αξιολόγησης του προτεινόμενου μοντέλου μπορεί να αξιοποιηθεί και σε μελέτες άλλων μοντέλων που εφαρμόζονται σε αυθεντικά περιβάλλοντα είτε γενικής είτε ειδικής αγωγής.

Λέξεις-κλειδιά: ολόπλευρη ανάπτυξη, σχεδιασμός μαθησιακής εμπειρίας, καθολική σχεδίαση για τη μάθηση, τροχιές μάθησης, πολυτροπικοί σταθμοί μάθησης, ενσώματη μάθηση

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CHAPTER 1

Introduction

While academic achievement is often perceived as solely dependent on cognitive abilities, it is increasingly recognized that social, emotional, and physical development play crucial roles. The concept of whole child development underscores the holistic nurturing of various aspects of a child's well-being, including physical, social, emotional, cognitive, and spiritual dimensions. This holistic perspective is fundamental in early childhood education, particularly in Kindergarten, where the foundations of lifelong learning are laid. Embraced as a cornerstone of the United Nations Agenda 2030 for Sustainable Development, it advocates for inclusive and equitable education systems that cater to the diverse needs of every child. Additionally, the Convention on the Rights of the Child (1989) emphasizes the significance of spiritual, moral, and social development in creating nurturing environments for children. Extensive research supports the notion that comprehensive education fosters well-adjusted, empathetic, and successful individuals, emphasizing the importance of whole child development (Smith & Johnson, 2020).

Today's technological advances, coupled with considerations of the changing needs of the learners, call for exploring new directions for multimodal teaching and learning for whole child development. Learning experience (LX) design is a process concerned with both the effectiveness of designed learning interventions and the interconnected and interdependent relationship between the learner-as-user, the designed learning experience, and the learning context (Schmidt & Huang, 2022). In LX design, effective technology integration in education relies not only on the tools but also on educators' pedagogical strategies (Dias & Atkinson, 2001; Cheng & Tsai, 2020; Southgate, 2020). Also, several studies have highlighted the significance of teacher guidance and instructional support for students in utilising digital tools to foster learning (Kennewell & Beauchamp, 2007). As Haleem et al. (2022) mention, the emphasis should be on considering the responsible and purposeful use of technology, ensuring that it aligns with the learning goals and instructional strategies, rather than being used merely for novelty or entertainment purposes. Further challenges in LX design include the alignment with state standards and resource creation (Hicks, 2017; Hamand, 2019). Finally, teachers may struggle with assessing the pedagogical value of digital resources, compounded by a lack of training (Kayumova & Sadykova, 2019; Abreu & Barbosa, 2022).

The learning setup in early childhood classrooms involves the use of learning stations to foster collaboration and teamwork. However, this dissertation seeks to reimagine learning stations to support multiple representations and modalities, thereby supporting holistic child development, with a specific focus on promoting kinesthetic learning in the classroom. This shift acknowledges that each child learns uniquely and underscores the importance of providing multiple learning experiences tailored to their preferences and needs an approach which is fully aligned with the principles of Universal Design for Learning (UDL). By integrating activities that engage different senses, modes of expression, and types of interaction, educators can create and enact dynamic learning environments that effectively meet the diverse needs of young learners (King-Sears, 2007). Moreover, there is a growing emphasis on the idea that "two representations are better than one"(Ainsworth, 2006), highlighting the efficacy of utilising multiple representations for enhanced learning outcomes. The multiple representations in the learning stations can be enriched with digital tools such as tablets, multimedia technology, and interactive boards, promoting multimodal learning experiences (Moreno & Mayer, 2007; Preston & Mowbray, 2008; Park et al., 2011; Habeeb, 2018; Sankey et al., 2010; Novitasari et al., 2020; Lee-Cultura et al., 2020). For example, creative applications of tablets in kindergarten have been explored in combination with three-dimensional objects to promote spatial, motor and interpersonal skills (Raths, 2015). In addition, educators have been trying to foster student engagement by incorporating movement-based learning activities via digital games into the curriculum (Retalis et al., 2014; Utoyo, 2019; Siregar et al., 2021).

LX design that addresses the above-mentioned needs and ideas remains challenging. There is a pressing need for learning design frameworks facilitating seamless integration of multimodal digital resources to benefit early childhood learners (Fowler, 2014). According to Kuhail et al. (2022) and MacDowell & Lock (2023), future research should focus on conceptual frameworks for immersive technologies across contexts, providing guidance on deployment and integration in classrooms (Kuhail et al., 2022; MacDowell & Lock, 2023). Fowler (2014) also advocates for the development of pedagogical guidelines and best practices to ensure safe and effective use of technologies in education.

Seeking to fill this research gap, the present dissertation focuses on presenting a new LX design, aiming to support educators with the design of effective learning experiences to achieve whole child development by harnessing modern teaching strategies and tools. These experiences are geared towards supporting holistic child development, with a specific emphasis on kinesthetic learning, while also facilitating the integration of educational digital tools. The work goes on with investigating the impact of the LX design in classroom behavior and student engagement, the effect on students' academic performance and, the teachers' acceptability based on the enactment of the LX design in authentic education settings. In sum, this study is motivated by the lack of LX designs to support educators with the design and implementation of holistic multimodal learning experiences. The study has a dual research goal:

(i) To report on the LX design,

(ii) To report of the evaluation of the LX design as enacted in authentic education settings, focusing on three guiding research question: classroom behavior and student engagement (RQ1), students' academic performance (RQ2), and teachers' attitudes and perceptions (RQ3).

A mixed-method approach was employed for evaluation. Through a detailed description of the LX design and findings from the evaluation, this work advances the development of learning designs that facilitate the seamless integration of holistic multimodal learning experiences in education.

1.1 Identifying the research gap

Education is more than just academics; it encompasses the holistic development of the child, including cognitive, social, emotional, and physical growth. Despite this understanding, there remains a significant gap in the practical implementation of learning experiences that support the whole child approach within educational systems. This dissertation aims to address this gap by focusing on the design, implementation and evaluation of a new learning experience.

One of the critical gaps in the current educational landscape is the lack of well-defined LX designs to guide teachers in creating holistic learning environments. Many existing curricula are primarily academically focused and do not adequately address the multifaceted needs of young learners (Diamond, 2010). There is an urgent need for LX designs that integrate various developmental dimensions, thereby fostering a more balanced educational model.

Teachers play a pivotal role in implementing the whole child approach, yet they often lack the necessary support and resources to do so effectively.Comprehensive teacher training is essential, not only in academic content but also in strategies that promote social, emotional, and physical development (ASCD, 2012). Unfortunately, many educators are not equipped with the skills or knowledge required to implement holistic teaching practices. This dissertation seeks to bridge this gap by providing teachers with robust a LX design and practical guidance to facilitate whole child development.

Integrating a whole child approach necessitates a fundamental shift in teaching methodologies (Slade & Griffith, 2013). This paradigm shift is unfamiliar territory for many educators and calls for reliable solutions to support the transition. This dissertation aims to contribute to this shift by introducing a novel LX design grounded in specific pillars that promote holistic child development.

An additional gap in current educational practices for whole child development is the limited focus on kinesthetic digital learning in the classroom. Kinesthetic learning, which involves physical activity and movement, is a crucial component of holistic education, particularly in early childhood settings. This dissertation will explore this aspect, emphasizing the need for kinesthetic digital learning activities as part of a comprehensive LX design.

In conclusion, this dissertation identifies several key research gaps in the current educational landscape: the lack of LX designs to guide teachers, the need for comprehensive teacher support, the necessity for paradigm shifts in teaching methodologies, and the missing focus on kinesthetic digital learning. By addressing these gaps, this study aims to provide valuable contributions to the field of educational technology and learning design, ultimately supporting the effective implementation of a whole child approach in education.

1.2 Research design and research objectives

The primary objective of this dissertation was to develop, implement, and assess a new LX design aimed at supporting teachers in the application of holistic educational approaches within authentic classroom settings. This research sought to address the gaps in existing educational practices by providing a comprehensive LX design that integrates various developmental dimensions, thus fostering a balanced educational model that supports the whole child.

To evaluate the effectiveness of the proposed LX design, three empirical investigations were conducted using the case study research method. These investigations took place in authentic educational settings, allowing for a realistic assessment of the LX design's impact. The evaluations focused on three key aspects:

- Classroom Behavior and Student Engagement
- Students' Academic Performance
- Teachers’ Acceptability

The general evaluation framework for the LX design was based on the triangulation strategy. Triangulation involves cross-verifying data from multiple sources to identify patterns and explain complex situations (O'Donoghue & Punch, 2003). This approach enhances the reliability and validity of the research findings by combining quantitative and qualitative methods. The use of multiple methods allows for answering different or complementary research questions and enhances the interpretability of the data. By employing a triangulation strategy, the research aimed to provide a comprehensive evaluation of the LX design, offering robust evidence of its effectiveness and practicality in real-world classroom settings.

This dissertation aims to contribute significantly to the field of educational technology and learning design by introducing and empirically validating a new LX design. By supporting teachers in implementing holistic educational approaches, the study seeks to enhance student engagement, improve academic performance, and ensure teacher acceptability. The findings from this research have the potential to inform future educational practices and policies, ultimately promoting a more balanced and holistic approach to education.

1.3 Structure of the thesis

This dissertation is structured into six chapters:

- Chapter 1 constitutes an introduction to the study, presenting the research gaps, and a summary of the major findings and the importance of this work.

- In Chapter 2 we explore the holistic development of children, a comprehensive educational approach that encompasses physical, emotional, and social growth alongside academics. We analyze the ASCD Whole Child Framework and the challenges educators face in implementing such an approach, particularly in Kindergarten classrooms, aiming to fill a crucial gap in educational research by proposing innovative solutions to support holistic child development taking into account the foundational academic skills, the strategies and the classroom setup followed in Kindergarten.
- Chapter 3 analyzes the UDL framework, emphasizing its principles of engagement, representation, and action and expression, and its role in creating engaging learning environments. Additionally, it explores learning trajectories, structured roadmaps for students' academic development in various subjects, underscoring their significance in supporting personalized instruction and fostering holistic student growth.
- Chapter 4 introduces the proposed LX design developed to support holistic child development in early childhood education. This chapter delves into the detailed structure of the LX design, outlining its design and enactment form, and elaborating on the roles of teachers and students in the learning process. Additionally, it advocates for multimodal instructional strategies, examines various educational platforms, identifies the most suitable one for supporting holistic child development, and establishes the prerequisites for the successful implementation of the new LX design.
- Chapter 5 presents the evaluation of the proposed LX design through three empirical investigations conducted in authentic education settings, aiming to assess improvements in students' academic skills, the impact in classroom behavior and student engagement and teachers' acceptability.
- In Chapter 6 we summarize key findings from the case studies and discuss the findings holistically. The chapter concludes with a discussion of contributions to current knowledge, limitations of the work, and suggestions for future research.

CHAPTER 2

Importance of the Whole Child Development & Kindergarten Context

2.1. Introduction

This chapter explores the multifaceted nature of child development, including physical growth, language, emotions, and social skills, and the importance of a holistic approach to education that nurtures all these interconnected areas. Drawing from insights by experts and global educational agendas, it highlights the need for a well-rounded education that goes beyond academics to nurture successful individuals. Further, the chapter explores the ASCD Whole Child Framework, introduced in 2007, which articulates a vision of education that ensures each child is healthy, safe, engaged, supported, and challenged. This framework serves as a guide for integrating a whole child approach into school improvement processes, emphasizing the critical role of various components such as school climate and culture, curriculum and instruction, and community and family engagement in supporting holistic child development.

Despite the widespread endorsement of this approach, the chapter acknowledges the challenges faced by educators and institutions in implementing it, notably the need for additional resources, comprehensive teacher training, and a paradigm shift from traditional academic-focused methods to a more balanced educational model. It highlights the specific difficulties of adapting curriculum and teaching practices to accommodate the diverse needs and learning styles of children, as well as the resistance to change within educational systems.

Following, we explore the context of Kindergarten classrooms, focusing on the foundational academic skills emphasized by teachers and policymakers, alongside the teaching strategies employed to facilitate instruction. This information is crucial for designing learning experiences that navigate the challenges associated with implementing whole child development experiences, ensuring alignment with current classroom practices. Furthermore, we examine the prevalent classroom setup in Kindergarten; the learning stations approach. The corresponding section aims to address significant gaps in the literature and confront the challenges associated with this pedagogical strategy.

The chapter concludes with the acknowledgment that, to the best of our knowledge, there are no recent empirical studies specifically investigating the implementation of learning stations in Kindergarten settings to support the holistic development of young learners, a crucial aspect of their comprehensive growth. This absence in the literature underscores a critical need within educational research. Through this study, we aim to bridge this gap by making a novel contribution to the field, aiming to enhance the application of learning stations through innovative design and utilization.

2.2 Theory and Practice in Holistic Child Development

Child development involves various aspects, including physical growth, intellectual, language, emotional, and social development (Word Health Organization, 2012). While these dimensions are often considered separately, in reality each influences all of the others (Figure 1). In his study, Diamond (2010), challenges conventional notions of academic success by highlighting the intricate relationship between academic achievement and holistic child development. He argues, “If we want the best academic outcomes, the most efficient and cost-effective route to achieve that is, counterintuitively, not to narrowly focus on academics, but to also address children’s social, emotional, and physical development. Similarly, the best and most efficient route to physical health is through also addressing emotional, social, and cognitive wellness. Emotional wellness, similarly, depends critically on social, cognitive, and physical wellness”. This statement emphasizes the critical importance of adopting a holistic approach to education, one that acknowledges the multifaceted nature of student learning.

Figure 1. The Whole Child Development

The whole child development is integral to global educational agendas, such as the United Nations Agenda 2030 for Sustainable Development (2015), which promotes inclusive and equitable education. The Convention on the Rights of the Child (1989) also highlights the importance of spiritual, moral, and social development. Extensive research has shown the benefits of a well-rounded education in fostering well-adjusted, empathetic, and successful individuals (Smith & Johnson, 2020). The holistic perspective holds particular significance within Kindergarten settings, as it lays the foundation for a child's future growth and development (Young, 1996; Shavkatovna, 2023; Tang et al., 2023). Scholars advocate for viewing children as "whole persons" (Noddings, 2005; Sanderse et al., 2015) and emphasize the significance of creating nurturing environments where children feel safe, secure, and accepted, in contrast to the didactic teaching approaches (Diamond, 2010).

In 2007 ASCD (formerly the Association for Curriculum Development and Supervision) outlined a whole child approach to education as its core mission. It developed 5 tenets based upon child development theory, which underpins the approach and states that each child in each school and in each community deserves to be healthy, safe, engaged, supported and challenged (Figure 2). This framework has been used as the scaffold in the development of a range of school improvement processes that ensures that the approach is integrated and systemized into the processes and policies of the school, district, and community. The framework does not seek to divorce itself from academic development but it does seek to expand what constitutes academic development in the 21st century and aims to refocus attention on all attributes required for educational and societal success.

Figure 2. ASCD Whole Child Framework (2007)

Although this approach was originally launched in the U.S., it has become a widely adopted initiative with countries across the Americas, Europe, and Oceania using the approach to refocus their educational systems on local, regional, and national levels (Slade & Griffith, 2013). To be effective and sustainable, the whole child approach must be incorporated into schools' improvement planning. School improvement processes can be either piecemeal, "which entails making adjustments to the current paradigm of education" or systemic, "which entails transforming the current paradigm into a different one" (Joseph & Reigeluth, 2010, p. 97). If we wish to have long lasting, meaningful change in the way our schools function and in what they are able to achieve we must strive for systemic change (Slade & Griffith, 2013).

In 2012, ASCD took this understanding one step further by cross-referencing five whole child tenets and their indicators with the key components of an effective school improvement process. Two of these components are as follows:

- Curriculum & Instruction: Students develop critical-thinking and reasoning skills, problem solving competencies, technology proficiency and content knowledge through evidence based, relevant, differentiated instructional pedagogy and comprehensive curriculum.
- Professional Development & Capacity: Staff demonstrates the knowledge, skills, and dispositions necessary to ensure each child is prepared for long term success. They are supported by differentiated, job embedded professional development.

Aligning the tenets and indicators to the key components of effective school improvement processes formalized the integration of a whole child approach into the systems and policies of the school. The whole child framework then becomes embedded in the school improvement process and becomes an integral part of what the schools does in addition to the policies, structures, and processes it develops moving forward (Slade & Griffith, 2013).However, although the integration of the whole child approach into the systems and policies of the school is a commendable goal with the potential to significantly enhance the learning and development of students, is not without its challenges.

One of the challenges in adopting a whole child development approach is the necessity for curriculum resources, along with comprehensive teacher training and professional development. This approach often requires training for educators, diverse and engaging learning materials, and adequate physical space to accommodate a range of activities. Unfortunately, many educational institutions, particularly those in underfunded areas, face budgetary constraints that limit access to these essential resources (Ohi, 2015). Moreover, integrating whole child development principles into existing curriculums demands a paradigm shift from traditional academic-focused teaching methods to a more balanced approach. This shift can be challenging, as it involves developing a curriculum that equally emphasizes academic, social, emotional, and physical development – a new territory for many educators (Fleming & Kearns, 2022). Furthermore, catering to the diverse needs of each child in a classroom setting presents a complex task. Children come with different learning styles (Dunn, 1984; Moran, 1991), interests, and developmental paces. Addressing all these variables within one educational model could be a challenge for educators (Tomlinson et al., 2003; Yassin & Almasri, 2015). Additionally, balancing the inclusion of holistic development activities with the need to cover academic content and prepare for standardized tests poses a significant challenge due to time constraints (Kelly & Berthelsen, 1995). Resistance to change also presents a substantial barrier. This includes reluctance from educators to adopt new methodologies and educational philosophies (Guthrie, 2011).

While the challenges in implementing the whole child development approach are substantial, they are not unsurpassed. This thesis proposes a new approach to support Kindergarten teachers in effectively organizing the existing curriculum to design holistic and engaging learning experiences by providing resources and professional development. In the next section, we will explore the educational context of Kindergarten, focusing on examining the foundational domains that students at the Kindergarten grade level are supposed to be taught and assessed on, and identifying where the current focus lies.

2.3 Foundational Curriculum Domains in Kindergarten

Analyzing the importance of the Kindergarten domains of academic, emotional, cognitive, and physical skills, sheds light on the critical role these areas play in children's development and school readiness.

Emotional development is a key aspect that significantly impacts a child's readiness for school. Research has shown that emotional skills, such as recognizing and managing emotions, are crucial for social interactions and behavioral regulation (Fantuzzo et al., 2007). Children who possess strong emotional development are better equipped to navigate the challenges of the school environment and establish positive relationships with peers and teachers.

Cognitive development, encompassing intellectual abilities and problem-solving skills, is fundamental for academic success and future learning experiences. Advanced cognitive skills enable children to engage in critical thinking, memory retention, and language development, all of which are essential for effective learning and adaptation to new tasks in school.

Physical development, including both gross and fine motor skills, plays a vital role in children's overall development and school readiness. Gross motor skills, involving movements of large muscles, and fine motor skills, requiring precise hand movements, are essential for physical activities, object manipulation, and eye-hand coordination. Proficiency in these skills enables children to participate actively in school activities and tasks that demand physical coordination.

Foundational academic skills lay the groundwork for Kindergarten students' educational journey. These fundamental skills include the trio of reading, writing, and arithmetic, recognized as important predictors of future academic achievement (National Early Literacy Panel, 2008; Locuniak & Jordan, 2008; 2009; Boivin & Bierman, 2013). Mastery of these skills ensures a seamless transition to the challenges of first grade and beyond. As young learners practice literacy, they acquire essential reading strategies, such as letter recognition, phonemic awareness, and comprehension skills, enabling them to decode words and comprehend written texts.

Similarly, the cultivation of writing skills help students express their thoughts, experiences, and ideas through written language, fostering both creativity and communication abilities. Moreover, the introduction to basic arithmetic concepts equips kindergartners with the numeracy skills needed to navigate mathematical concepts, laying a foundation for future mathematical proficiency.

Reading proficiency is a developmental process, with Kindergartners mastering a specific sequence of skills. Initially, children acquire phonemic awareness, including sound identification in words, phoneme blending, and word segmentation. Subsequently, they practice with the alphabet, associating letters with their respective sounds and identifying patterns in words. As children progress to the automatic alphabet phase, they leverage their prior knowledge to decode unfamiliar words, thereby enhancing reading fluency (Burke et al., 2009). Proficiency in decoding, encompassing speed and accuracy, is a prerequisite for successful reading. Each of these skills necessitates rigorous practice before advancing to the next, with phonological awareness serving as the foundational step. Recent research underscores the systematic nature of phonological awareness skill acquisition (Cassady et al., 2008). The development of phonological awareness entails two primary phases (Runge & Watkins, 2006). Initially, children must learn to categorize, manipulate, segment, and blend sounds. Subsequently, they transition to recognizing and generating rhyming words, involving sound identification and various associated cognitive tasks. Kindergarten curricula offer opportunities for enhancing phonological awareness by guiding students in recognizing and generating rhyming words, with an emphasis on recognizing ending sounds while reducing the cognitive manipulation component (Runge & Watkins, 2006). Explicit formal instruction targeting these aspects of phonological awareness has demonstrated its efficacy in facilitating rapid skill acquisition (Cassady et al., 2008). By the end of the Kindergarten school year, students should be able to connect the sounds of words to their visual representation in print.

Moreover, young children are eager to draw and write (Baghban, 2007), and preschool classrooms typically offer writing materials and opportunities for writing, because writing is an activity that appeals to young children (Love, Burns, & Buell, 2007). Children's earliest strategies for writing are embedded in and formed through social activities that reflect the role of writing in communication (Neuman & Roskos, 1997). In an analysis of young children's use of literacy materials in dramatic play activities (e.g., Post Office, restaurant) in preschool, Neuman and Roskos reported that children often used writing for sharing information (e.g., showing another child how to write), business transactions (e.g., writing a bill at a restaurant), organizing activities (e.g., working together to write and address a letter at the Post Office) and as a memory device (e.g., writing down an order). Similarly, Dyson (1988) described young children's use of writing to organize their thoughts and to “communicate their ideas to themselves and to others” (p. 32), while Love et al. (2007) highlighted the ways in which children used name-writing for signing up for classroom jobs and turn-taking activities. When preschool children begin to use letters in writing, they often focus on copying and then writing their own names (Levin et al., 2005). Names provide a rich source for children's experiments with code-focused processes including letter formation, print direction, and print orientation (Aram & Biron, 2004; Bloodgood, 1999). Personal names are the first “clearly meaningful text that is resistant to being forgotten and unchanging in pronunciation” (Tolchinsky, 2006, p. 89), factors that make children's names especially compelling written forms. One's own name provides a source of conventional letter shapes (Tolchinsky, 2006), and young children often repeat the known letters of their name when they attempt to write other words. For example, Bloodgood (1999) found that almost half of the characters that children included in writing samples were letters found in their own names, and Treiman and Broderick (1998) found significant advantages for letters in the child's name when they were asked to write dictated letters. Levin et al. (2005) have suggested that name-writing may also arouse children's interest in letters more generally and alert them to graphic features of the alphabet. Children's understanding of different written forms (e.g., lists, stories) as well as the act of writing may promote young children's developing understanding of the alphabetic principle (Bus et al., 2001, Juel, 2006). Writing integrates the important early literacy skills of phonological awareness and letter knowledge and provides an avenue for learning about letters and sounds (Aram, 2005; Martlew & Sorsby, 1995; Ukrainetzet al., 2000; Whitehurst & Lonigan, 2001). Clay (2001) argues that “writing is of critical importance for learning to read” (p. 18) because it directs children's attention to print. When they write letters, children learn to attend closely to the features that distinguish each letter from all others.

In addition to literacy, arithmetic curriculum encompasses a range of fundamental mathematical concepts, including counting, number recognition, and basic operations like addition and subtraction. These early mathematical experiences foster logical thinking and mathematical reasoning among young learners (Clements & Sarama, 2008). To excel in math, students must attain fluency in basic mathematical calculations, which entails memorizing number facts and combinations. Fluency, in combination with solid number knowledge and robust memory skills, is pivotal in predicting increased math proficiency by second grade (Locuniak & Jordan, 2008). Kindergarten math curriculum places substantial emphasis on student practice in addition and subtraction, recognizing that simple counting alone does not significantly contribute to fluency (Ray & Smith, 2010). Instead, strategic counting methods, coupled with regular practice with number combinations while observing patterns, are key to enhancing number fluency and increasing the likelihood of later math skills mastery. It is worth noting that finger counting can be adaptive during the initial stages of learning number combinations, particularly in Kindergarten (Jordan et al., 2008). Furthermore, research suggests that not only does number competence in Kindergarten play a vital role in later math skills, but the rate of growth in early number competence is also a predictor of math performance up to the third grade (Jordan et al., 2009). Therefore, supporting children in achieving not only number competence but also an adequate rate of growth in Kindergarten can significantly improve their math skills trajectory throughout their educational journey.

It is clear that nowadays the focus is mainly on academics. Thus, it's very important to find a way to train teachers to be able to implement more holistic approaches. To do so, according to ASCD tenets (2012), curriculum resources and professional development are needed. In the next section, we will explore several teaching strategies that Kindergarten educators use to teach all these multiple skills that are under each domain.

2.4 Teaching Strategies applied in Kindergarten Education

Teaching strategies are a fundamental component of the educational process, involving a variety of methods and techniques employed by educators to teach skills that fall under each domain. These strategies include a variety of activities and approaches used in the classroom, primarily aimed at actively engaging students in the learning process. Kindergarten teachers use a variety of teaching strategies designed to create a rich and engaging learning environment. Following this, we have identified specific teaching strategies used in Kindergarten classrooms.

2.4.1 Teamwork

Dividing the class into groups is recommended to encourage learners of mixed abilities to work with one another. By doing so, those who have more knowledge of the subject can share their knowledge and help their peers understand the topic better. This approach aligns with Vygotsky's theory of social development, which emphasizes the importance of more knowledgeable peers in the learning process (Vygotsky, 1978). Studies of classroom instruction show that teachers can promote cooperative learning by splitting the class into small groups and dividing different tasks amongst students. Johnson and Johnson's research on cooperative learning provides evidence of the effectiveness of this strategy in enhancing student learning and social skills (Johnson & Johnson, 1999).

Previous studies reveal that group assignments improve teamwork and help students to succeed. Slavin's work on cooperative learning and academic achievement underscores the benefits of group work in improving student outcomes (Slavin, 1996). However, group work needs to be well-managed and requires a level of independence. Kagan's research on cooperative learning structures suggests effective ways to manage group work and foster independence among students (Kagan, 1994). Integrating group work in the classroom, as evidenced by these studies, not only fosters a better understanding of academic content but also enhances essential skills like teamwork and independence, crucial for students' overall development.

2.4.2 Hands-On Activities

Hands-on activities in kindergarten are a cornerstone of early childhood education, providing young learners with opportunities to explore, experiment, and understand the world around them through tactile and interactive experiences (Copple & Bredekamp, 2009). The effectiveness of hands-on learning in promoting cognitive development, fine motor skills, and active engagement in young children is well-documented in educational research. Engaging in hands-on activities allows children to develop both cognitive and fine motor skills. Piaget’s theory of cognitive development highlights the importance of sensory experiences in the learning process for young children (Piaget, 1970). Activities like building blocks, clay modeling, and puzzle-solving contribute to spatial awareness, problem-solving skills, and hand-eye coordination. Moreover, hands-on activities embody the principle of active learning, where children learn by doing. This approach is in line with Kolb's experiential learning theory, which states that learning is a process whereby knowledge is created through the transformation of experience (Kolb, 1984). In a kindergarten setting, activities such as gardening, water play, and art projects offer experiential learning opportunities. In addition to this, hands-on activities stimulate creativity and imagination in children. Vygotsky's work on the role of imaginative play in the psychological development of children underscores the significance of creative activities in cognitive and social development (Vygotsky, 2004).

Through hands-on activities like drawing, storytelling, and role-playing, children can express themselves creatively and explore different perspectives. Participating in group hands-on activities promotes social skills and teamwork. As children work together on projects, they learn to communicate, share resources, and collaborate to achieve common goals. The importance of social interaction in learning is further supported by Bandura's social learning theory, which emphasizes that learning occurs within a social context (Bandura, 1978). Hands-on activities also play a role in emotional development and building self-efficacy. Children gain confidence as they successfully complete tasks and make discoveries, aligning with Bandura's concept (1977) of self-efficacy as a key factor in how people view their ability to impact their own lives. In conclusion, hands-on activities in kindergarten are not just about keeping children busy; they are a crucial component of a well-rounded early childhood education. By providing opportunities for exploration, creativity, and social interaction, these activities lay a strong foundation for lifelong learning and development.

2.4.3 Visualization

Visualization in kindergarten plays a critical role in enhancing young learners' comprehension, memory, and creative thinking. This teaching strategy, rooted in the use of visual aids and activities, helps children to better understand abstract concepts, develop spatial awareness, and engage in imaginative exploration. Visual aids such as charts, diagrams, and pictorial representations can significantly aid in comprehension and memory retention for young learners. According to Dual Coding Theory, proposed by Allan Paivio (1971) combining verbal information with visual aids enhances learning and memory retention. In kindergarten, this might involve using story maps to enhance literacy skills or visual timelines to understand sequences of events. Moreover, visualization activities help develops spatial awareness and cognitive skills. Piaget’s theory of cognitive development emphasizes the importance of visual and spatial learning in the concrete operational stage, where children begin to think logically about objects and events (Piaget, 1970). Simple activities like puzzles, building blocks, and sorting games in kindergarten foster this aspect of cognitive development. Incorporating visual arts in kindergarten, such as drawing, painting, and crafting, stimulates creativity and imagination. Vygotsky’s work on the importance of imagination in childhood development highlights how creative activities can enhance cognitive and social development (Vygotsky, 2004). These activities encourage children to express themselves and explore their imaginative capacities.

Visualization can also be a powerful tool for emotional expression and understanding. Art therapy principles suggest that engaging in visual and artistic expression can help children process emotions and communicate feelings they might not yet have the words for (Malchiodi, 1998). This can be particularly effective in kindergarten, where emotional development is as crucial as academic learning. Visual elements in learning materials and environments can increase engagement and motivation among young learners. Mayer’s Cognitive Theory of Multimedia Learning asserts that well-designed visual and multimedia instructional materials can enhance learning by engaging sensory modalities effectively (Mayer, 2014). In kindergarten classrooms, this might involve interactive whiteboards, educational videos, and visually rich storybooks. In conclusion, the use of visualization in kindergarten is an essential component of early childhood education. It not only aids in the cognitive development of young learners but also plays a significant role in fostering creativity, emotional expression, and engagement in the learning process.

2.4.4 Gamification

The gamification strategy in kindergarten refers to the use of game design elements in non-game contexts to enhance learning and motivation among young children. This approach is increasingly popular in early education due to its effectiveness in engaging students, reinforcing learning, and developing various skills. Gamification makes learning more engaging and enjoyable for children. By incorporating game elements like points, badges, and leaderboards into educational activities, teachers can significantly increase student motivation and engagement. This aligns with the principles outlined by Ryan and Deci (2000) in their Self-Determination Theory, which emphasizes the role of intrinsic motivation in learning. Gamification in kindergarten often involves learning through play, which is a natural and effective way for young children to learn. According to Piaget's theory of cognitive development, play is essential for cognitive growth in early childhood (Piaget, 1962). Games provide a context for children to explore, experiment, and understand new concepts in an interactive and enjoyable way. Many educational games encourage social interaction, teamwork, and healthy competition.

Through gamified activities, children learn to communicate, collaborate, and follow rules, enhancing their social and emotional skills. Furthermore, gamification allows for personalized learning experiences. By using games that adapt to a child's skill level, educators can cater to individual learning needs, ensuring that each student finds the activities both challenging and achievable. This is in line with Tomlinson's work on differentiated instruction (Tomlinson, 2001). Gamification provides immediate feedback, which is crucial for learning. Immediate feedback from games helps children understand what they have mastered and what they need to work on, fostering a growth mindset as described by Dweck (2006). In conclusion, gamification in kindergarten represents a powerful educational approach that leverages the natural inclination of children towards play and games. It provides an engaging, interactive, and personalized learning experience that supports cognitive, social, and emotional development in young learners.

2.4.5 Technology Integration

In today's digital age, Kindergarten teachers incorporate technology into the curriculum (Haugland, 2012). They use educational apps and interactive whiteboards to make learning more engaging and interactive. These tools can help introduce young learners to basic concepts in literacy and numeracy in a fun and engaging way. Haugland's research emphasizes the importance of age-appropriate software in enhancing learning (Haugland, 2012). The use of digital storybooks, educational videos, and online games can significantly enrich the learning experience, making complex concepts more accessible and understandable to young minds. The productive use of technological tools as active learning strategies can develop a vibrant learning community. Technology aids educators in preparing and improving lesson plans, offering a wealth of resources for curriculum development and instructional strategies. Integrating technology in the classroom is crucial for preparing students with the skills needed in the 21st century, such as digital literacy, critical thinking, and problem-solving. This preparation is in line with the skills framework proposed by Trilling and Fadel in their work on 21st-century skills (Trilling & Fadel, 2009). The use of PowerPoint presentations, videos, virtual classrooms, robots, and augmented reality (AR) not only adds liveliness to the classroom but also enhances engagement and learning. Research by Papert on constructivism in the digital age underscores the value of interactive and immersive learning experiences (Papert, 1993). Furthermore, these technologies can lead to more inclusive and effective learning environments. They cater to diverse learning styles and needs, improving inclusivity in the classroom.

The concept of Universal Design for Learning (UDL) supports this approach, advocating for multiple means of engagement, representation, and expression (Rose & Meyer, 2002). Technology in kindergarten classrooms can enhance collaboration among students and foster a sense of inquisitiveness. It allows educators to compile data on student performance, providing insights into individual learning progress and areas needing improvement (Lieberman & Bates, 2009). The recent shift to online learning due to global events has led schools to re-examine their teaching methods. The integration of technology proved indispensable during this transition, as highlighted by the global shift to online education (Greenhow & Chapman, 2020).

In conclusion, the integration of technology in kindergarten is a multifaceted strategy that enhances educational experiences, prepares students for future challenges, and creates a dynamic, inclusive, and effective learning environment. This approach is not just about using digital tools but about integrating these tools into the curriculum in a way that is pedagogically sound and beneficial for young learners.

2.4.6 Active learning

Active learning in kindergarten shifts the focus from traditional, teacher-centered instruction to student-centered, engaging, and interactive experiences. This approach is grounded in educational theories that emphasize the importance of active participation in the learning process, especially for young children in their formative years. Active learning strategies in kindergarten involve hands-on activities, collaborative projects, and interactive games. These approaches align with Piaget’s theory of cognitive development, which emphasizes the role of active engagement in learning for young children (Piaget, 1962). By actively engaging in learning experiences, children can explore concepts and ideas in a way that is meaningful and relevant to them.

Active learning fosters critical thinking and problem-solving skills. As noted by Vygotsky, social interaction is a crucial component of learning (Vygotsky, 1978). Group activities and discussions encourage children to think critically, solve problems collaboratively, and articulate their thoughts. Active learning enhances retention and understanding. According to the experiential learning theory by Kolb, learning is a process where knowledge is created through experiences (Kolb, 1984). Kindergarten students learn best when they can touch, manipulate, and experiment with objects and ideas. This approach promotes independence and autonomy among young learners. By giving children choices and the opportunity to lead their learning, educators foster a sense of responsibility and self-regulation.

Active learning also supports social and emotional development. Cooperative learning and group activities help children develop important social skills like sharing, taking turns, and empathizing with others. This aligns with Bandura’s theory, which posits that people learn from one another via observation, imitation, and modelling (Bandura, 1978). Active learning is adaptable to diverse learning styles, catering to the unique needs of each child. Gardner’s theory of Multiple Intelligences suggests that children have different kinds of intelligences and learning styles (Gardner, 2012). Active learning allows educators to provide various activities that cater to these different styles.

In conclusion, active learning in kindergarten represents a dynamic and effective educational approach that not only enhances cognitive development but also nurtures social and emotional growth. By engaging young learners in meaningful, interactive experiences, educators lay a strong foundation for lifelong learning and development.

2.5 Learning Stations as Kindergarten classroom setup

The typical setup in a Kindergarten classroom involves the use of learning stations. This pedagogical practice finds its roots in the historical evolution of Kindergarten, which was initially conceptualized as a space for fostering social integration and holistic development among young children, echoing the ideals put forth by Friedrich Froebel (Muelle, 2013). Drawing from this foundational philosophy, the incorporation of learning stations in Kindergarten classrooms aligns with the overarching goal of facilitating children's cooperative skills and teamwork (The National Association for the Education of Young Children, 1995). Within the context of learning stations, children are provided with opportunities to collaborate, take turns, and communicate effectively with their peers, thereby promoting social interaction and decision-making skills.

Despite the historical emphasis on play-based learning in Kindergarten, recent trends have witnessed a shift towards a more structured academic focus, often at the expense of free play and exploration (Barsness, 2017). In response to these shifts, the adoption of learning stations offers a balanced approach that integrates academic learning with hands-on exploration and play (Reyes, 2010). Through engaging in activities such as block manipulation or clay modeling, children not only develop foundational mathematical and fine motor skills but also exhibit higher levels of engagement and fewer behavioral challenges (Reyes, 2010). By incorporating learning stations into the curriculum, educators can create an environment that nurtures children's social imitation, self-expression, and structured play, in alignment with the core principles of Kindergarten education (Barsness, 2017).

A learning station typically operates as a temporary arrangement where students rotate through various activities, each designed to address specific educational objectives (Copple & Bredekamp, 2009). This approach, endorsed by the National Association for the Education of Young Children (NAEYC), underscores the importance of developmentally appropriate practices in early childhood education. Learning stations facilitate the segmentation of lessons into manageable segments, offering diverse perspectives and hands-on experiences that cater to different learning styles (Kagan, 1994). By promoting engagement, collaboration, and active learning, learning stations serve as a valuable tool for enhancing the educational experience of Kindergarten students within a supportive and inclusive learning environment.

2.5.1 Using Learning Stations for Teaching Foundational Academic Skills in Kindergarten

Learning stations serve as a valuable tool in nurturing children's literacy skills, offering an instrumental environment for engaging in meaningful literacy activities (Stegelin, 2005). Within the context of kindergarten education, teachers play a pivotal role in fostering literacy development by providing children with enriching activities, prominently through play-based approaches (Cavanaugh et al., 2017). Research indicates a strong correlation between pretend play opportunities and various literacy skills, including decoding, oral reading, fluency, comprehension, and writing conventions (Cavanaugh et al., 2017).

In a reading station, children are exposed to a plethora of books and encouraged to engage in pretend reading, thereby enhancing book handling skills and print awareness (Cavanaugh et al., 2017). Additionally, exposure to literacy props such as stuffed animals and puppets facilitates verbal expression and social interactions among children, further enriching their language development (Anderson et al., 2014). Songs, poems, and nursery rhymes further contribute to phonemic awareness and letter-sound recognition, fostering a holistic approach to literacy development (Cavanaugh et al., 2017). By integrating literacy-rich environments into play-based activities, educators promote oral language development and reinforce the notion that literacy is an integral part of daily life (Anderson et al., 2014).

The writing station provides children with opportunities to explore writing in various forms, accommodating diverse developmental stages and encouraging the use of developmental spelling (Anderson et al., 2014). Through authentic writing experiences, such as composing letters or creating lists, children not only refine their handwriting skills but also imbue writing with purpose and authenticity (Reyes, 2010; Anderson et al., 2014). Writing extends beyond the confines of the writing station, permeating other learning stations where children engage in imaginative play and authentic tasks (Bautista et al., 2019). This integration of writing across stations fosters creativity and empowers children to utilize writing as a tool for communication and self-expression.

Similarly, learning stations facilitate the exploration of mathematical concepts, providing children with hands-on experiences that enhance their understanding of foundational mathematical principles (Hansel, 2015). Manipulatives such as building blocks offer opportunities for children to explore shapes, measurement, geometry, and spatial relations, promoting problem-solving skills and spatial visualization (Hansel, 2015). Child-led explorations with blocks, supplemented by teacher-led discussions and reflections, deepen children's conceptual understanding and enrich their vocabulary (Pyle et al., 2017b).

In essence, learning stations offer a multifaceted approach to learning, allowing children to engage with diverse materials and experiences across various academic domains. Whether practicing literacy or math skills, the setup of learning stations provides students with opportunities for hands-on exploration and meaningful learning experiences, fostering a holistic approach to academic development through play-based activities.

The challenges that the implementation of learning stations in kindergarten has is that not everyone is in favor of this type of learning (Graue, 2009). Parents feel that their children will be left behind if they are playing at school (Hamand, 2019). Since playful learning is promoted through the activities designed in learning stations this is automatically a barrier. The value of play is not a priority anymore (Graue, 2009). However, this was how kindergarten students learned many years ago when kindergarten was their first formal learning experience. Kindergarten was to expose children to new experiences and to make them feel comfortable away from their homes (Graue, 2009). They were to learn how to be in a group, raise their hand, follow direction, and to listen to others.

Some teachers do not integrate many playful activities in the kindergarten classrooms (Lynch, 2015). Teachers could spend valuable time with their students teaching them academic skills instead of having them play since they are stressed out from the fact that there are too many important skills to teach and not enough time to teach everything. Since kindergarten is in the elementary school, many teachers feel that they are looked down upon because their students are playing and the others are sitting in desks (Lynch, 2015). Teachers felt that they needed to follow the direction of everyone else. Another reason teachers no longer use learning stations is all the materials it requires (Lynch, 2015). The space that is needed for all the play materials and manipulatives takes most of the room in the classroom, so kindergarten teachers had to get rid of them so they would have room for academic needs.

Principals and superintendents are another reason why many teachers feel they cannot have play-based learning stations in their classroom (Lynch, 2015). Administrators feel that they are missing important instructional time (Graue, 2009). According to Lynch (2015), policy factors influence what happens in the classroom. Teachers have been told that if they want to have play in the classroom they will need to have a purpose. Teachers feel pressure that they need to concentrate on state standards, the curriculum, and standardized tests that are mandatory so there is no time for play-based learning. During learning stations many teachers do not take advantage of the instructional opportunities they have with the children (Graue, 2009). Teachers often use this time to get ready for the next day, or just let the children play with no guidance or support (Hamand, 2019).

However, a number of recent studies across various educational levels and subjects have effectively utilized learning stations to enhance classroom setup and lesson delivery. Draayer (2021) highlighted the station rotation model's efficacy in blended learning environments, noting significant improvements in second graders' reading comprehension and technological proficiency over a four-month period. Similarly, Georgiou and Ioannou (2019) demonstrated the positive impact of technology-enhanced embodied learning in mathematics, facilitated by a structured learning experience design involving learning stations, on student engagement and achievement in thirteen primary classrooms. Further, Tsivitanidou et al. (2021) revealed how immersive Virtual Reality (VR) significantly influenced high school students' learning outcomes in a physics course, underscoring the importance of students' attitudes towards science and digital technologies in the learning process, with learning stations playing a pivotal role in the structured inquiry-based learning environment. This was echoed in a subsequent study by Georgiou et al. (2021), which evaluated immersive VR simulations' effect on understanding the Special Theory of Relativity among 109 high school students. Bulunuz and Jarrett (2010) investigated in-service teachers' comprehension of earth and space science concepts via hands-on learning stations, noting an initial low conceptual grasp but significant improvement post-intervention, alongside shifts in teaching preferences. Köseoğlu et al. (2009), assessed high school course content on wastewater purification developed through learning stations, emphasizing the method's effectiveness in engaging students and fostering knowledge retention, as evidenced by positive feedback from students.

2.5.2 Teachers Role in Learning Stations

The teacher’s role in a classroom setup in learning stations differs with a regular classroom. Teachers should set-up the learning stations, design the learning activities, interact with the children, and be an arbitrator when problems arise (Pattillo & Vaughan, 1992). Teachers are researchers, watching children how they play and how they can keep improving and making new learning stations (McDonald, 2018). The teacher must have an environment set up so that it is child-centered with engaging activities for children to participate in. According to Pattillo and Vaughan, (1992) each station needs to be self-learning since learning stations promote independence. Each station needs materials provided so children can work in small groups or independently.

The teacher visits each station for short periods of time to monitor the children’s’ work and support learning. While the child is playing the teacher is observing, guiding them, and planning how they can tie in the standards that need to be taught (McDonald, 2018). Pattillo & Vaughan (1992), discuss a variety of ways a teacher interacts with the children at a learning center. The teacher can observe the child and watch what they are doing. Teachers can also use nondirective statements while visiting a center. This is where the teacher will talk about what the child is doing but it does not need any response back from the child. Teachers will often use two different types of questions when working with children at a center. They will either ask open-ended or closed-ended questions. The teacher may also use directive statements to give directions to children at the center. The last way is physical intervention. This is where the teacher may have to model what is expected at the center such as how to play a game or how to work in a center. When children attend a learning station, problems often arise. The teacher’s role is to be an arbitrator where they assist children in handling conflicts (Pattillo & Vaughan, 1992). The teacher is not there to solve the problem but to encourage and guide them to find a resolution. Children need to be able to discuss their feelings and tell what is bothering them. This is one of the main reasons to have learning stations since it lets children have the responsibility and independence. It teaches them on how to get along with others.

Since accountability is very important the teacher must have some type of assessment to show what the children are learning (Pattillo & Vaughan, 1992). Most of the assessments are done informally by observation by using checklists with the learning standard kindergarten students are required to know (Pattillo & Vaughan, 1992; Blessing, 2019). The teacher can ask probing questions to see what each child knows to see what the child's skill level is (Pattillo & Vaughan, 1992). They can collect pieces of their work or take pictures of what they have created to put in a child's portfolio. Assessments are valuable pieces of information since it will determine what skills children know and what they still need to work on (Blessing, 2019). This also helps when planning for new station activities (Pattillo et al., 1992). Pattillo and Vaughan (1992) state, when a teacher plans for a learning station they first need to think about the goals and standards they want the children to achieve. Each activity in the station is focused on this goal and what is being taught in the classroom. Materials are put into the station for children to use so the station will be engaging. The activity must be something that children can do independently and many learning stations have anchor charts for students to follow (Pattillo & Vaughan, 1992).

2.6 Addressing challenges in implementing a Whole Child Approach in Kindergarten

Implementing a whole child approach in educational systems presents several challenges that need to be addressed to ensure its effectiveness and sustainability. These challenges include resource allocation, teacher training, paradigm shifts in teaching methodologies, and overcoming obstacles specific to Kindergarten settings.

One of the primary challenges is the allocation of adequate resources to support holistic child development. This includes access to comprehensive curriculum resources, and diverse and engaging learning materials. Limited access to resources hampers efforts to provide a well-rounded education that addresses all dimensions of child development. Another significant challenge is the need for comprehensive teacher training to equip educators with the knowledge and skills necessary to implement a whole child approach effectively. Teachers require training not only in academic content but also in strategies for fostering social, emotional, and physical development in students. However, many educators may lack the training and support needed to implement holistic teaching practices successfully.

Integrating a whole child approach requires paradigm shifts in teaching methodologies, moving away from traditional, academically-focused methods that emphasize academic subjects and standardized testing, prioritizing the acquisition of factual knowledge and cognitive skills, towards a more balanced educational model that equally values social, emotional, and physical development. To overcome these challenges and effectively support holistic child development, reliable solutions are needed. In this study, we aim to fill this gap by introducing a novel learning experience design grounded in specific pillars. In the next chapter, we will explore the two main pillars upon which we have built this new learning experience design to foster whole child development.

CHAPTER 3

Universal Design for Learning & Learning Trajectories for Whole-Child Development in Kindergarten

3.1 Introduction

The chapter thoroughly explores the two primary pillars guiding the forthcoming learning experience design: the Universal Design for Learning (UDL) framework and learning trajectories. The UDL framework serves as a dynamic blueprint for crafting inclusive learning environments tailored to the diverse needs of all students. Throughout this chapter, we will highlight the foundational principles of UDL, which encompass multiple means of engagement, representation, and action and expression. These principles are rooted in scientific understanding of human learning and affirm the belief that all students can achieve success with the right support.

Furthermore, the chapter explores the concept of learning trajectories, providing a structured roadmap for understanding and guiding students' academic development. They outline the progression of learning in specific subjects, including literacy, numeracy, social-emotional development, and motor skills. The chapter details the components of learning trajectories and their application in early childhood education. Learning trajectories are essential for laying a strong foundation for future academic success, identifying learning difficulties early, and providing personalized instruction aligned with students' developmental stages. Several tools, such as Edmentum Mapping, Achieve the Core, and Learning Trajectories by Clements and Samara, are presented as valuable resources for educators. These tools offer standards-aligned content, assessment resources, and guidance for designing age-appropriate activities to support students' academic growth.

Throughout the chapter it’s emphasized the importance of UDL and learning trajectories in promoting inclusive and equitable education. Their role is highlighted in fostering personalized learning experiences, supporting diverse learners, and nurturing the holistic development of every child.

3.2 The UDL Framework

The UDL framework is a set of principles and guidelines for designing and delivering instruction that supports diverse learners and developmentally appropriate practice (NAEYC, 2009) by providing multiple means of representation, expression, and engagement (Copple & Bredekamp, 2009; CAST, 2012; 2018). It is based on the belief that all students can learn and succeed when provided with appropriate supports and accommodations. The UDL framework supports the whole child development by ensuring that all students have access to learning opportunities that cater to their unique needs and preferences.

Emerging as a transformative approach in educational strategy, the UDL framework aims to optimize teaching and learning for all children based on scientific insights into how humans learn (CAST; 2018). Grounded in the principles of universal design in architecture and product development, UDL extends this inclusivity to education. It recognizes the different needs of learners and proposes flexible learning environments that can accommodate individual learning differences. At its core, UDL is built upon three primary principles that address the why, what, and how of learning (Figure 3).

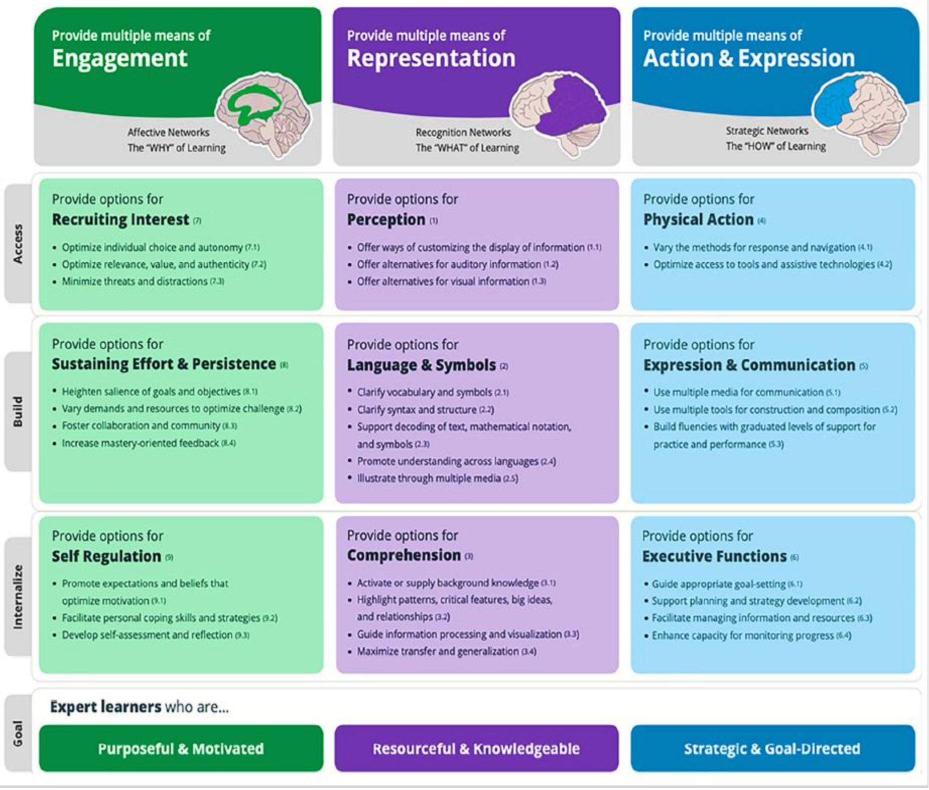

Figure 3. UDL Guidelines (CAST, 2018).

These principles are: (i) multiple means of engagement; (ii) multiple means of representation and; (iii) multiple means of action and expression (Table 1).

Table 1. The Principles of the UDL Network

UDL Principle	Network Description	Evidence-Based
Multiple means of representation	How students acquire curriculum content "the learning experience"	Glass, Meyer, & Rose, 2013; Rose & Strangman, 2007
Multiple means of expression	How students demonstrate knowledge of curriculum	Glass, Meyer, & Rose, 2013; Rose, Meyer & Hitchcock 2005; National Center on Universal Design for Learning, 2012
Multiple means of engagement	Student motivation and engagement with curriculum	Glass, Meyer, & Rose, 2013; Rose & Strangman, 2007

Implementing the UDL framework requires proactive curriculum design that considers potential barriers to learning from the outset. Educators are encouraged to integrate flexibility in the methods of instruction, materials used, and assessments to gauge learning outcomes. This foresight in planning allows for a more adaptable and responsive learning environment that can address the diverse needs of students without frequent modifications or accommodations. UDL includes the use of a variety of flexible curriculum and materials to help students achieve challenging goals.

The Every Student Succeeds Act (ESSA, 2015) defines and endorses UDL as a scientifically based approach to personalize learning, emphasizing flexibility and support for all students. UDL aims to cultivate expert learners by ensuring curriculum accessibility for all. With three principles, nine guidelines, and 31 checkpoints, UDL addresses the needs of all learners by focusing on accessibility, collaboration, and community building within learning environments. These guidelines foster the creation of engaging learning experiences that cater to individual learner needs. This approach is particularly important when designing activities for kindergarten students, as it ensures the inclusion of multiple modalities, active learning, and kinesthetic experiences that foster the whole child development.

3.2.1 Multiple Means of Engagement

As we consider the UDL principles, it is crucial to focus on the first word of each principle: multiple. We do not rely on a single strategy to engage children; instead, we employ a variety of methods to ensure that all children become engaged, excited, and motivated about being in the classroom and learning developmentally appropriate content (Lohmann, 2023).

Beginning with the principle of multiple means of engagement, it encompasses the ways teachers keep learners interested in classroom instruction and is underpinned by the belief that learners differ in how they become engaged and motivated to learn. This principle addresses key questions: How do we help children get excited about learning? How do we keep them excited? The principle of multiple means of engagement is supported by the affective brain network and answers the question, "Why should I learn?" (Glass et al., 2013). The affective network of the brain controls our emotions and how we process feelings and experiences (Kim et al., 2016). Research from the first two decades of the twenty-first century discusses how the UDL framework aligns with the functioning of our brains (Lohmann, 2023).

CAST (2022) argues that there is no single optimal means of engagement that suits every learner's preferred style of engagement; therefore, it is essential to provide multiple means of engagement to ensure that all individual needs for optimal engagement are met. This can be achieved, for example, by offering choices in learning contexts and tools (Lohmann, 2023). Offering choices is believed to promote student motivation, self-determination, independence, autonomy, pride, accomplishment, and can increase engagement (CAST, 2022). Incorporating interactive learning activities such as group discussions, hands-on experiments, multimedia presentations, and role-playing activities provides multiple avenues for students to engage with the material based on their preferred learning styles (Romprasert, 2023). Using game elements such as points, levels, and rewards in educational activities can motivate learners who are more engaged by competition and challenges (Alsawaier, 2018). Offering personalized learning paths tailored to individual student interests, abilities, and goals can enhance motivation and engagement by allowing learners to take ownership of their learning journey (Bray & McClaskey, 2014). This can be achieved by ensuring that activities and resources are appropriate and contextualized to learners' backgrounds. Moreover, children become engaged when potential threats and distractions in the learning environments are minimized (CAST, 2022). Providing a safe learning space for learners, it has been recommended that the level of novelty, sensory stimulation, social demands, support, and requirements for public display are discussed in whole class discussions and adjusted to meet the needs of each learner. Other strategies for increasing student engagement and persistence include heightening the salience of goals, varying demands to optimize challenge, fostering collaboration, providing mastery-oriented feedback, promoting high expectations, teaching self-regulation skills, facilitating personal coping skills, and developing self-reflection skills (CAST, 2022).

3.2.2 Multiple Means of Representation

Research on learning with representations has shown that when learners can interact with an appropriate representation, their performance is enhanced. Attention has been focused on learning with more than one representation, seemingly predicated on the notion that "two representations are better than one" (Ainsworth, 2006).

Imagine opening a page in a typical textbook and, in addition to text, finding photographs, diagrams, graphs, maps, pictures, concept maps, and a host of specialized graphical representations, such as evolutionary trees, timelines, cartograms, or electrical circuit diagrams. In the digital world, there are even more possibilities, with animations, videos, and simulations now commonplace, and augmented reality and haptic representations becoming increasingly available. They may be talking to peers, writing notes, drawing a sketch, uploading a video they have created, or summarizing their understanding in a mind map. Furthermore, learners can engage in kinesthetic experiences, where they physically manipulate objects or engage in hands-on activities to enhance their understanding. This may involve conducting experiments, building models, or participating in interactive simulations that allow them to physically interact with the content, reinforcing their comprehension through tactile feedback and bodily movement. With the integration of kinesthetic experiences, learners can deepen their understanding of abstract concepts and enhance their overall learning experience. This approach is supported by research on the benefits of movement in early childhood education (Gallahue & Donnelly, 2007). According to Ainsworth (2006), learners are not only consuming the representations provided to them but also creating new ones of their own.

The concept of multiple means of representation is underpinned by the belief that all individual learners perceive and comprehend incoming information presented to them differently. For example, some children may grasp information efficiently when it is presented visually, while others may prefer printed text (Meyer, Rose & Gordon, 2014). By being responsive to how information is presented to learners, educators ensure that all learners' needs are met. To reduce barriers to grasping information and learning, it is essential that educators ensure instructional content and information are perceptible to all learners. This can be achieved by: (i) providing the same information through different formats (e.g., visual, auditory, or kinesthetic); (ii) offering formats of information that can be adjusted by learners; (iii) clarifying vocabulary, symbols, structure, images, and syntax, (iv) illustrating information through multiple media (e.g., simulations, graphics, activities, and videos); (v) using scaffolding techniques to activate background knowledge, (vi) highlighting critical features and big ideas, (vii) Maximizing generalization of learning to new contexts.

3.2.3 Multiple Means of Action & Expression

The UDL principle of multiple means of action and expression emphasizes providing learners with various options for demonstrating their understanding and knowledge. This principle recognizes that students have diverse ways of expressing themselves and engaging with learning tasks. By offering multiple means of action and expression, educators can empower students to showcase their learning in ways that align with their strengths, preferences, and abilities.

Implementing multiple means of action and expression involves providing students with choices in how they demonstrate their understanding. This can include options such as written assignments, oral presentations, multimedia projects, artistic creations, role-playing activities, digital storytelling, and more. By offering a range of options for students to express themselves, educators can tap into individual strengths and talents, fostering creativity, engagement, and deeper learning experiences. Furthermore, the principle of multiple means of action and expression supports the development of essential skills such as communication, critical thinking, problem-solving, creativity, and self-regulation. By encouraging students to express themselves in diverse ways, educators promote a more inclusive and supportive learning environment where all learners can effectively demonstrate their knowledge and skills. Ultimately, embracing multiple means of action and expression enhances student agency, autonomy, and success in the learning process.

3.3 Mapping academic growth with Learning Trajectories

Learning trajectories in education represent a comprehensive framework for understanding and guiding students' academic development. They describe the progression of learning in specific subjects, outlining a sequence of concepts and skills that students typically follow as they become more proficient (Confrey et al., 2009a). Learning trajectories are crucial when teaching fundamental skills in Kindergarten as they provide a structured roadmap for educators to guide instruction and assess student progress effectively. By outlining the sequence of learning goals and milestones that students need to achieve, learning trajectories ensure that educators have a clear understanding of the developmental progression of fundamental skills in young learners. In Kindergarten, where students are at a critical stage of foundational skill development, learning trajectories help educators tailor instruction to meet the diverse needs of students. By following a well-defined trajectory, teachers can scaffold learning experiences, provide appropriate support, and monitor student growth in essential areas such as literacy, numeracy, social-emotional development, and motor skills. Moreover, learning trajectories in Kindergarten support the whole child approach by addressing various aspects of development comprehensively. They enable educators to create a holistic learning environment that nurtures not only academic skills but also social skills, emotional well-being, creativity, and physical development in young learners.

Learning trajectories have their roots in cognitive science and developmental psychology, with a significant contribution from researchers such as Jean Piaget and Lev Vygotsky, who laid the groundwork for understanding developmental stages in children. However, the formal concept of learning trajectories, particularly in mathematics education, was more prominently developed and articulated by researchers Douglas H. Clements and Julie Sarama. Their work in the early 2000s, especially in defining learning trajectories for early mathematics, played a pivotal role in shaping this approach (Clements & Sarama, 2004). Since then, research has explored learning trajectories across various domains, including early childhood mathematics, early algebra reasoning, geometric and spatial thinking, measurement, distribution, and statistical reasoning (Clements & Sarama, 2009; Blanton & Knuth, 2012; Battista, 2007; Barrett et al., 2012; Leavy & Middleton, 2011; Lehrer et al., in press; van Galen et al., 2008; van den Heuvel-Panhuizen & Buys, 2005; van den Heuvel-Panhuizen, 2008; Watson & Kelly, 2009).

The Learning trajectories typically consist of three components (Clements & Sarama, 2004; Maloney et al., 2014; Sarama & Clements, 2009):

- Learning Goals: The specific skills and understandings that students need to acquire.
- Developmental Progression: A sequence of steps or stages that students typically go through as they develop these skills and understandings.
- Instructional Tasks and Strategies: The activities and teaching methods that can effectively support students at each stage of the developmental progression.

Learning trajectories have been implemented across various grade levels, from early childhood education to higher education. In early grades, especially in kindergarten, learning trajectories focus on fundamental concepts like number sense, basic arithmetic, and early literacy skills. As students advance, these trajectories become more complex, incorporating advanced mathematical concepts, critical reading, and writing skills. An example of a learning trajectory in mathematics could be the progression from understanding basic number concepts to more complex arithmetic. Young children might start with counting and basic addition, and then move to subtraction and eventually to multiplication and division as they progress through elementary school. In language learning, a trajectory might begin with phonemic awareness in kindergarten, progress to basic reading and comprehension in early elementary grades, and then advance to more sophisticated literary analysis and writing skills in later grades. Learning trajectories are important in education for several reasons:

- Personalized Learning: They allow educators to understand where a student is in their learning process and provide personalized instruction that meets the student at their level.
- Informed Curriculum Development: Learning trajectories help in designing curriculum and instructional materials that are developmentally appropriate and aligned with how students learn.

- Effective Assessment: They provide a framework for assessing students' progress in a more nuanced and developmental manner.

In kindergarten, learning trajectories are particularly important because they help in laying a strong foundation for future academic success by ensuring that young children grasp essential early concepts. They enable early identification of learning difficulties and timely intervention, which is crucial at this developmental stage.

Summing up, learning trajectories are an important tool in education, providing a structured and developmentally informed approach to teaching and learning. Their application in kindergarten is especially critical, as it sets the stage for students' future academic journeys, ensuring that the foundational concepts and skills are well established.

3.3.1 Overview of Learning Trajectory Tools in Education

Several learning trajectory tools have surfaced to assist teachers and educators in delivering impactful instruction and assessments to students. The following examples illustrate a few of these valuable resources.

Edmentum Mapping for Math and ELA: Edmentum Mapping is an educational tool designed to support teachers in their instruction of both Mathematics (Math) and English Language Arts (ELA) in K-12 settings. It offers a comprehensive curriculum mapping framework that aligns with state and national standards (Figure 4). The tool provides educators with detailed learning progressions, standards-based content, and resources to create customized lesson plans and assessments. Teachers can use Edmentum Mapping to track student progress, differentiate instruction, and ensure that their teaching is aligned with the desired learning outcomes. It is a valuable resource for educators seeking to implement data-driven and standards-aligned instruction.

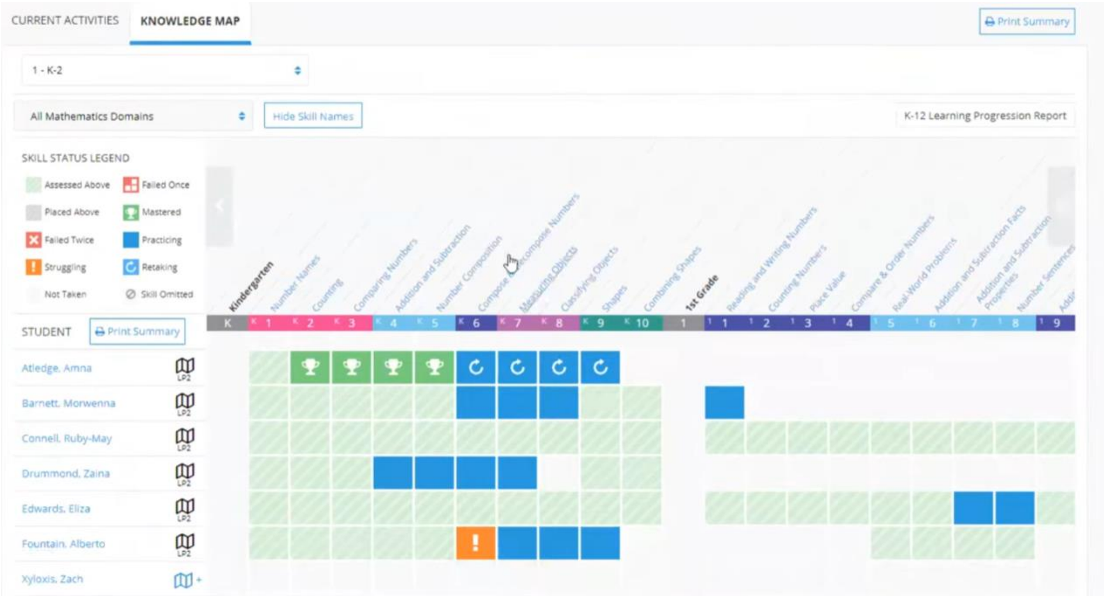

Figure 4. Sample of Edmentum Curriculum Mapping for Kindergarten Mathematics

Achieve the Core: Achieve the Core is a web-based platform that offers a wide range of free, high-quality resources for educators, particularly in the field of English Language Arts and Mathematics. The platform provides access to standards-aligned lesson plans, instructional materials, assessments, and professional development resources. What makes Achieve the Core particularly valuable is its focus on the Common Core State Standards (CCSS) in the United States. It helps teachers understand and implement these standards effectively in their classrooms. The platform's resources, including a coherence map (Figure 5) model lessons and student work samples, support educators in creating rigorous and coherent instruction that promotes student achievement and deeper understanding.

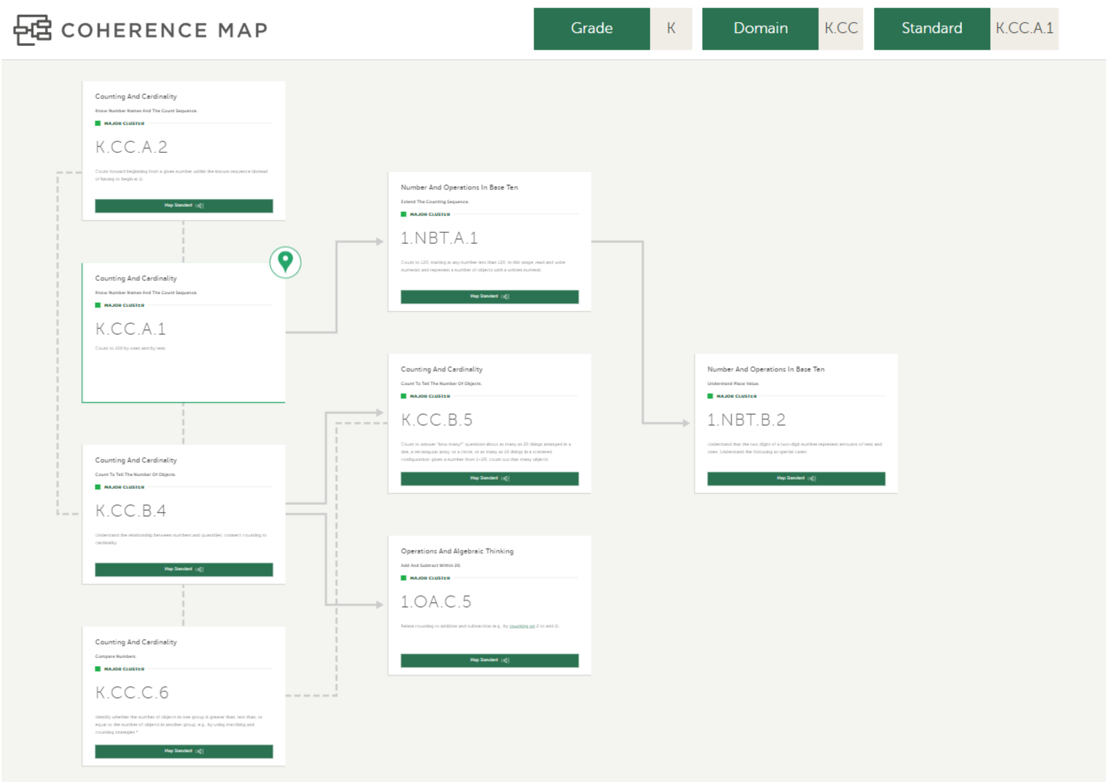

Figure 5. Example of Achieve the Core Coherence map for Kindergarten Counting Domain

Learning Trajectories by Clements and Samara (Clements & Sarama, 2009; 2014; 2017; 2020): Learning Trajectories, developed by Douglas Clements and Julie Sarama, are research-based tools that describe the developmental progression of mathematical understanding in young children. These trajectories offer a detailed sequence of learning milestones and competencies, allowing educators to assess and support children's mathematical development from early childhood through elementary grades (Figure 6). Clements and Sarama's work is influential in the field of early math education, and their learning trajectories provide a valuable framework for teachers to design age-appropriate activities and interventions that help children build a solid mathematical foundation.

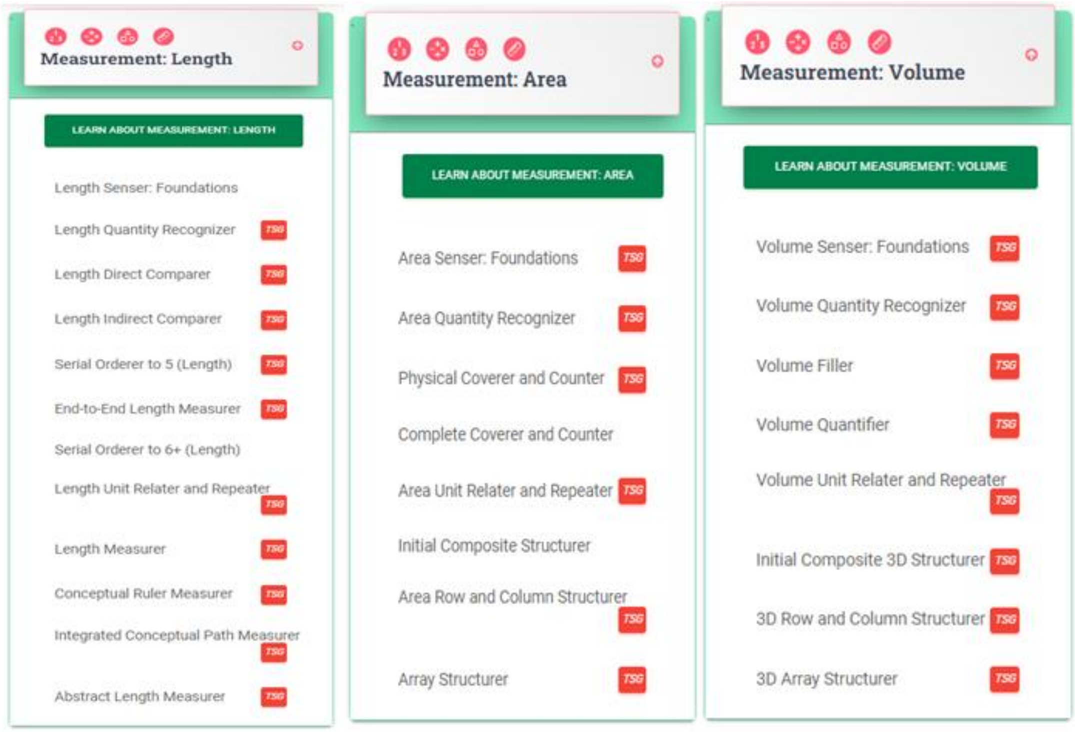

Figure 6. Example of Learning Trajectories by Clements and Samara for Measurement Domain Birth to Grade 3

These learning trajectory tools serve as valuable resources for educators, offering guidance, content, and strategies to enhance the teaching and learning experience in both Math and ELA. They empower teachers to align their instruction with standards, differentiate learning, and foster students' academic growth.

CHAPTER 4

A New Learning Experience Design Approach for the Whole Child Development in Kindergarten

4.1 Introduction

The challenge of implementing holistic approaches in curriculum delivery (Dunn, 1983; Moran, 1991; Kelly & Berthelsen, 1995; Tomlinson et al., 2003; Ohi, 2015; Yassin & Almasri, 2015; Fleming & Kearns, 2022) can be addressed through the integration of a learning experience design, ensuring successful implementation in real classroom settings (Guthrie, 2011). Seeking to fill this research gap, this thesis introduces a new learning experience design (LX) to help Kindergarten teachers organize existing curriculum elements into holistic and engaging learning experiences within learning stations, fostering both academic achievement and whole child development.

Emphasizing the importance of addressing various facets of child development; cognitive, social, emotional, and physical, the design encourages educators to create interactive and stimulating environments conducive to curiosity, exploration, and creativity. By incorporating hands-on activities, sensory experiences, and play-based learning, teachers can effectively engage children in ways that support their overall growth. To cater to diverse learning styles and preferences, the design advocates for multimodal instructional strategies, integrating visual, auditory, kinesthetic, and tactile elements into lessons and activities. Recognizing the significance of social-emotional learning, the design promotes activities that nurture positive relationships, emotional regulation, and empathy. Through collaborative projects, group discussions, and reflective exercises, educators can facilitate both academic and social-emotional development while fostering a sense of community in the classroom. The LX design also provides guidance on assessing children's progress across various developmental domains, utilizing informal observations, formative assessments, and authentic performance tasks. The technology integration into the learning experience design is also important to enhance instructional delivery and student engagement. Interactive multimedia resources and educational apps are used to provide interactive learning experiences.

In addition to outlining the principles and process of the LX design, this chapter explores the roles of teachers and students in the learning process. Teachers are positioned as facilitators, guiding students through multimodal experiences and providing support, while students actively engage with multiple modalities and collaborate with peers. Thereafter, we explore the features of various teaching platforms, ultimately identifying Kinems Learning Games as the most suitable platform for our LX design. With its focus on kinesthetic learning and dynamic educational experiences, Kinems aligns well with our goals for holistic child development.

4.2 The Learning Experience (LX) Design

Starting with the principles of the LX design presented in this study, firstly, it places a strong emphasis on addressing the cognitive, social, emotional, and physical aspects of child development. By integrating activities that target multiple domains, educators can ensure that children's growth is nurtured comprehensively. Drawing from research-based learning trajectories, the design outlines a structured roadmap for guiding students' academic development. By aligning instructional goals and activities with developmental progressions, educators can scaffold learning experiences effectively and support students in mastering essential skills and concepts. Recognizing the importance of movement in learning, the LX design prioritizes the integration of kinesthetic learning experiences. Meanwhile, learning stations are set up to engage students in interactive and tactile tasks that reinforce learning objectives and promote teamwork and collaboration. Through collaborative projects and peer interactions, students develop communication skills, teamwork abilities, and social-emotional competencies while working towards common learning goals. Following the principles of the UDL framework, the design incorporates multiple representations of content to accommodate diverse learner needs. Visual, auditory, and tactile modalities are utilized to present information in various formats, ensuring that all students can access and engage with the curriculum effectively. Technology integration into the LX design is important to enhance instructional delivery and student engagement. Interactive multimedia resources and educational apps are used to provide interactive learning experiences.

The new LX design comprises two distinct forms; the Design Form and the Enactment Form, which are subsequently presented (see figure 7).

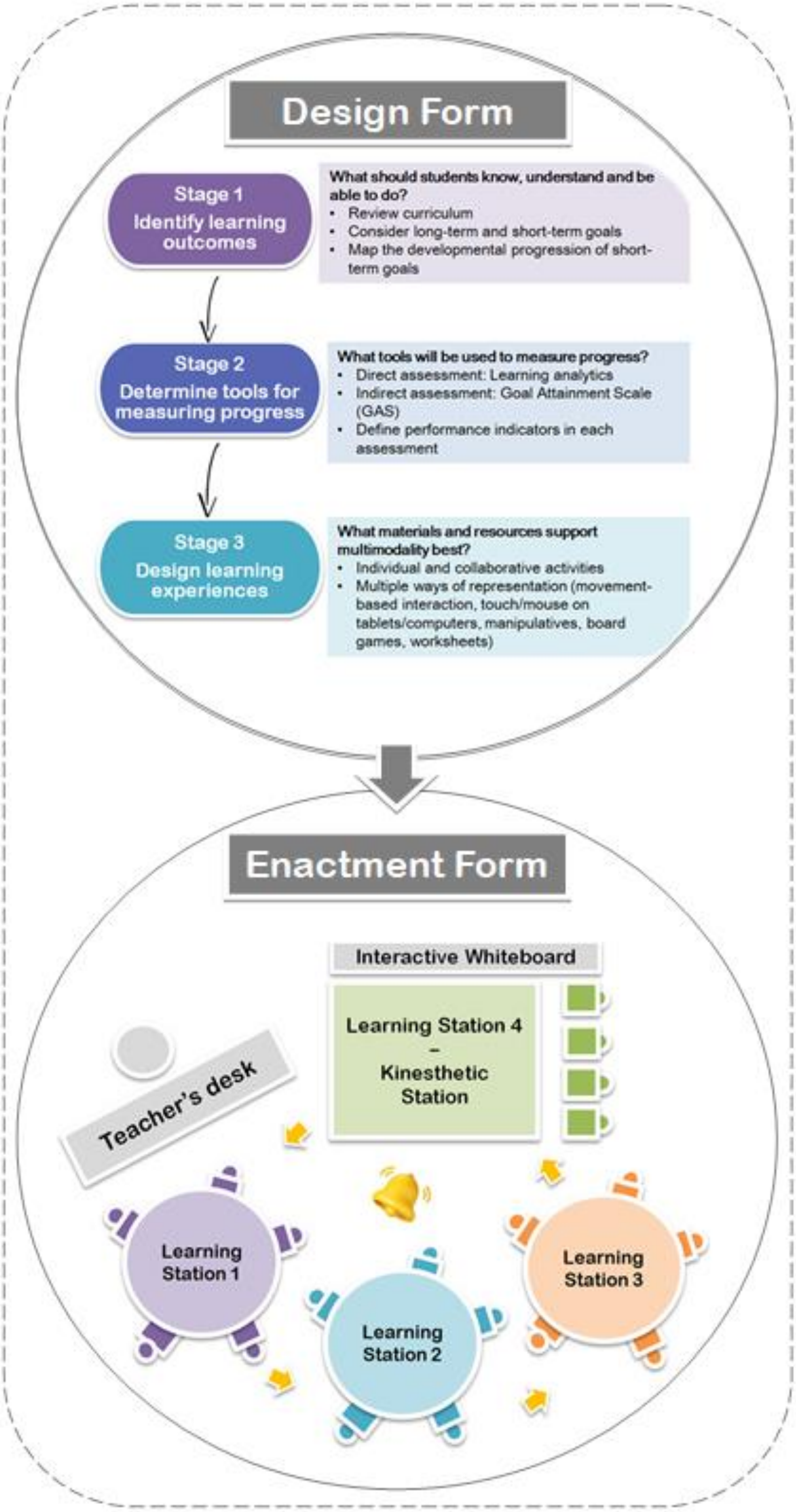

Figure 7. A New LX Design Approach

4.2.1Design Form

In this phase, we follow to the principles of backward design, as outlined by Wiggins and McTighe (2006). Initially, we conducted a comprehensive review of the Kindergarten language and mathematics curricula to identify learning outcomes, from which we considered both long-term and short-term goals in collaboration with teachers. Subsequently, we mapped the developmental progression of the short-term goals, sequencing them from simpler to more complex tasks a process which was based on the principles of learning trajectories (Clements & Samara, 2009; 2014; 2017; 2020). In the second stage, we determined tools to measure progress, including learning analytics for direct assessment and the Goal Attainment Scale (GAS) for indirect assessment (Kiresuk et al., 1994), defining specific performance indicators. For instance, for the Kindergarten math unit “Geometry”, our long-term goal was that "By the end of the school year, students should be able to recognize and name basic 2D and 3D shapes, understand shape properties, and effectively combine them to compose shapes". We then mapped the developmental progression of the short-term goals, organizing them sequentially from simpler to more complex tasks (Figure 8). This progression starts with objectives such as "Recognize and name basic 2D shapes (circle, square)" and advances to goals like "Identify shapes and their attributes in the environment". Subsequently, we defined specific performance indicators, including achieving mastery of over 80% in digital learning activities as measured by learning analytics and attaining a score of 0, +1, or +2 in goal achievement on the GAS assessment.

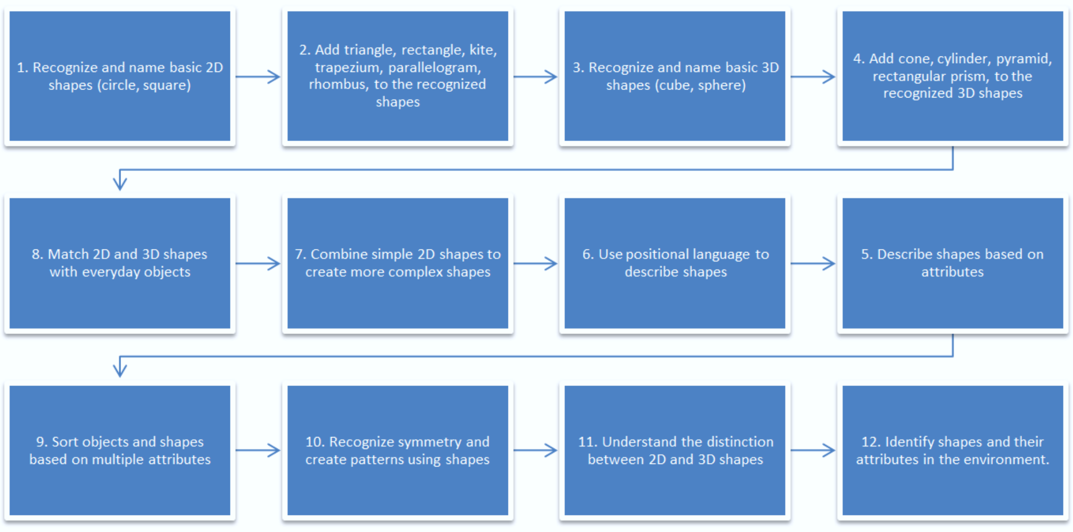

Figure 8. Exemplary progression for the Geometry Unit in Kindergarten

4.2.2 Enactment Form

The Enactment Form of the LX design encompasses the third stage, during which we designed the multimodal learning experiences in collaboration with teachers for orchestrating the classroom into learning stations. These experiences are meticulously designed to address short-term goals within a station rotation model. When designing the learning experiences for the stations, we prioritize two key characteristics. Firstly, stations should be designed to blend individual and collaborative activities, fostering both independent learning and peer interaction. Secondly, they should aim to promote multiple ways of representation and interaction. For example, one station could emphasize movement-based interaction or tablet/laptop-based personalized learning with touch or mouse interaction, or we could have two different stations to implement both modalities. Manipulatives are utilized in another station, board games in yet another, while traditional pencil and paper activities are provided in a fourth station. These multiple modalities cater to the varied learning preferences and needs of students, ultimately aiming to enhance motivation, engagement, and learning outcomes. For instance, for the seventh short-term goal presented in figure X, "Sort objects and shapes based on multiple attributes," the learning activity at each learning station could be as follows:

- Learning station 1 – "Attribute sort race": In this activity, students engage in a movement-based race to sort objects and shapes based on specific attributes, fostering teamwork and reinforcing sorting skills.
- Learning station 2 – "Sort the objects into the right color": This tablet activity involves a digital sorting game where students drag and drop objects into different colored boxes, promoting visual discrimination and critical thinking skills.
- Learning station 3 – "Shape safari adventure": This collaborative board game activity involves finding different shapes and objects along the way. Each player takes turns rolling a dice and moving their game piece on the board. When landing on a space, they draw a card with an object or shape depicted on it. Together, they discuss and decide how to categorize the object based on its attributes, such as shape, color, or size, advancing through the game by correctly sorting objects.

- Learning station 4 – "Object Sorting Challenge": Students are provided with a worksheet depicting a variety of objects alongside available shape categories. They are tasked with holding a colorful marker, drawing a line, and sorting the objects into the appropriate categories.

Our LX design aims to surpass the challenges in implementing the whole child development in Kindergarten by helping Kindergarten teachers. The goal is cultivate a rich and impactful learning environment that promotes motivation, engagement, and academic success for all students. Next, we'll discuss the teachers' roles and the digital tools that can support this LX design.

4.3 Roles of Teachers and Students in the learning process

The educational activities within the learning experience design aim to empower students as active learners, encouraging their engagement in multimodal learning experiences, either individually or in groups. When students are working with multiple modalities in learning stations, the teacher's role becomes that of a facilitator and guide. Teachers should:

- Create a Supportive Environment: Establish a conducive and safe atmosphere for students to explore and engage with various learning modalities.
- Facilitate Learning Experiences: Introduce and explain the activities at each learning center, ensuring that students understand the objectives and expectations.
- Provide Guidance: Offer guidance and support as needed, assisting students in navigating the different modalities and activities.
- Encourage Collaboration: Foster collaboration among students, especially in centers that involve group activities, promoting teamwork and shared learning experiences.
- Monitor Progress: Keep a watchful eye on students' progress, intervening when necessary, and providing timely feedback.
- Adapt to Individual Needs: Recognize and accommodate individual learning styles and needs, tailoring support to ensure each student's success.
- Promote Reflection: Encourage students to reflect on their experiences, both individually and as a group, fostering metacognitive skills.

- Manage Transitions: Facilitate smooth transitions between learning centers, ensuring that students utilize their time effectively at each modality.
- Use Assessment Tools: Employ tools to assess student understanding and progress, adapting teaching strategies based on assessment outcomes.

In essence, the teacher's role shifts from being the primary source of information to a facilitator who guides, supports, and empowers students to take an active role in their learning through multiple modalities.

When students are working with multiple modalities in learning stations, their role becomes more active and participatory. Students are expected to:

- Engage Actively: Actively participate in the learning activities provided at each center, making the most of the resources available.
- Explore Multiple Modalities: Explore and engage with various learning modalities, such as visual, auditory, kinesthetic, and tactile, to enhance their understanding.
- Collaborate with Peers: Collaborate and interact with peers, especially in centers that involve group activities, sharing ideas, and contributing to a collective learning experience.
- Take Initiative: Take the initiative to navigate through different activities and modalities, demonstrating independence in the learning process.
- Seek Clarification: Seek clarification from the teacher or peers if they encounter challenges or have questions about the activities.
- Manage Time Effectively: Manage their time effectively at each learning center, ensuring they have the opportunity to engage with all modalities and complete assigned tasks.
- Express Creativity: Express creativity and individuality in activities that allow for personal interpretation and expression.
- Demonstrate Responsibility: Demonstrate responsibility for their own learning, including caring for materials, respecting others' ideas, and contributing positively to the learning environment.
- Use Technology Effectively: If technology is involved, use it effectively and responsibly to enhance the learning experience.

In summary, students' roles shift from passive recipients of information to active participants, exploring, collaborating, and taking ownership of their learning experiences through the multiple modalities provided in learning centers.

4.4 Exploring Educational Platforms

In most of today's Kindergarten classrooms, educators have hardware tools like interactive whiteboards/panels, tablets, iPads, laptops, and desktop computers. Software tools, such as N2Y, Lexia, Teachtown, and the Kinems Learning Games Platform, can support the learning experience design and the effective integration of those hardware devices. Each of these platforms offers distinct features and capabilities designed to support educators and enrich student learning experiences.

4.4.1 N2Y Unique Learning System

N2Y is a teaching platform which offers customizable lesson plans and materials, making it easier for teachers to cater to various learning styles and abilities for their students pre-kindergarten through twelfth grade. The platform is also equipped with assessment tools that help track student progress, adapting instruction as needed (Figure 9).

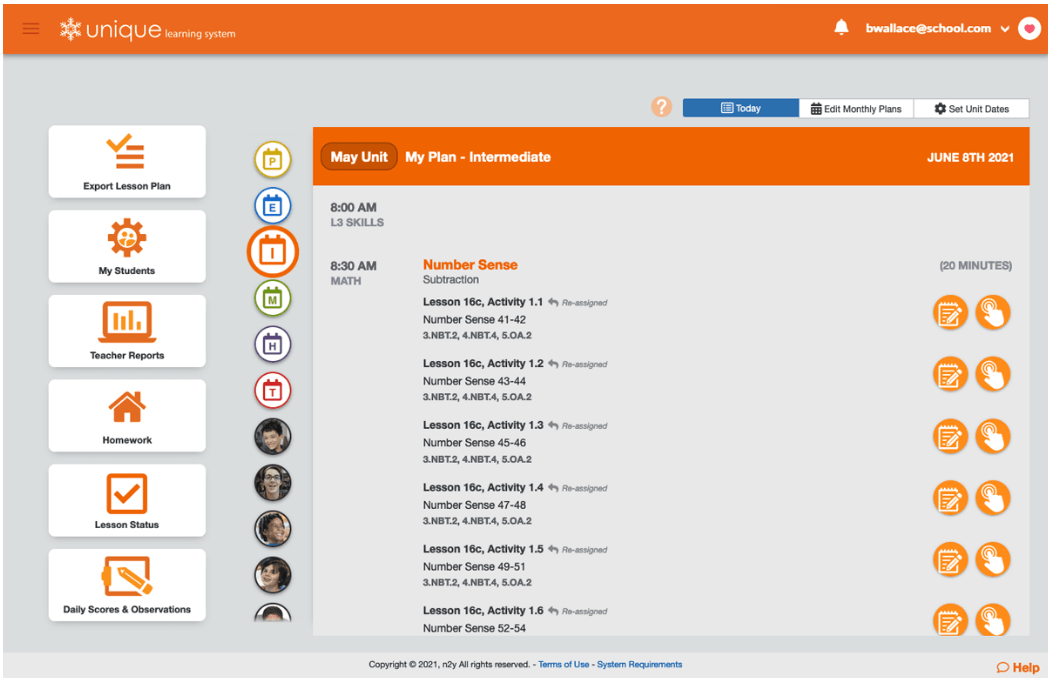

Figure 9. N2Y teacher's dashboard

For students, N2Y brings engaging and interactive content that simplifies learning, providing visual and auditory support to aid comprehension and retention through textbooks, software, relevant reading materials, videos, and recordings (see Figure 10). This focus on differentiated instruction ensures that each student's individual needs are met, making learning accessible and enjoyable.

Figure 10. N2Y students' learning resources

4.4.3 Lexia

Lexia is a targeted solution for literacy improvement across all age groups. It provides teachers with real-time data and reports, highlighting students' reading strengths and weaknesses. The platform enables educators to tailor lesson plans and activities to specific literacy skills, backed by professional development modules that guide effective literacy instruction (Figure 11).

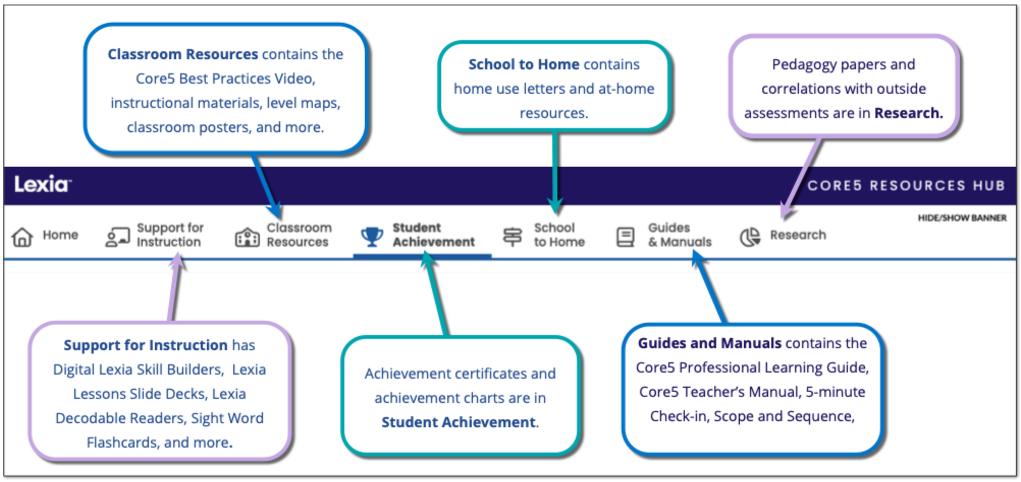

Figure 11. Lexia teacher's dashboard

For students, Lexia provides personalized learning paths, allowing them to progress at their own pace with interactive activities that make reading and language learning more engaging. This comprehensive approach supports a range of learners, from early readers to those who struggle with literacy skills (Figure 12).

Figure 12. Lexia students' dashboard

4.4.4 TeachTown Basics

Teachtown is specifically designed for children with autism and other developmental disabilities. It offers a specialized curriculum that aligns well with Individualized Education Plans (IEPs), providing educators with data-driven insights to monitor student progress (Figure 13). The blend of computer-delivered and teacher-led activities within Teachtown engages students with age-appropriate content, focusing on social skills, communication, and behavioral strategies. This specialized attention ensures that students with developmental disabilities receive the most effective and personalized educational experience.

Figure 13. Teachtown teacher's dashboard

4.4.5 Kinems Learning Games

The Kinems learning games platform supports learning in grades PreK-5. It introduces a unique aspect of kinesthetic learning by integrating movement-based learning into educational activities, encouraging physical activity in lessons. It provides a well-organized curriculum planner from which teachers can select preferred activities that are fully aligned to learning goals (Figure 14).

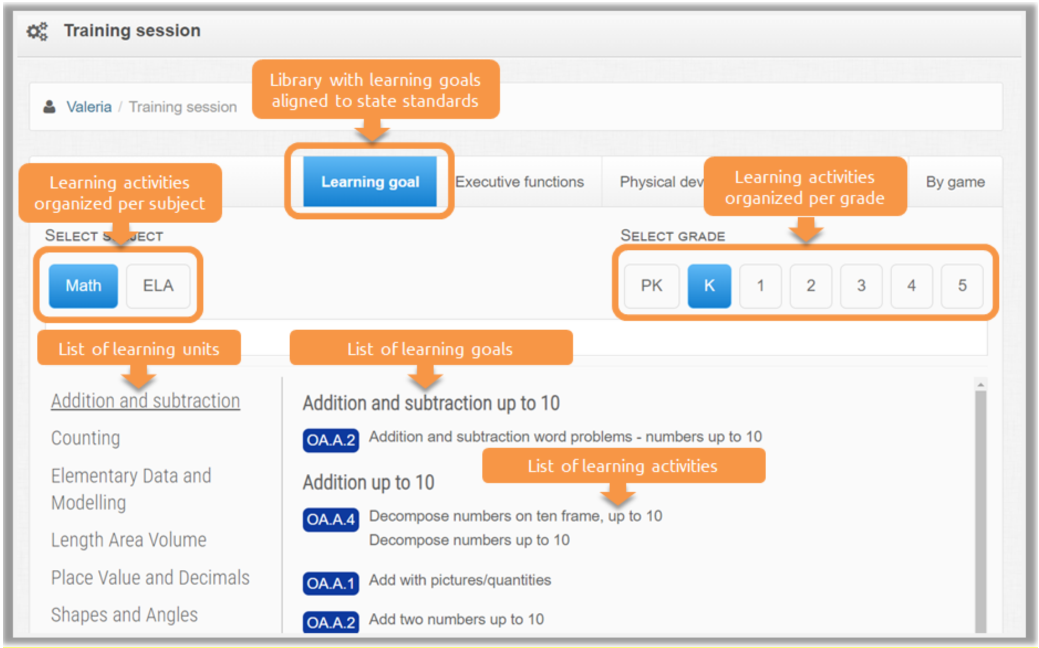

Figure 14. Kinems teacher's dashboard

The platform's 37 customizable learning games support over 450 learning activities for Mathematics and Language, and its learning and kinetic progress monitoring mechanism is designed specifically for PreK-5 children assessment. The game-based activities are offered in four different modalities, promoting multimodal learning:

1) Kinesthetic/Movement-based learning games for a “movement” learning experience.
2) PC/tablet-based personalized learning for a “technology” learning station refining fine motor skills.
3) Printable worksheets for a “pencil & paper” learning station
4) Cut-and-glue card games for a collaborative learning station

In the digital games, teachers can modify game settings, such as duration, level of difficulty, number of words, and category of words, and save sessions for classroom use. Figure 15 demonstrates an example of the Kinems multiple modalities for the learning activity *"Sort the objects into the right color*".

Figure 15. Kinems multiple modalities

The platform's multimodality enables teachers to structure their classrooms into learning stations in accordance with the principles of Universal Design for Learning (UDL) as shown in Table 2.

Table 2. Kinems platform connections to the UDL principles

UDL Guideline	UDL Checkpoints	Connection
Principle I. Provide Multiple Means of Representation	Maximize transfer and generalization	Kinems supports students in mastering academic concepts through a range of activities, including both high-end technology and printable resources, to ensure skill generalization.
Principle II. Provide Multiple Means of Action & Expression	Provide options for physical action	The motion-based activities provided by Kinems support the practice of academic concepts by students.
Principle III. Provide multiple means of Engagement	Foster collaboration and communication	Kinems facilitates the development and implementation of collaborative activities in the classroom.
	Vary demands and resources to optimize challenge	Teachers can differentiate the difficulty or complexity of core activities based on individual student needs.
	Optimize individual choice and autonomy	Kinems provides learners with choices to determine the level of challenge perceived in completing activities.
	Heighten salience of goals and objectives	Learning goals are presented in multiple modalities and formats through the Kinems platform.

4.4.6 Selecting the teaching platform to support the learning experience design

In examining the teaching platforms, it's evident that while they share common goals and features, each offers unique strengths that cater to specific educational needs. Similarities among these platforms include a dedication to personalized learning experiences tailored to individual student needs, supported by comprehensive data and insights for teachers to monitor progress and adapt instruction. Additionally, they all prioritize differentiated instruction, aiming to engage students through interactive and visually stimulating content, while also providing professional development resources for educators.

However, it's the differences among these platforms that truly highlight their distinct advantages. N2Y stands out with its focus on customizable lesson plans spanning from pre-kindergarten to twelfth grade, while Lexia specializes in literacy improvement across all age groups. TeachTown offers a tailored curriculum for children with autism and developmental disabilities, aligning closely with Individualized Education Plans (IEPs). It's Kinems Learning Games that uniquely integrates kinesthetic learning into educational activities, promoting movement-based learning experiences for students in grades PreK-5. This emphasis on physical engagement sets Kinems apart, offering a dynamic approach to learning that aligns closely with our learning experience design's goal of holistic child development.

In conclusion, considering the emphasis on kinesthetic learning and the promotion of multimodal experiences, the most suitable platform for the implementation of our learning experience design in the case studies, is the Kinems Learning Games platform. Its innovative approach aligns perfectly with our objectives, promising a rich and engaging educational journey for our students.

4.5 Prerequisites for the Implementation of the New LX Design Approach

In this section we will explore some key aspects and prerequisites crucial for educators aiming to implement the proposed LX design effectively. Following a detailed presentation of the LX design itself, alongside an exploration of teachers' roles and the digital tools/platforms that could facilitate its implementation, we will now turn our attention to essential considerations for educators venturing into LX design implementation.

To kickstart the LX design implementation process, educators should engage in brief yet comprehensive professional development sessions tailored to equip them with the necessary knowledge and skills. Furthermore, the successful implementation of the LX design depends on the availability of digital platforms that offer comprehensive resources to support multimodal learning experiences. These platforms should seamlessly integrate various modalities, including kinesthetic learning, to ensure active engagement and whole child development within the classroom setting. In instances where educators do not have access to such platforms, they must proactively seek out alternative resources that support multimodality.

When evaluating potential digital platforms, educators must prioritize those that prioritize kinesthetic learning and offer a wealth of academic resources designed to facilitate body-brain interaction. Failure to do so may prevent the successful execution of the LX design, as it heavily relies on the integration of kinesthetic learning as an integral part of in classroom instruction to ensure meaningful engagement and interaction between the body and brain.

Importantly, the LX design is not constrained by specific educational contexts and can be adapted for use with both special education and general education students. Its versatility allows for implementation across various settings, catering to the diverse needs and learning styles of students.

Building upon these prerequisites, the LX design was systematically applied through three (3) case studies, the detailed results of which will be presented in the subsequent chapter. These case studies provide valuable insights into the practical implementation and efficacy of the LX design authentic educational settings.

CHAPTER 5

Implementation and Evaluation of the LX Design – Case Studies

5.1 Introduction

This chapter provides a detailed exploration of the aim and methodology of the case studies conducted to evaluate the LX design. Through three empirical investigations, we wanted to comprehensively assess the impact and effectiveness of the LX design in authentic educational settings. The evaluations focused on various dimensions, including its influence on classroom behavior and student engagement, its effect on students' academic performance, and teachers' perceptions and acceptability towards the LX design.

The main research questions that guided our study, along with their corresponding sub-questions, to shed light on the practical implications and outcomes of integrating the LX Design into educational practices are presented. The evaluation framework utilized in the case studies, based on the triangulation strategy, will be discussed, highlighting the methodological approach adopted to ensure robust data collection and analysis.

A detailed overview of the evaluation tools employed for data collection is also included. Subsequently, each of the three case studies will be presented, providing valuable insights into the impact of the LX design on classroom dynamics, student performance, and teacher perspectives.

5.2 Aim of the case studies

In order to evaluate the LX design, three empirical investigations were conducted with the case study research tool, which was applied in authentic education settings. The aim of the implementations was to assess:

- The impact of the LX design in classroom behavior and student engagement; Learning Experiences,
- The effect on students' academic performance; Learning Effectiveness,
- Teachers' acceptability towards the development and implementation of the LX design; Acceptability.

The general evaluation framework of the LX design was based on the triangulation strategy and is presented in Figure 16, where the strategy and its objectives are shown.

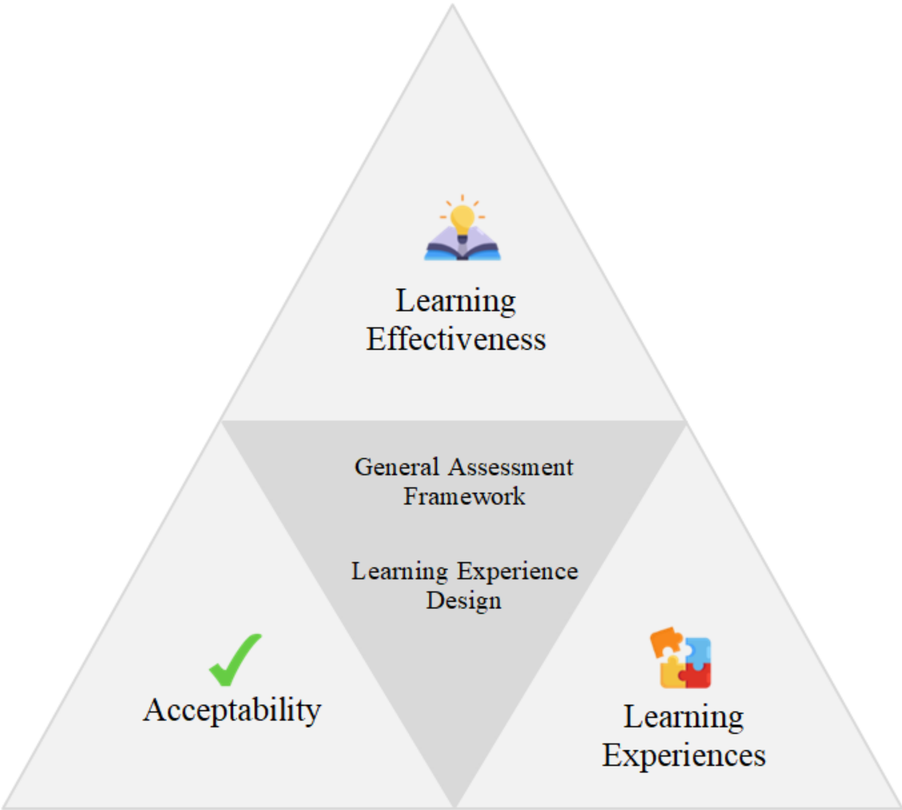

Figure 16. General Assessment Framework of the LX Design

A combination of qualitative and quantitative data collection, analysis and presentation methods was used, utilizing multiple sources of information which are presented in detail in the following section.

The term "triangulation" refers to the method of cross-verifying data from multiple sources to explore patterns in research data or explain a complex situation (O'Donoghue & Punch, 2003). By using multiple methods, such as the combination of quantitative and qualitative approaches, we have the possibility to answer different or complementary questions, or even to enhance their interpretability. Out of the four main types of triangulation in the present study, the following ones were followed:

- Data triangulation - Collecting data at different times and from different sources,
- Methodological triangulation - Using multiple data collection methods.
    - Within method - use of different types of the same method.

- Between methods - using different methods in order to achieve convergent validity and to compensate for any weak points of each method when only one of them is used (Abdalla et al., 2018; Heale & Forbes, 2013).

5.3 Research questions

In this section, we will explore the research questions that drive our study, centered on a comprehensive exploration of the practical implications and outcomes of integrating the LX Design into educational practices to foster holistic child development. The evaluation process was guided by the following Research Question (RQ): What was the impact from the implementation of the LX design in authentic classroom settings? Three sub-questions along with their corresponding informative questions (IQ) were formulated, for the needs of this case study (see Figure 17):

RQ1. How does the implementation of the LX design impact classroom behavior and student engagement? RQ1 investigates the influence on the classroom behavior (I.Q.1.1), and it explores the impact in students' engagement (I.Q.1.2).

RQ2. What is the effect of integrating the LX design on students' academic performance? RQ2 investigates the influence of the LX design on students' performance in academic and cognitive skills (I.Q.1.1), as well as the impact in students' proficiency in academic skills, important for school progress (I.Q.1.2).

RQ3. What are the attitudes and perceptions of Kindergarten teachers towards the development and implementation of the LX design?

RQ3 seeks to gather valuable insights on teachers' perspectives concerning the LX design (I.Q.3.1), the implementation of the multimodal learning activities (I.Q.3.2), and the integration of the movement-based learning activities in their classrooms (I.Q.3.3).

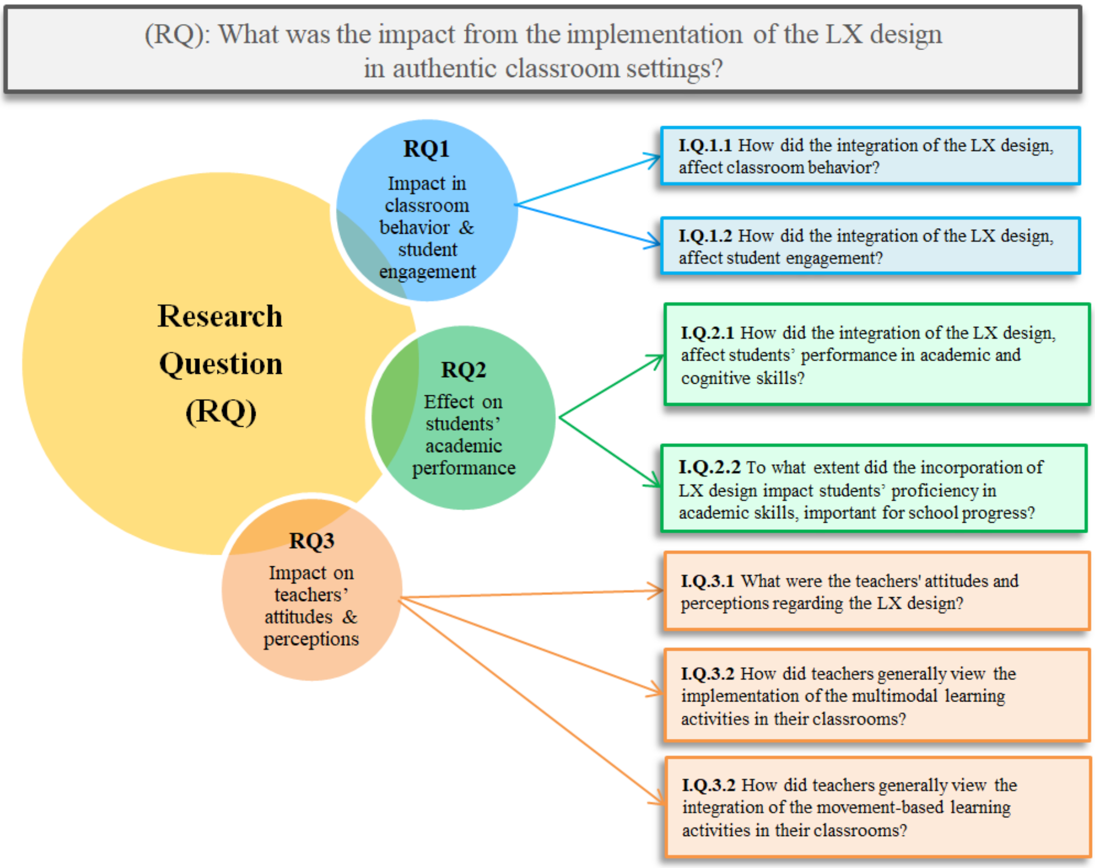

Figure 17. The Research Question with the three sub-questions (circles) and informative questions (rectangles) of the Case Studies

5.4 Evaluation tools for data collection

A variety of evaluation tools were used in the case studies to assess the effectiveness of the LX design implementation in authentic classroom settings (Figure 18):

- **Classroom Behavior Checklists:** A five-point checklist, inspired by the Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1991), assessed classroom behavior in various domains. It rated aspects like participation, cooperation, instruction sequence, and rotation between stations, attention to tasks, and project completion. Teachers used this tool after interventions.
- **Goal Attainment Scale (GAS) template:** We utilized a carefully crafted spreadsheet based on the Goal Attainment Scale (GAS) (Kiresuk et al., 1994) for consistent and reliable assessment of academic performance. Teachers used the 5-point rating scale, yielding standardized insights into students' achievements, enhancing the credibility of our study's conclusions.

- **Social validity survey**: It was developed by researchers based on social validity surveys used in applied behavior analysis and education (Carter & Wheeler, 2019), incorporating statements and a scale ranging from "Strongly Disagree" to "Strongly Agree”. It also included an open question so that teachers could provide comments regarding the strong and weak points of the enactment. The main focus was to assess teachers' attitudes toward the implementation of the LX in everyday educational practice, their perception of the time and effort invested, and the ease of implementation. Additionally, it aimed to evaluate teachers' beliefs regarding the effectiveness of the LX design for student learning, their overall satisfaction, and their understanding of the implementation procedures. It was carried out at the end of the school year by the researchers.

  Teaching journal: Keeping a teaching journal is a way for educators to monitor, assess, and improve student development (Maloney & Campbell-Evans, 2002). Typically kept in either a notebook or electronic format (Hiemstra, 2001), in this study we developed an electronic teaching journal, enabling teachers to record personal notes and comments after each session. The electronic teaching journal created also included a 5-point scale ranging from 1 (very poor) to 5 (very good). It was strategically chosen to capture teachers’ perceptions regarding the effectiveness of the classroom orchestration based on the LX design.
- **Learning & Kinesthetic analytics:** The Kinems platform offers a dynamic assessment that records each student's learning performance in tables, graphs, and reports, which are saved in a cloud-based system. This tool was validated through previous studies (Kourakli et al., 2017; Kosmas et al., 2018), demonstrating its effectiveness and appropriateness for assessing the learning progress of young children.

  Summative math test: It was carefully developed in collaboration with the experienced school principal in mathematics education, who also executed the test with the students, ensuring its face validity. The assessment tasks covered the mathematical concepts of counting and cardinality, shapes, measurable attributes, addition, subtraction, and place value. Students engage in hands-on activities such as counting objects, identifying and sorting shapes, measuring lengths, solving addition and subtraction problems with objects, and understanding place value using base-ten blocks and were assessed by utilizing a 4-point scale ranging from 1 (poor) to 4 (excellent).

- **Pre- and post-tests**: They were carefully developed in collaboration with the experienced school principal in mathematics education, who also executed the tests with the students, ensuring its face validity. The assessment tasks covered key mathematical skills for school readiness, including calculus, geometry, and simple math problems. Students were evaluated through tasks such as counting objects, identifying shapes, and solving basic addition and subtraction problems using manipulatives, by utilizing a scale ranging from 1 to 4, with 1 representing the lowest mastery level and 4 the highest. The statistical analysis involved the investigation of the differences between pre- and post-test scores on students' learning scores.
- **Parents' Written Reports:** As part of the action evaluation process in the third case study, parents were asked to provide written reports to the program coordinators to assess the overall effectiveness of the LX design.

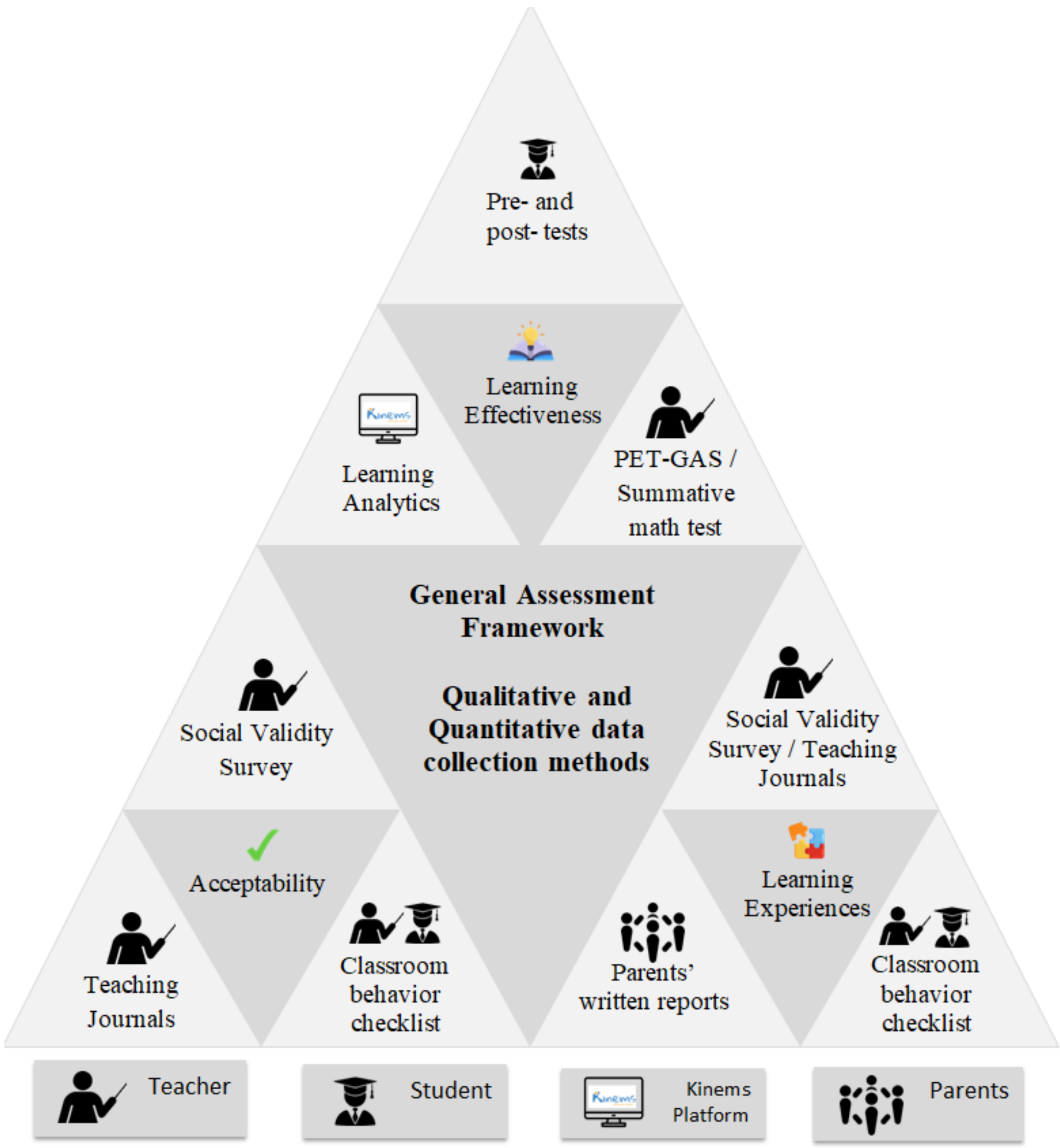

Figure 18. Evaluation Framework for Case Study I Application of the Proposed Approach

5.5 Evaluation process

In the evaluation process, three case studies were conducted and are presented as follows: two case studies were conducted in authentic general education Kindergarten settings. The third case study aimed to assess whether the LX design could also support remote instruction with special education students, primarily at a Kindergarten academic level, who were not receiving any form of instruction during the Covid-19 pandemic.

Participating educators underwent 60-minute training on the use of the Kinems Learning Games platform. The Kinems Learning Games platform was selected as the educational platform for its unique features, including tailored academic activities for Kindergarten and support for classroom orchestration in learning stations. Notably, it is the sole platform supporting Kinesthetic learning, making it ideal for promoting multiple modalities of learning in early childhood education and fostering holistic development. Additionally, the Kinems platform facilitated remote instruction, a crucial asset for the third case study. In sections 5.5.1, 5.5.2, and 5.5.3, the three applications of the proposed LX design are detailed.

5.5.1 Case Study I

5.5.1.1 Context

This case study aimed to evaluate the outcomes resulting from the short-term implementation of the LX design approach for practicing mathematical concepts in Kindergarten (Table 3). It was conducted with the active involvement of two experienced kindergarten teachers and a total of 33 five-year-old students, consisting of 15 girls (45,5%) and 18 boys (54,5%). The interventions were carried out once a week for a period of 6 weeks and took place in two classrooms within a private kindergarten school setting. Each learning session had duration of approximately 60 to 90 minutes. The kindergarten teachers had dual responsibilities: first, teaching the core math concepts, and subsequently, designing and implementing the multimodal learning experiences.

Table 3. The comprehensive list of labeled math goals chosen for the case study

Math Goal	Description
MG1	Identify and match three-dimensional shapes with real objects
MG2	Identify and select two-dimensional shapes
MG3	Create complex shapes by selecting and matching simple shapes
MG4	Compare two groups of objects and select the most or few objects
MG5	Distinguish the most or fewest objects in groups of objects
MG6	Place numbers from 1 to 10 in order

Case study I encompassed three distinct phases:

Preparation phase: In this phase educators designed the learning activities for the four learning stations following the LX design by utilizing the Kinems educational resources. Additionally, they participated in a one-hour onsite training session focused on the utilization of the Kinems both digital and non-digital tools.

Implementation phase: In this phase, the educators implemented the six, 60 to 90 minutes sessions, orchestrating their classrooms into learning stations. To begin each session, the teachers presented the materials for each center to the entire class group. They then demonstrated the activities that the students would engage in at each station. Live feedback and advice were readily provided by the teachers to address any questions or concerns raised by the students. To ensure equitable participation and cooperation, the students were divided into four groups, with careful consideration given to periodically reshuffle the groups throughout the sessions. This approach allowed all students to collaborate with one another, contributing to a rich and dynamic learning environment. Throughout the implementation phase, the teachers closely monitored and facilitated the activities at each station, guiding the students and ensuring their engagement and progress. The emphasis on regular rotations and diverse group compositions fostered a sense of inclusivity and collective learning, which further enriched the multimodal learning experiences in the classroom. The rotation between centers was carefully managed by the teachers. After ensuring that the majority of students had completed the activities at the initial centers, they signaled the end of the time period and rang the bell again, prompting the students to move in a circle to the next workstation. In consideration of individual needs, any student requiring extra time to complete a center activity was encouraged to do so without interruption. The teaching intervention continued until all groups and students had experienced all four learning centers. This approach allowed for a comprehensive and dynamic learning experience for every student, ensuring a holistic understanding of the math concepts under exploration (Maxwell & White, 2017). For instance, when they addressed the mathematical concept in geometry, a range of activities was selected to provide a comprehensive learning experience. The first learning station featured the "Tika Bubble" Kinems game, where students were asked to match 3D shapes with real objects. The second station utilized the "Tika Bubble" Kinems Board game, integrating tangible materials for interactive learning. Kinems “Tika Bubble” worksheets were employed in the third station to reinforce concept comprehension. In the fourth station, students were matching tangible materials like toys and plastic shapes based on shape attributes (refer to Figure 19).

Figure 19. Snapshots of multimodal learning stations

Evaluation phase: During this phase, the overall assessment of the effectiveness of the proposed LX design was conducted using the evaluation tools. All data was collected and thoroughly analyzed. The ethics of the investigation was ensured through anonymity and coding for the protection of personal data. All students and teachers had voluntarily participated to this initiative.

5.5.1.2 Findings

RQ#1: Impact in classroom behavior and student engagement

To assess classroom behavior during the interventions for each math goal, teachers completed classroom behavior checklists at the end of each session. The data collected from these reports were analyzed and summarized in Figure 20. The Behavior Evaluation Criteria axis illustrated the six criteria: C1=active class participation, C2=cooperation in groups, C3=sequence of instructions, C4=smooth rotation between stations, C5=focused attention on cognitive tasks, and C6=completion of projects. Each criterion was rated on a 5-point scale: 1=very poor, 2=poor, 3=moderate, 4=good and 5=very good performance, as shown in the Performance Rating axis. The results depicted in Figure 8, indicate that the class's overall performance was very good across most math goals. Specifically, criteria (C) C1, C2, and C4 demonstrated consistently the highest performance in all math goals. In instances where we observed a slightly lower performance in certain math goals, this can be attributed to students' enthusiasm for extended gameplay with the educational games. To address this challenge related to effective time management, teachers proactively employed a solution by configuring a timer within the Kinems platform settings.

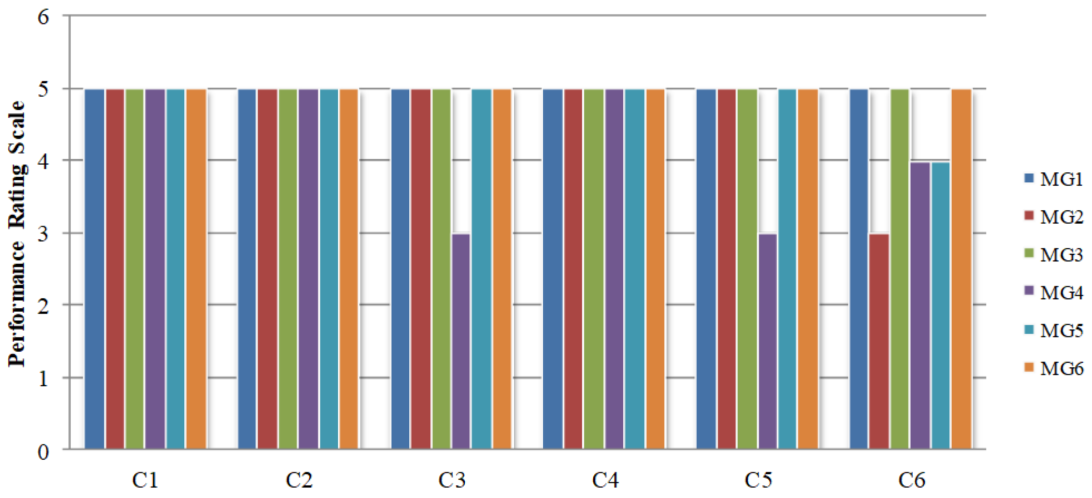

Figure 20. Classroom behavior per math goal

RQ#2: Effect on students' academic performance

Figure 20, provides a comprehensive summary of the GAS assessment, individually scored by the teachers, to evaluate the children's performance in each math goal (MG). The "Number of students" axis represents the total number of participants in the pilot activity, which amounted to 33 children (N=33). On the "Goal Attainment Scale (GAS)" axis, goal attainment levels are classified as follows: -2= much less than expected, -1= less than expected, 0= desired level, +1= more than expected and 2= much more than expected.

From the analysis in Figure 21, it is evident that there were no significantly lower or less than expected results observed in any of the six MGs. On the contrary, all students successfully reached the desired level of attainment for each goal. Furthermore, noteworthy achievements were observed in four specific learning objectives, where a total of twenty three (23) students demonstrated exceptional performance beyond the expected level. One student achieved a score of +1 in MG2, while an impressive six students were assessed with a +2 score. Moreover, in MG4, two students scored +1, and six students scored +2. In MG5, seven students were assessed with a +2 score, while in MG6, one students was assessed with a score of +1. The feedback provided by the teachers emphasized that the implementation of the Kinems educational gaming platform's multimodal learning experiences within learning stations resulted in greater motivation and engagement, particularly for the three students who typically faced challenges in maintaining focus during other activities, due to difficulty in articulation, mild attention deficit and attention deficit and hyperactivity. The incorporation of movement-based learning technology with the use of the Kinems platform not only increased motivation but also extended the duration of engagement, allowing even those with concentration difficulties to achieve the desired learning outcomes.

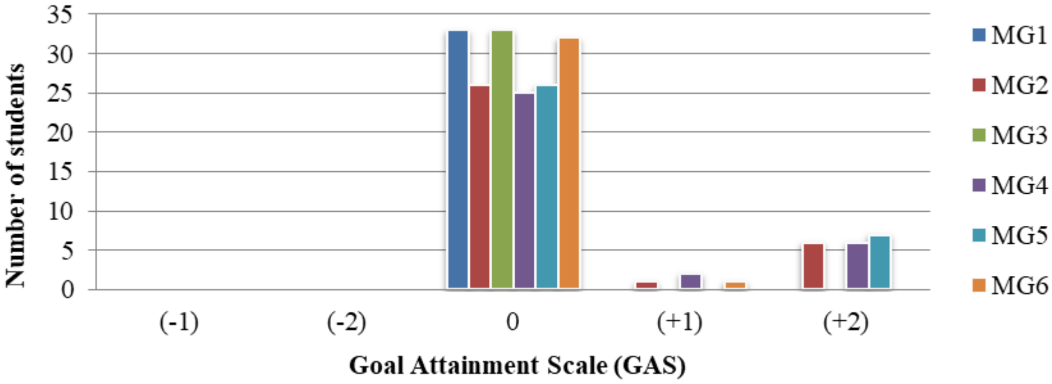

Figure 21. Students' academic performance based on GAS assessment

The obtained results are validated through data extracted from the Kinems platform. Table 4 comprehensively illustrates students' individual performances aligned with specific math goals. These insights are derived from the analysis of Kinems performance reports, recorded upon the conclusion of each activity, and are effectively captured through the lens of learning analytics. Across most Kinems activities, students achieved a high success rate of over 80%, providing more correct answers than incorrect ones. These data provide strong evidence of the students' heightened concentration, as indicated by the assessments in the classroom behavior report forms (see Figure 19). More significantly, the data demonstrate that the students not only successfully achieved the desired level of attainment but also surpassed it, as reflected in the teachers' gas assessment for each goal (refer to Figure 21).

Table 4. Students' academic performance in math goals

Math Goals	Total number of questions	Correct answers	Wrong answers	Success
MG1	104	103	1	99%
MG2	102	76	26	74,5 %
MG3	157	136	21	86,6%
MG4	145	144	1	99%
MG5	60	59	1	99%
MG6	132	114	18	86,4%
Total	700	632	68	90% (average)

Overall, the findings presented in Figure 22, demonstrate a remarkable achievement, with an impressive 90% of the answers provided by students being correct, while only 10% were found to be incorrect. This result serves as a testament to the students' high level of concentration and deep engagement with the embodied learning activities facilitated by the Kinems platform. The efficiency of the Kinems data management system allowed for the quick and easy collection of this valuable information, enabling the comprehensive assessment of students' performance. The substantial success rate achieved in the learning activities fully aligned with specific math goals, reinforces the effectiveness of the multimodal approach and emphasizes the platform's capacity to foster a conducive and interactive learning environment. These outcomes provide promising insights into the potential benefits of incorporating Kinems into educational settings, empowering educators to track and understand students' progress accurately and effectively.

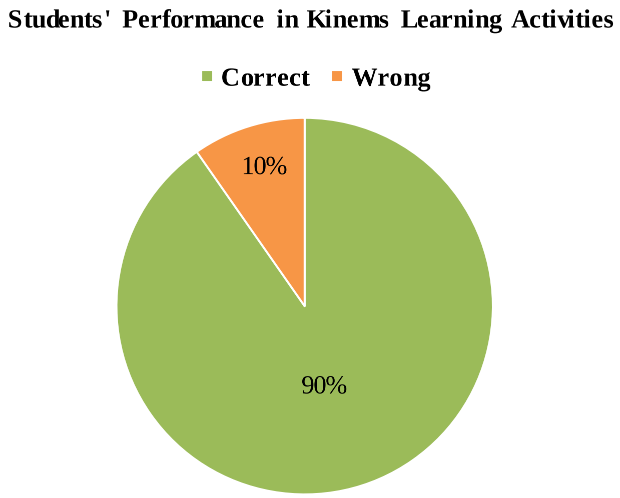

Figure 22. Students' correct and wrong answers in the movement-based learning activities

RQ#3: Teachers' attitudes and perceptions towards the development and implementation of the LX design

To investigate the third research question pertaining to teachers' perceptions towards the development and implementation of the LX design, we conducted an analysis based on a Social Validity questionnaire. The quantitative outcomes from this questionnaire are visually presented in Figure 23. The questionnaire encompassed a series of targeted questions, and the responses provided by the teachers are graphically depicted.

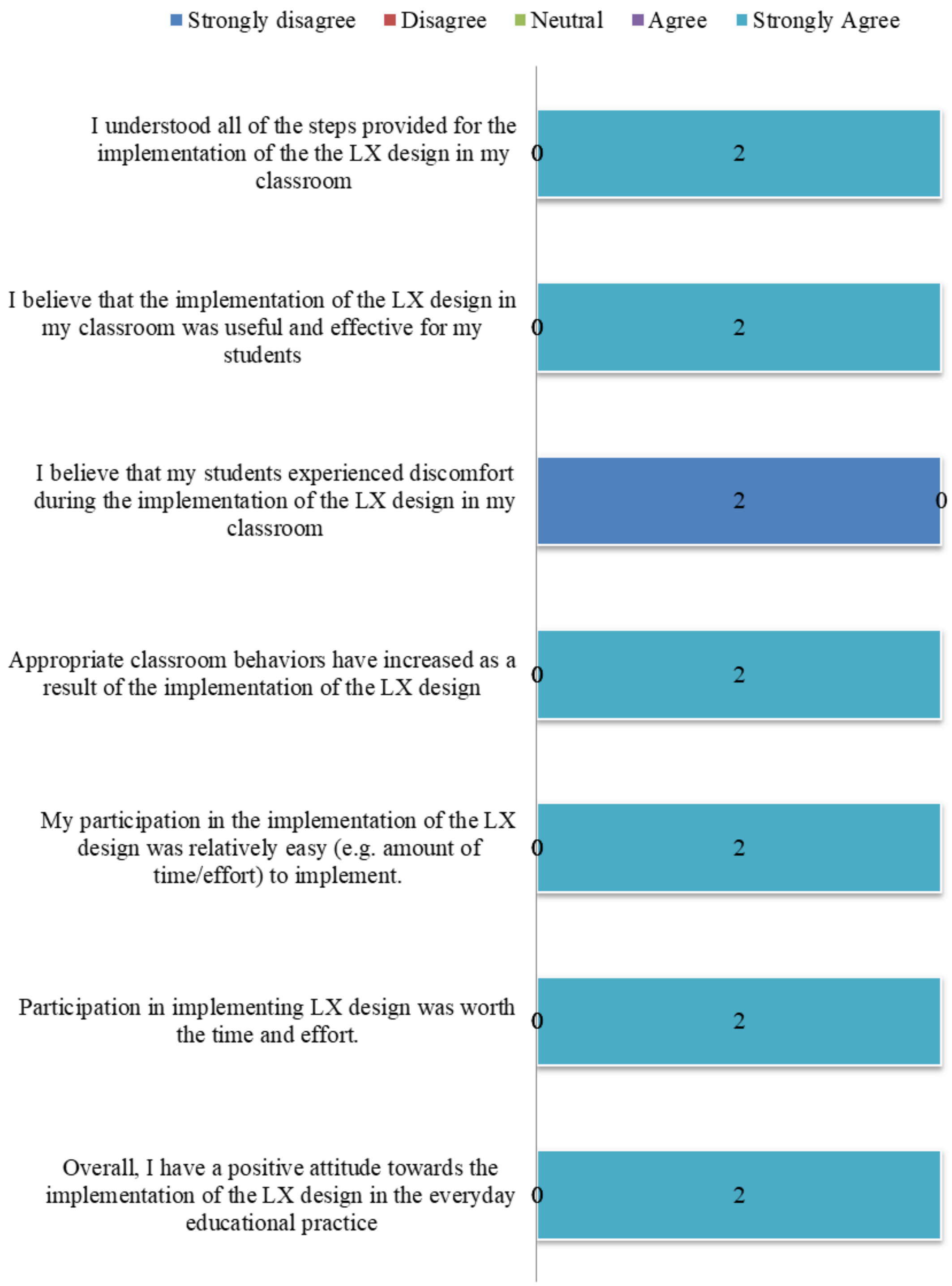

Figure 23. Social Validity Survey results

Overall, the teachers exhibited a positive attitude towards the incorporation of the LX design in their classrooms. They perceived the implementation as highly valuable in terms of time and effort invested, and found it relatively straightforward to put into practice. Furthermore, the teachers reported observing a notable improvement in students' appropriate classroom behaviors, and they firmly believed that their students did not experience any discomfort during the sessions. The teachers regarded the implementation as not only useful but also highly effective for their students' learning experiences, and they found the LX design instrumental in seamlessly integrating the multimodal learning stations with the utilization of the Kinems platform. These findings underscore the positive impact and successful integration of multimodal learning experiences within the classroom setting, showcasing the potential benefits of the movement-based learning experiences platform and their role in enhancing students' learning outcomes.

The positive findings mentioned above are further corroborated by the results presented in Figure 24, gathered from teaching journals immediately after each session. These records shed light on the high level of classroom orchestration achieved during the learning stations. Among the six sessions evaluated, an impressive four received a rating of "very good," with only two sessions deemed "good". Teachers' valuable feedback indicated that the presence of a group of students in the movement station could sometimes lead to disruptions in the classroom environment, as not all students were consistently quiet while supporting their classmates during gameplay. Consequently, to address this concern, an alternative approach was suggested: the design of an additional learning station and having students take turns one by one in front of the sensor. This thoughtful recommendation aims to enhance the smooth functioning of the learning stations and optimize students' engagement with the multimodal learning experiences offered by the Kinems platform. Such insights from teachers' reflections provide valuable guidance for future implementations, ensuring an even more effective and conducive learning environment within the classroom.

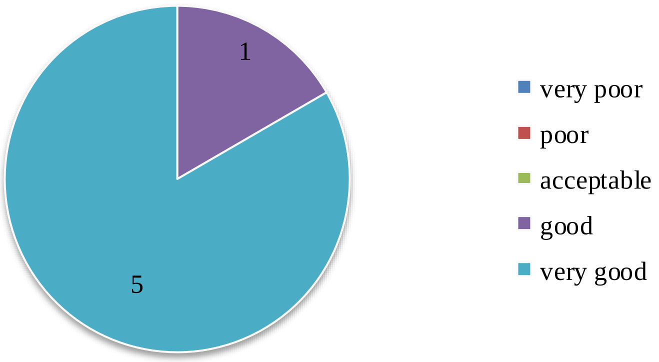

Figure 24. Overall assessment of classroom orchestration in multimodal learning stations

Furthermore, with regards to classrooms' overall academic achievement, it was consistently observed across all sessions that teachers perceived the students' academic performance as very good (Figure 25). This positive outcome can be attributed to two main factors. Firstly, the students exhibited a high level of engagement and active participation in the movement-based learning activities, which significantly contributed to their academic progress. The multimodal learning experiences provided by the Kinems platform effectively captured the students' interest and enthusiasm, fostering a dynamic and interactive learning environment. Secondly, during the practice sessions at other learning stations, the students demonstrated exceptional levels of concentration. Their focused attention on the learning material and tasks at hand facilitated efficient learning and skill development. The seamless integration of multimodal learning experiences with the use of the LX design allowed for a holistic approach to education, effectively promoting both physical and cognitive growth among the students. As a result, the students' academic achievements flourished, affirming the effectiveness of this innovative approach in enhancing overall academic performance within the classroom setting.

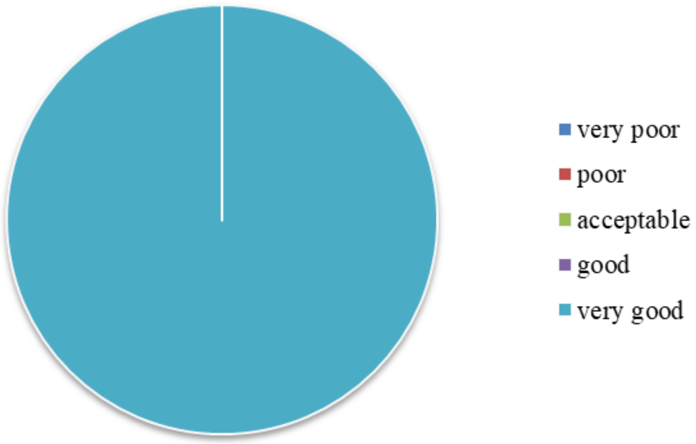

Figure 25. Classroom's overall academic achievement in multimodal learning stations

During the insightful discussion with the teachers, they candidly acknowledged that the remarkable effectiveness of the multimodal learning stations was predominantly attributed to the Kinems platform's provision of multiple forms of learning material representation in a single, cohesive setting. The wealth of Kinems resources served as a powerful source of motivation for the students, to the extent that the teachers designated the days of the interventions as "Kinems Day." Their feedback revealed various positive aspects of the students' experiences during the interventions. One teacher expressed, "*Students had the opportunity to practice the same learning goal using multiple modalities, tools, and manipulatives all within a single session. This approach allowed the children to explore and become acquainted with a diverse range of materials, fostering the creation of new mental structures and enriching their learning experiences*". Another teacher highlighted that "*The multiple benefits of group work facilitated by the different tools, it expanded the students' systems of communication and interaction, fostering both creativity and learning. The excitement and anticipation of the students for the sessions were palpable, as they eagerly awaited new movement-based learning games and the chance to engage in teamwork with new materials in small groups. The entire process held significant meaning for the children, motivating their active participation and overall development*". Such enthusiastic responses from the teachers confirmed the meaningful impact of the LX design in student motivation, engagement, and holistic growth within the classroom environment.

5.6.1.3 Discussion

The results indicate that the overall performance of the class was very good across most learning interventions. This suggests that the multimodal learning interventions were successful in promoting positive classroom behaviors and engagement among the students. These findings highlight the importance of clear instructions and well-defined activities during the interventions to ensure smooth classroom behavior, addressing the challenge that Hicks (2017) identified in terms of classroom management during orchestration in learning stations. Additionally, the case study revealed an intriguing insight; students were significantly enthused by the activities involving movement, which led them to engage in practice sessions that surpassed our initial expectations. Consequently, teachers capitalized on this enthusiasm by configuring practice durations using the Kinems platform. This facilitated smoother transitions among students. In essence, our findings underscore the importance of establishing rules and boundaries when incorporating a highly engaging digital tool, indicating the necessity of setting appropriate time limits.

Moreover, the findings provided evidence that all students successfully reached the desired level of attainment for each of the six math goals. Furthermore, noteworthy achievements were observed in four specific learning objectives, where a significant number of students demonstrated exceptional academic performance beyond the expected level. This indicates that the multimodal learning experiences in learning stations were highly effective in enhancing students' academic performance. These findings are consistent with Haleem et al., (2022) emphasis on considering the responsible and purposeful use of technology, ensuring that aligns with the learning goals and instructional strategies, rather than being used merely for novelty or entertainment purposes. Furthermore, in our study, the feedback from teachers emphasizes that the implementation multimodal learning experiences resulted in greater motivation and engagement, especially for students who typically faced challenges in maintaining focus during other activities. The incorporation of movement-based learning not only increased motivation but also extended the duration of engagement, allowing even those with concentration difficulties to achieve the desired learning outcomes. The data extracted from the Kinems platform performance reports further validate the students' success in achieving and surpassing the desired level of attainment in the learning activities. The high success rate observed in most Kinems activities, with students providing more correct answers than incorrect ones, demonstrates the students' heightened concentration and deep engagement with the movement-based learning activities facilitated by the Kinems platform.

Furthermore, the findings from the social validity questionnaire indicate that teachers exhibited a positive attitude towards the incorporation of the LX design in their classrooms. They perceived the implementation as highly valuable in terms of time and effort invested and found it relatively straightforward to put into practice. This supports the notion that appropriate scaffolding and guidance are crucial to maximize the educational benefits of technology while minimizing potential distractions or misuse (Harris et al., 2009). The positive responses from teachers suggest that the integration of the LX design was well-received and considered effective in enhancing students' learning outcomes. Moreover, teachers reported observing a notable improvement in students' appropriate classroom behaviors during the sessions.

5.5.2 Case Study II

5.5.2.1 Context

The primary objective of the second case study was to evaluate the outcomes resulting from the year-long implementation of the LX design for practicing mathematical concepts in Kindergarten (Figure 26). Two kindergarten teachers, one assistant, and a cohort of 49 five-year-old students participated. The group of students consisted of 26 girls that were approximately 53% of the total students, and 23 boys, making up the remaining 47%. The learning interventions occurred weekly over 28 weeks in two kindergarten classrooms of a private school, lasting 60 to 90 minutes each. During the intervention, students were divided and worked in mixed-ability groups of 4–5 students. The researchers provided teachers with selected and sequenced learning activities to orchestrate their classrooms into learning stations.

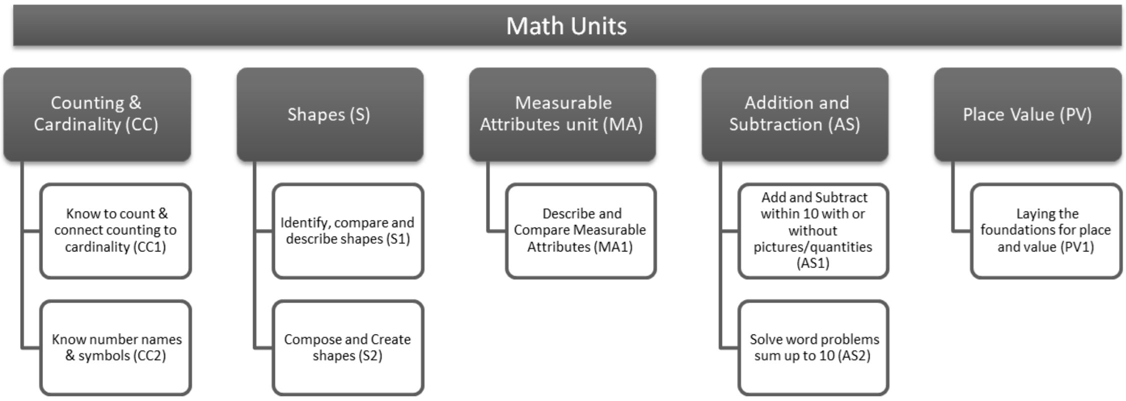

Figure 26. A visual representation depicting the chosen Kinems mathematical units and objectives

Case study II, encompassed three distinct phases:

Preparation phase: In this phase educators organized the learning activities for the six learning stations following the approach and by utilizing the Kinems educational resources. Additionally, they participated in a one-hour live training session focused on the utilization of Kinems' both digital and non-digital tools.

Implementation phase: In this phase, the educators were conducting one-hour weekly sessions, orchestrating their classrooms into learning stations. First, the educator was presenting the purpose of the learning activities in each station, explaining how the resources had to be used. Then, the students were divided into groups. Each group was assigned into a specific learning station except the movement-based station; students were working in the rest five learning centers while taking turns at the movement-based station. Meanwhile, based on the Station Rotation Model (SRM), each group should rotate to the next station on a fixed schedule or at the teacher's discretion. Thus, learners were given the opportunity to experience and gain the benefits of both movement-based, non-digital, digital learning, and several collaborative learning situations chosen carefully by the educator (Christensen, Horn & Staker, 2013). During the SRM, teachers were monitoring the work done in the learning stations, providing students with help and support when needed.

For instance, when addressing the mathematical concept in geometry, a range of activities was selected to provide a comprehensive learning experience. The first learning station featured the "Shape in Place" Kinems game, where students were asked to assemble 2D shapes. The second station utilized the "Shape in Place" Kinems Board game, integrating tangible materials for interactive learning. Kinems worksheets were employed in the third station to reinforce concept comprehension. In the fourth station, students were engaged in the categorization of recyclable materials based on shape attributes. The fifth station encouraged the creation of objects using paper and plastic shapes, while the sixth station fostered fine motor skill development through shape collage activities (refer to Figure 27).

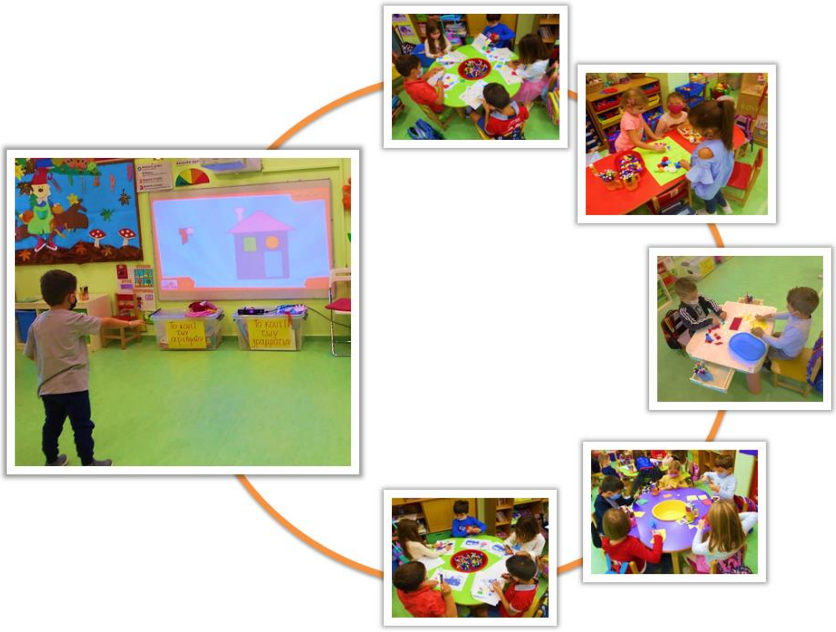

Figure 27. Students working with multiple representations in math learning stations

Evaluation phase: During this phase, the overall assessment of the effectiveness of the LX design was conducted using the evaluation tools. All data was collected and thoroughly analyzed. The ethics of the investigation was ensured through anonymity and coding for the protection of personal data. All students and teachers had voluntarily participated to this initiative.

5.5.2.2 Findings

RQ#1: Impact in classroom behavior and student engagement

The majority of classroom sessions, specifically 36 out of 56 (equivalent to 28 sessions per classroom), showed an academic performance that exceeded expectations (+2) at the GAS scale as indicated shown in Figure 26. This finding was supported by teachers' feedback mentioning that "*Students demonstrated a strong comprehension of the academic concept and completed the activities with ease. The movement-based learning experiences on counting were engaging and motivated them to concentrate* *and provide accurate answers*". In 5 out of 56 sessions, the classroom performance was assessed as more than expected (+1), and in 12 out of 56 sessions, it was assessed as expected (0) (Figure 28). As reported by the teachers, the students exhibited a high level of concentration and engagement, although not all questions were answered accurately, which was anticipated given the challenging nature of the academic concept. Out of the 56 sessions observed, the classroom performance was rated as lower (-1) in only 3 sessions. The teachers' calendar notes indicated that some students sought additional explanations on the academic concept during the station rotation.

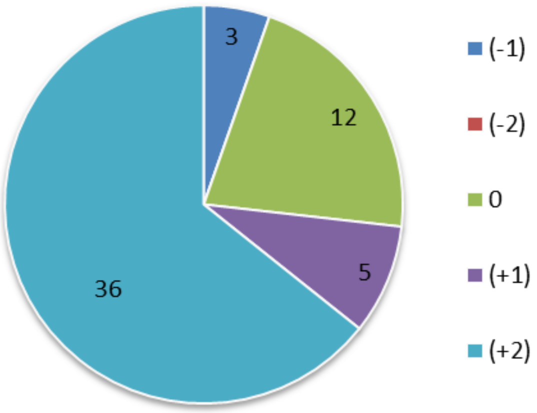

Figure 28. Assessment results about the overall classroom performance per session

Moreover, teachers' field notes provide further evidence regarding the impact in classroom behavior and student engagement. Specifically, they mentioned that over the yearlong implementation, students: (i) accomplished group goals, (ii) developed stronger cooperation skills, and (iii) enhanced self-esteem and self-confidence. The teachers overall reported that the positive learning experience had a significant impact on the classroom dynamics, specifically noting an improvement in teamwork and collaboration among the students.

RQ#2: Effect on students' academic performance

The assessment of students' academic and cognitive progress relied on two key indicators, namely accuracy (i.e., the total number of correct questions) and speed (i.e., the time taken to complete learning activities). These data were collected through the Kinems platform which provides an overview of students' mastery levels across various math goals. The selected math units and their corresponding goals are presented in Figure 29.

By examining the relationship between accuracy scores and reaction time, it was found that most students had either fully mastered (accuracy score of 80% or above) or partially mastered (accuracy score between 50% and 80%) the assigned math goals, with only a few students struggling, and in most goals, none at all (Figure 27). The research results are significant as they indicate that academic achievement was positively impacted by the implementation of movement-based learning centers using multiple modalities, even with a practice frequency of only once per week. The retrieved aggregated data provided valuable insights into the progress of the students. Detailed reports also yielded crucial information on students' session-wise and overall progress. Monitoring in detail each student’s performance in Kinems-enabled activities, we could see that students’ progress on each separate learning goal in terms of accuracy and reaction time.

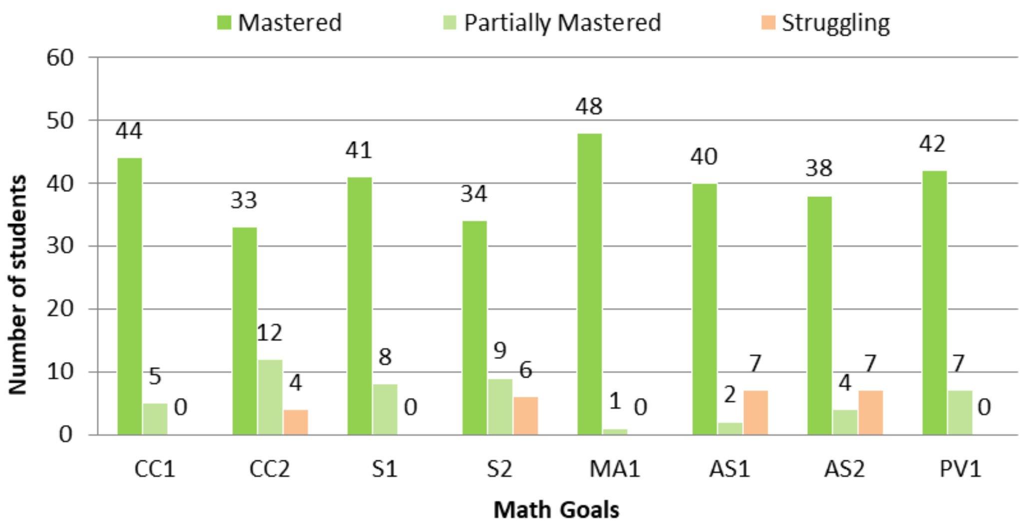

Figure 29. Students’ mastery level per math goal

For example, a student's progress in Kinems-enabled activity related to the learning goal GR.MATH.CONTENT.PK.G.1b (Goal S1) is illustrated in Figure 30 after completing 10 groups of questions. During the sessions, the first student demonstrated a notable improvement in accuracy and reaction time, achieving a final 100% score with a reaction time of 6.9 seconds.

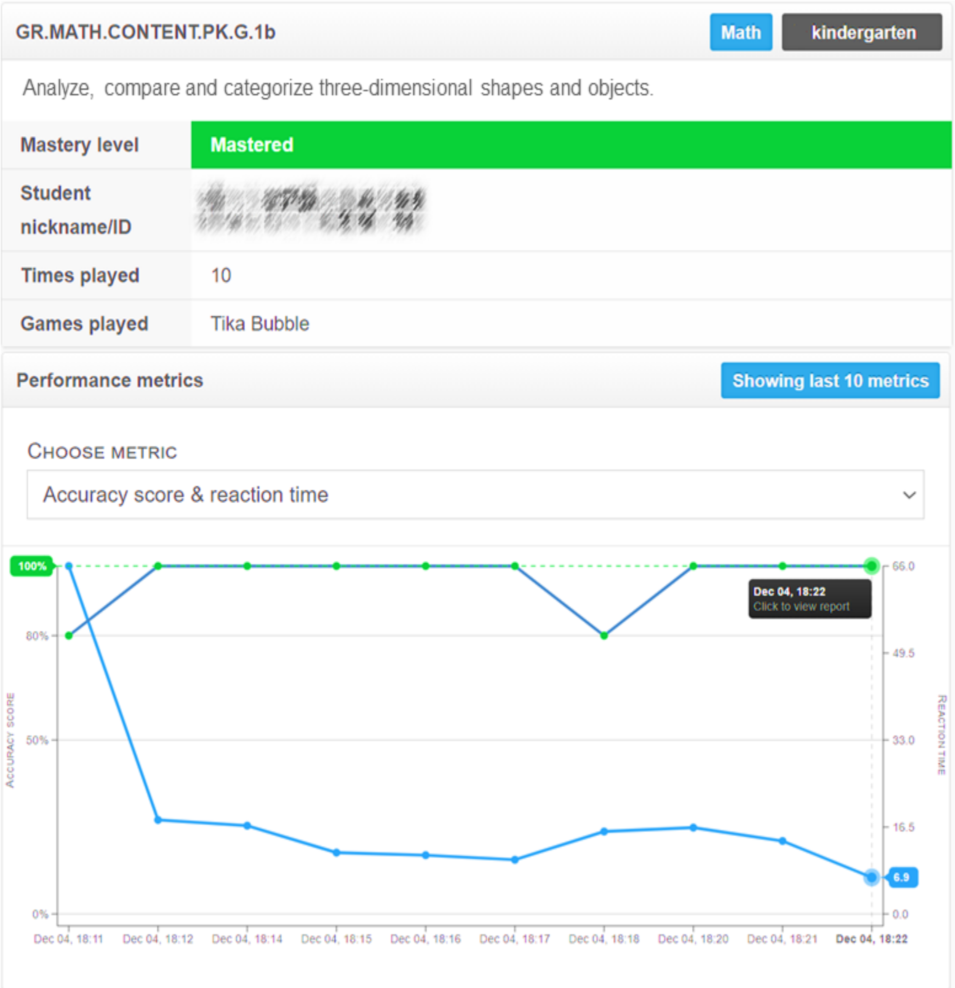

Figure 30. Kinems Learning Games graphic display of accuracy score and reaction time over timeFigure

Another example, that shows the progress of a student in a number tracing activity related to the goal CC2 is illustrated in Figure 31. This particular student attained the highest score in the post-test.

Figure 31. The kinesthetic analytics of the Zoko Write game from Kinems Learning Games

The summative math test results revealed that most students displayed excellent or good knowledge in the respective units by the end of the academic year, as shown in Figure 32. This finding holds significant importance in terms of students' academic performance, as no students were evaluated as average or poor.

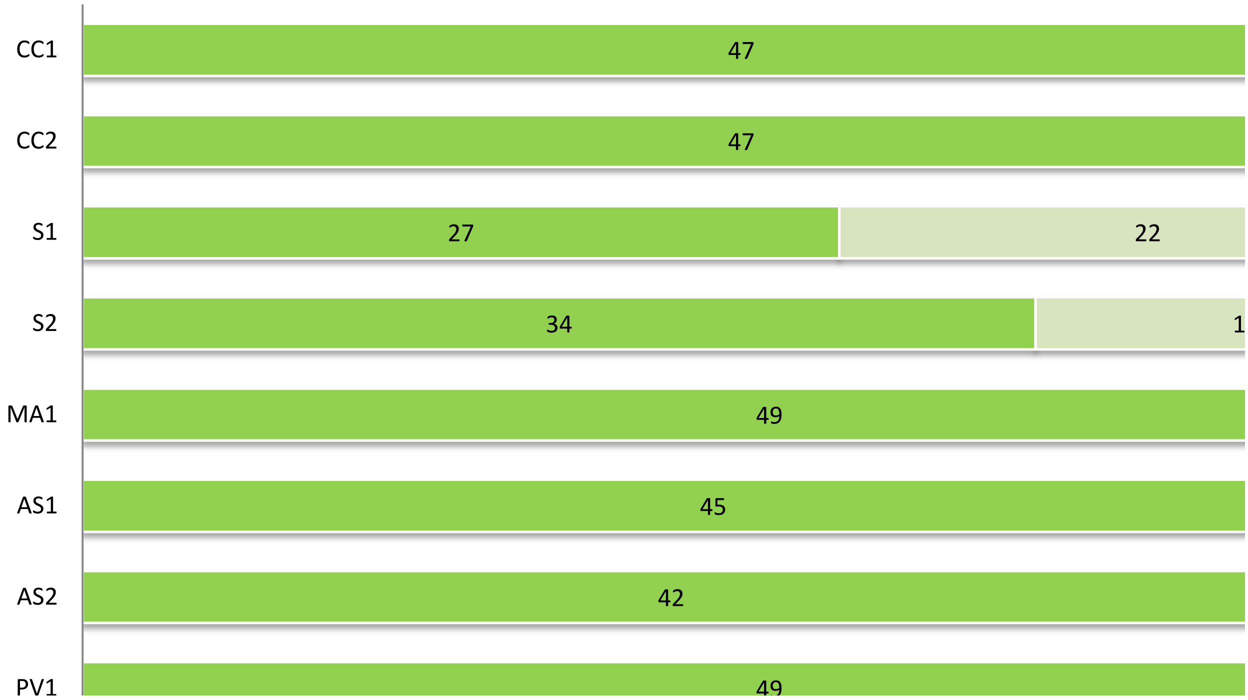

Figure 32. Student's results per unit on the summative math test

The positive findings mentioned above is further supported by the correlation between pre- and post-test scores, which indicates that students performed very well in three key mathematical skills essential for school readiness; calculus, geometry and simple math problems as illustrated in Figure 33. Specifically, the students' calculation ability was assessed on a scale of 1 to 4. In the pre-test, only one relevant question was included, whereas the post-test evaluated two relevant questions related to the students' ability to add and subtract numbers. The mean score for the "add numbers ability" was 3.71±0.54, while for the "subtract numbers ability" it was 3.49±0.61. Following the implementation, there was a statistically significant improvement in the students' calculation abilities (2.83±1.08 vs. 3.60±0.53; $p<0.001$). In the post-test, 26 out of 49 students (53.06%) achieved a perfect score, compared to 19 out of 49 students (38.78%) in the pre-test. Notably, no student obtained the lowest score in the post-test, whereas 5 students (10.20%) received the lowest score in the pre-test. This difference remained statistically significant even after adjusting for gender. The effect size, measured using Cohen's d, was 0.89 (95% CI: 0.47-1.32), indicating a large effect.

In terms of their geometry skills, the students were initially assessed on their ability to recognize 4 different shapes in a pre-test. After the intervention, they were asked to recognize 5 different shapes. Their performance was evaluated on a scale from 1 to 4. A statistically significant increase was observed in the shape recognition capabilities when comparing the two tests (3.75±0.63 vs. 4.00±0.00; p=0.017). It is noteworthy that after the 28-week implementation intervention, all students were able to correctly identify all shapes. In the pre-test, 6 out of 49 students (12.24%) had limited shape recognition capabilities, and 2 out of 49 students (4.08%) demonstrated moderate shape recognition capability. Even after adjusting for gender, the difference remained statistically significant. The effect size, measured using Cohen's d, was 0.56 (95% CI: 0.14-0.97), indicating a medium effect.

The students' proficiency in solving mathematical problems was assessed and scored on a scale of 1 to 4. In the pre-test, their ability to comprehend the problem and propose an intuitive mathematical solution was evaluated. In the post-test, their proficiency in solving simple mathematical problems involving addition or subtraction was assessed. A statistically significant increase was observed in the students' mathematical problem-solving abilities when comparing the two tests (2.98±0.84 vs. 3.68±0.41; p<0.001). In the pre-test, 15 students (30.61%) achieved a perfect score, while in the post-test, a total of 27 students (55.10%) achieved a perfect score. It is noteworthy that subtraction posed more difficulty in the post-test. Among the students, 27 achieved a perfect score for both addition and subtraction, 18 achieved a perfect score for addition but not for subtraction, and none achieved a perfect score for subtraction without achieving one for addition. Even after adjusting for gender, the difference remained statistically significant. The effect size, measured using Cohen's d, was 1.05 (95% CI: 0.62-1.48), indicating a large effect.

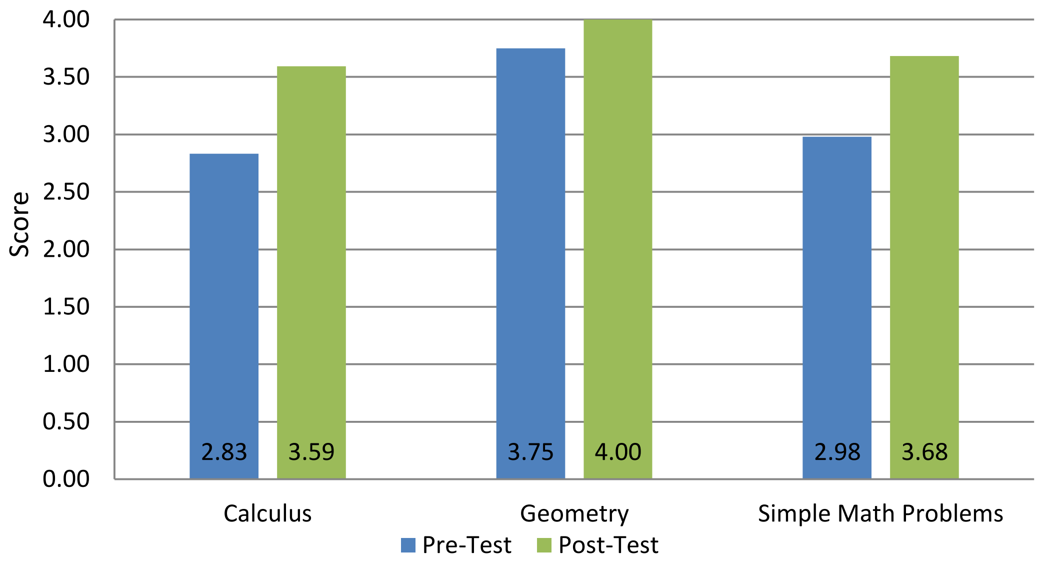

Figure 33. Calculation, Geometry & Simple math problems ability in Pre-Posttest

RQ#3: Teachers' attitudes and perceptions towards the development and implementation of the LX design

To explore the third research question regarding teachers' perceptions towards the attitudes and perceptions towards the development and implementation of the LX design, a social validity questionnaire was administered, and the results are presented in Figure 34. Teachers generally had a positive attitude, found the implementation to be worth the time and effort, and relatively easy to implement. They reported an increase in appropriate classroom behaviors, and believed that their students did not experience discomfort during the sessions. The teachers found the implementation to be useful and effective for their students, and the proposed LX design helped them integrate the multimodal and movement-based learning experiences effectively.

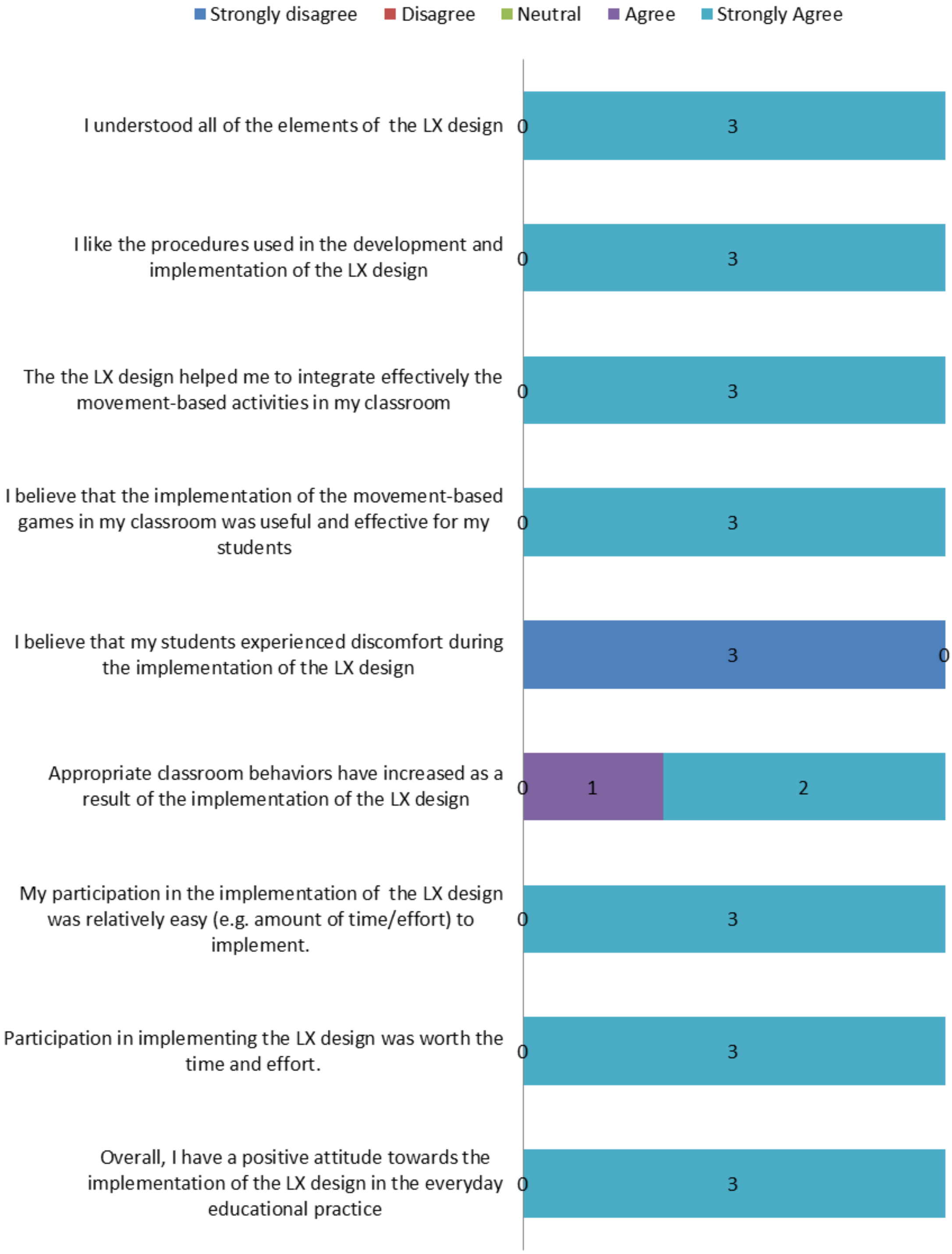

Figure 34. Social Validity Survey results

The positive findings mentioned above are further supported by the results depicted in Figure 35, which indicate a high quality of classroom orchestration in learning stations. Specifically, out of the 56 sessions assessed, 45 were rated as very good. Teachers' feedback on these sessions included statements such as, "*Today's station rotation was particularly exciting and ran smoothly. Students were able to complete* *all learning activities successfully within the allocated time, while accurately following the given instructions*".

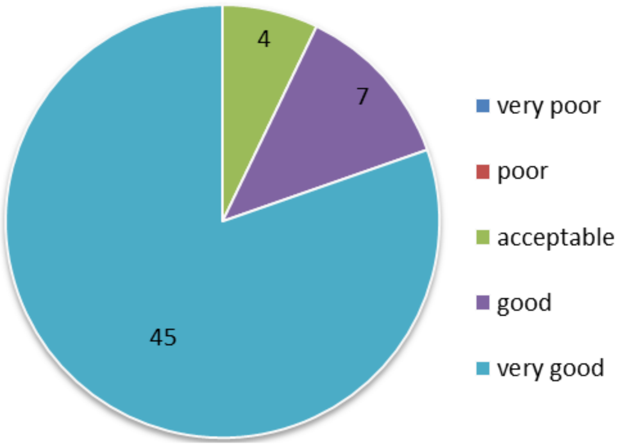

Figure 35. Assessment results about the quality of the classroom orchestration in stations

5.6.2.3 Discussion

Implementing the LX design improved the academic achievement and cognitive development of kindergarten students. The students were able to achieve the learning objectives, as evidenced by their mastery of the skills practiced on the Kinems learning platform, as well as their excellent performance on the summative math test at the end of the school year. Our findings confirm the assertion made by MacDowell & Lock (2023) that the implementation of immersive technologies should prioritize meaningful and intellectually engaging learning. By considering learning outcomes, pedagogical approaches can be explored and technology can be leveraged to design effective learning experiences. Additionally, our study addresses an open research question regarding the enactment of the movement-based learning games in schools and the need for systematic evaluation studies to assess its potential value in authentic classroom environments, as previously suggested by Kourakli et al. (2017). In terms of social-emotional development, the implementation of the multimodal learning experiences had a significant impact on the classroom dynamics, particularly in enhancing teamwork and collaboration among the students.

Moreover, the case study indicates that the integration of multimodal learning experiences in learning stations is effective, as evidenced by the classroom's high level of concentration and improved academic performance, as most sessions had the highest scores. Moreover the classrooms, demonstrated higher proficiency in the three critical mathematical skills as indicated by their post-test scores compared to their pre-test scores. These findings are consistent with Ainsworth's (2006) emphasis on the importance of using multiple representations for effective learning.

Teachers had a positive attitude towards implementing the LX design in their classrooms, finding it to be useful and effective for their students. The teachers believed that the time and effort invested in the implementation of these learning experiences was worthwhile. The LX design was found to effectively facilitate the integration of the multimodal learning experiences. This supports the notion that purposeful planning is crucial for successful immersive experiences, as emphasized by MacDowell and Lock (2023). Moreover, during the sessions, students were actively engaged and seamlessly transitioned from one representation/modality to another, as evidenced by the high scores in the teacher's classroom orchestration quality assessment. This finding supports Mayer, Rose, & Gordon's (2014) assertion that utilizing multiple representations can promote student motivation, foster playful learning experiences, and encourage movement within the classroom.

All in all, engaging a large classroom with multiple representations integrating also high-end technology, like movement-based learning games for a whole school year, can be challenging. The results suggest that this integration in authentic kindergarten classrooms was well-designed and effective. While we can't pinpoint the exact "ah-ha" moment for each student, this approach provides multiple representations and engaging learning experiences, enhancing concentration and fostering positive learning environments.

5.5.3 Case Study III

5.5.3.1Context

The primary objective of the third case study was to evaluate the outcomes resulting from the implementation of the LX design aimed to support remote instruction during the Covid-19 pandemic for students in special education, facilitating the practice of academic skills. Thirteen (13) students with Special Education Needs (SEN), primarily at the Kindergarten academic and cognitive level, participated in the third case study, comprising 9 boys and 4 girls, with ages ranging from 7 to 15 years old. All of them were enrolled in special education programs in Greece. Specifically, 9 students attended two public primary special education schools in the Attica region, while the remaining 4 students attended a public secondary special education school in the Aetolia-Acarnania region. Among these students, ten were diagnosed with Autism Spectrum Disorder (ASD), with the rest having other neurodevelopmental disorders. Therefore, individuals within the autism spectrum made up the majority of the sample. Additionally, fifteen (15) educators and therapists actively participated in the study. They were responsible for designing remote learning sessions following the LX design, delivering synchronous instruction, and assessing their students' performance based on data collected from both synchronous and asynchronous activities. Furthermore, in this study, students' parents played an important role in supporting their children during the sessions whenever needed. This is why we also collected feedback from them in this study.

In the context of remote learning, two main modes of instruction are employed: synchronous and asynchronous learning. Synchronous learning involves real-time interaction between students and instructors through video-conferencing platforms, whereas asynchronous learning allows students to engage with learning resources independently, without the need for simultaneous online participation. This case study has validated a blended approach that combines both synchronous and asynchronous remote learning sessions. Educators utilized the Zoom video-conferencing platform.

In this blended model, the teacher or interventionist initiates the synchronous session using the Zoom platform. Students join the Zoom session and simultaneously log in to the Kinems student portal, with parental assistance in the case of young children. During the session, students engage with multimodal learning activities that facilitate their progress in mathematics and language. The learning flow within this model is as follows: The teacher shares their computer screen to present a Kinems game-based learning activity, emphasizing the type of interaction required with the digital game (e.g., using a mouse or finger to move the avatar left and right to select items) and the content focus (e.g., selecting all triangles). The teacher encourages active student participation (e.g., asking which item is a triangle, the blue or the yellow one?). Subsequently, the student practices on their own device, such as a laptop or tablet. Through the Kinems monitoring dashboard, the teacher can remotely launch and pause the game to provide explanations and scaffolding as needed. Then, the student engages with the worksheets, board games, and other manipulatives under the same academic concepts, that the educator has selected and informed parents to prepare before the session (i.e., print PDF files, collect math blocks, etc.). At the end of the session, the teacher assigns digital game-based learning activities for additional asynchronous practice at home. The teacher can also monitor student engagement and performance through detailed cloud-based reports, which are automatically generated upon game completion.

Case study III comprised of three distinct phases:

Preparation Phase: In this initial phase, educators, principals, and parents were informed about the context and purpose of the remote interventions. To formalize their participation, informative and consent forms were signed by educators and parents. Educators underwent two one-hour virtual training sessions to familiarize themselves with designing learning goals based on the principles of the LX design and utilizing the Kinems learning platform.

Implementation Phase: During this phase, educators conducted one-hour weekly synchronous learning sessions with their students using the Zoom teleconference platform. These sessions involved the implementation of the multimodal learning activities. Additionally, after each synchronous session, educators assigned learning activities for students to practice independently at home, constituting the asynchronous tele-education component. The implementation phase spanned a total of 5 weeks.

Evaluation Phase: In the final phase, the overall effectiveness and acceptability of the proposed systematic learning design approach were assessed using reliable evaluation tools, including questionnaires, interviews, and reports. All collected data underwent thorough analysis. Ethical considerations were ensured through anonymity and coding to protect personal data and the participation of all students and teachers in this initiative was voluntary.

5.5.3.2 Findings

RQ#1: Impact in classroom behavior and student engagement

The teachers scheduled specific days for the 1-hour synchronous sessions each week based on parents' availability and the child's needs. The majority of students participated in 2 synchronous sessions per week, while 4 students attended 3 synchronous sessions. Additionally, 1 student engaged in 4 synchronous sessions, another student attended 5 synchronous sessions, and 1 student participated in 1 synchronous learning session per week (Figure 36).

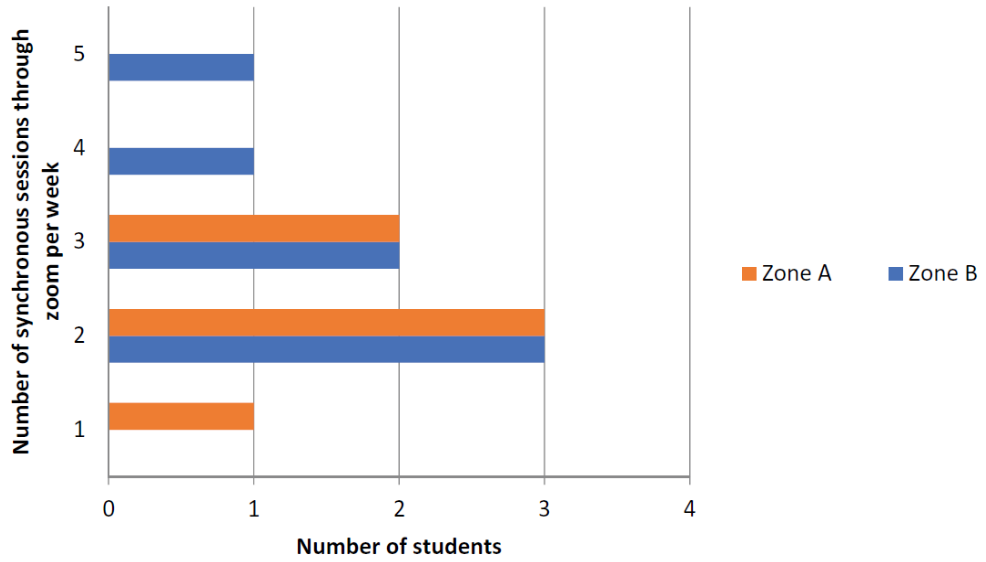

Figure 36. Students' grouping based on the frequency of synchronous learning sessions via Zoom

A remarkable example is Student STK2, who, despite having only 1 synchronous learning session per week, displayed a high level of engagement. This student played 151 games, answered 931 questions, and spent a total of 7 hours and 67 minutes actively participating (as shown in the Table 5). After each synchronous learning session, Kinems learning activities were assigned for additional practice at home. Within just one month, the student had developed significant autonomy in using the platform, which further contributed to her substantial involvement in both synchronous and asynchronous learning activities.

Table 5. Number of sessions and level of student involvement

Students	Number of synchronous sessions per week	Number of learning goals	Number of games	Number of questions	Total engagement (h)
Zone A					
STK4	3	4	199	612	0,54
STK7	3	1	55	202	1,11
STK3	2	3	27	74	5,46
STK8	2	5	17	53	2,58
STK6	2	4	72	36	1,69
STK2	1	8	151	931	7,67
Zone B					
STM1	5	6	35	157	4,44
STM3	4	9	55	161	1,63
STM4	3	5	48	176	3,37
STA5	3	4	71	208	1,08
STA6	2	1	32	204	0,71
STM2	2	8	21	46	2,78
STA3	2	4	51	174	2,04

Additionally, an assessment of the children's overall performance was conducted through a closed-ended questionnaire that was completed by teachers and therapists. A noteworthy discovery pertains to the children's engagement with the multimodal resources. According to the reports from practitioners, the majority of children displayed a growing interest in practicing with the multimodal activities, not only during their scheduled synchronous learning sessions but also asynchronously throughout the week (as shown in the Table 6). This finding underscores the effectiveness of a LX design that supports multimodal learning, serving as an engaging educational approach that enhances children's motivation and positive attitude towards learning.

Table 6. Increasing interest in multimodal resources

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	always never	1	7,7	7,7	7,7
	seldom	2	15,4	15,4	23,1
	occasionally	1	7,7	7,7	30,8
	frequently	1	7,7	7,7	38,5
	almost always	8	61,5	61,5	100,0
	Total	13	100,0	100,0	

Furthermore, professionals reported an improvement in cooperative behavior when working with children during the use of multimodal activities (as indicated in the Table 7). It appears that the multiple educational materials heightened the children's interest and motivation for learning activities, which, in turn, contributed to the development of a positive attitude. This positive outlook, fostered by the activities, also had a positive impact on the children's social skills and behavior, particularly in terms of cooperation.

Table 7. Cooperation with the teacher/therapist

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	almost never	1	7,7	7,7	7,7
	seldom	1	7,7	7,7	15,4
	frequently	2	15,4	15,4	30,8
	almost always	9	69,2	69,2	100,0
	Total	13	100,0	100,0	

RQ#2: Effect on students' academic performance

Students gradually became part of the project based on the availability of their parents and the readiness of the educators, considering the COVID-19 quarantine measures in place. Consequently, the participants were categorized into two zones, determined by the timing of their project involvement (refer to the Table 8). Interestingly, students who joined the project in different zones but practiced the same learning goals achieved notable success. For instance, student STK2 was in zone A, while student STA5 belonged to zone B. Both students focused on addition and subtraction, and both demonstrated significant achievements, regardless of their duration of participation.

Table 8. Students' goal and skills achievement

		Goal Achievement						
Students	Learning Goals	Much more than expected	More than expected	Expected	Less than expected	Number of Game Questions	Average Game Score	Average Skills Score
Zone A: Long Involvement Duration (5–4 weeks)								
STK4	4	1	1	1	1	53	70%	3,83/5
STK7	1	-	-	-	1	72	50%	1,17/5
STK3	3	1	1	-	1	612	70%	5/5
STK8	5	1	2	2	-	202	70%	4,67/5
STK6	4	–	1	1	2	74	60%	2/5
STK2	8	4	3	-	1	931	100%	4,58/5
Zone B: Short Involvement Duration (3–2 weeks)								
STM1	6	4	-	1	1	161	90%	3,9/5
STM3	9	6	2	1	-	176	60%	4,10/5
STM4	5	2	1	2	-	157	70%	4/5
STA5	4	1	2	1	-	204	80%	5/5
STA6	1	1	-	-	-	46	40%	3,5/5
STM2	8	4	4	-	-	208	70%	4,59/5
STA3	4	-	1	3	-	174	40%	4,3/5
Total	**62**	**26**	**17**	**12**	**7**	**3.070**	-	-

When we correlate the students' goal achievements with their individual needs, it becomes evident that even students with severe disabilities derived benefits from the implementation. Take for example non-verbal student STK6, who has a dual diagnosis of ASD and Attention-deficit/hyperactivity disorder (ADHD) and requires adult assistance to maintain attention. He achieved a score of +1 and 0 in 2 out of the 4 learning goals. However, for the other two goals, he received a score of -1, mainly because the duration of his learning sessions was reduced due to his difficulty concentrating during synchronous sessions. According to his teacher, if the remote learning sessions had continued for an additional month, the student would likely have achieved the highest goals for all the remaining learning objectives. This assertion aligns with his commendable average game score of 60%.

RQ#3: Teachers' & parents' attitudes and perceptions towards the development and implementation of the LX design

In Table 9, it is evident that the criteria related to the usefulness of the LX design, coupled with the utilization of the Kinems platform multimodal resources in remote learning, as well as the potential to recommend this approach to colleagues, and collectively received an average rating of 4.7 out of 5. This positive assessment is further supported by parents' feedback, as exemplified by their comments: "*Our first impressions of the learning interventions are very positive. Our child is very happy. He has his own time on the platform and he enjoys the multimodal learning activities*", and *"Kinems is an innovative tool for SEN children. It is helpful for teachers and parents based on good learning strategies and occupational therapy techniques".*

Regarding the practical application of the approach with the use of the Kinems platform resources in remote learning for SEN students, the average score was 4.4 out of 5. Additionally, qualitative comments from parents revealed:

- The joy their children experienced when engaging with the assigned learning activities.
- Parental satisfaction with their schools' participation in the program, which provided their children with the opportunity to practice academic skills through multimodal educational activities during the Covid-19 closure.
- Parents' willingness to integrate the Kinems platform as a fundamental educational tool in the classroom.
- The eagerness of children to practice with the multimodal learning activities at home.

- The consensus among parents that the multimodal learning activities were highly engaging and facilitated their children's acquisition of knowledge more effectively than traditional teaching methods.
- The expression of gratitude towards educators for their excellent cooperation with their children.

Table 9. Teacher evaluations per field- Data from the evaluation forms

Educators	Usefulness of the LX design in remote learning	Clarity of educational material	Functional implementation of the multimodal resources for SEN students	Positive correspondence from the family	Suggest the LX design to colleagues	Use of the LX design at school	AVG
Zone A							
TK6	5	5	5	5	5	5	5
TK10	4	5	5	3	4	3	4
TK5	5	5	4	5	5	5	4,8
TK11	5	4	4	5	4	4	4,3
TK9	4	5	2	3	3	2	3,2
TK4	4	5	5	5	5	5	4,8
TK3	5	4	5	5	5	5	4,8
Zone B							
TM2	5	5	5	5	5	5	5
TM1	4	5	4	5	5	5	4,7
TM6	5	5	4	5	5	5	4,8
TM5	5	5	4	5	5	5	4,8
TM7	5	5	4	5	5	5	4,8
TA4	4	5	5	5	5	5	4,8
TM4	5	5	5	5	5	4	4,8
TM3	5	4	5	5	5	5	4,8
AVG	**4,7**	**4,8**	**4,4**	**4,7**	**4,7**	**4,5**	**4,6**

5.6.3.3 Discussion

The main aim of this study was to investigate the application of the LX design also in the context of remote learning for SEN students. Despite the inability to carry out the station rotation model with groups of students and the kinesthetic learning experiences due to Covid-19 restrictions, the rotation of all the rest multimodal resources was effectively applied during synchronous and asynchronous sessions.

The results regarding students' performance are highly encouraging. According to the assessments conducted by educators, the majority of students exceeded expectations in terms of achieving the learning goals overall, regardless of the duration of their participation. Furthermore, there was a notable increase in motivation and cooperation, as well as enhanced interaction with educators during the intervention, regardless of the students' functional levels. The most significant improvements were observed in children who engaged more frequently with Kinems activities, both during synchronous and asynchronous learning. This suggests that the frequency of engagement with activities, rather than the duration alone, is a robust indicator of successful performance.

Moreover, a substantial majority of teachers and therapists provided highly positive evaluations of the Kinems education gaming platform, which supported the LX design. They recognized its efficiency in enhancing a wide range of students' academic skills and acknowledged its value as a tool for improving their educational practices. Parents also reported significant benefits, emphasizing the LX design's effectiveness in promoting their children's skills and emotional well-being. This aligns with the positive feedback received from educators. We consider the evaluations from both parents and professionals as crucial in supporting the effectiveness of the intervention and its recognition as an evidence-based practice (EBP).

In the field of special education, the concept of social validity plays a vital role in establishing an intervention as an EBP. This involves addressing socially important goals, utilizing procedures acceptable and feasible to natural change agents, such as caregivers and professionals, and achieving effective outcomes in natural settings, including homes and schools. Several studies using Kinems activities have reinforced the platform's efficacy in enhancing academic, cognitive, and motor skills, as well as promoting positive emotional well-being among children with SEN in Greece and Cyprus (Kourakli et al., 2017; Kosmas et al., 2018).

CHAPTER 6

Discussion

6.1 Overview of research output

This doctoral dissertation addresses a new LX Design model to support holistic development in kindergarten, which is based on learning trajectories and the principles of UDL. Holistic development involves nurturing a child's cognitive, motor, emotional, and social skills (World Health Organization, 2012). While these skills are often studied separately, they are interconnected in reality (ASCD, 2007). Research suggests that comprehensive education should promote the holistic development of the child (Darling-Hammond & Cook-Harvey, 2018). Holistic development is particularly important in early childhood education, as this stage lays the foundation for the child's future growth and progress (Young, 1996; Shavkatovna, 2023; Tang et al., 2023).

Studies have also emphasized the need for guidance and support for teachers to effectively use digital tools in educational practice (Kennewell & Beauchamp, 2007). As Haleem et al. (2022) mention, emphasis should be placed on the prudent use of technology, ensuring it aligns with learning objectives and educational strategies, not just for innovation or entertainment. Therefore, there is an urgent need to develop appropriate learning design frameworks that facilitate the integration of digital resources so that students can benefit (Fowler, 2014). According to Kuhail et al. (2022) and MacDowell & Lock (2023), future research should focus on designing learning design frameworks that provide guidelines for the effective and smooth integration of technologies in classrooms (Fowler, 2014; Kuhail et al., 2022; MacDowell & Lock, 2023).

Three empirical case studies were conducted to evaluate the effectiveness of the new LX design in authentic educational settings. The findings from each case study offer valuable insights into the impact of incorporating multimodal learning experiences, movement-based learning tools, and innovative holistic teaching approaches on various aspects of early childhood education. In the first case study the overall performance of the class was very good across most learning interventions. This suggests that the multimodal learning interventions were successful in promoting positive classroom behaviors and engagement among the students. These findings highlight the importance of clear instructions and well-defined activities during the interventions to ensure smooth classroom behavior, addressing the challenge that Hicks (2017) identified in terms of classroom management during orchestration in learning stations. Moreover, the findings provided evidence that all students successfully reached the desired level of attainment for each of the six math goals. Noteworthy achievements were observed in four specific learning objectives, where a significant number of students demonstrated exceptional academic performance beyond the expected level. This indicates that the multimodal learning experiences in learning stations were highly effective in enhancing students' academic performance. These findings are consistent with Haleem et al., (2022) emphasis on considering the responsible and purposeful use of technology, ensuring that aligns with the learning goals and instructional strategies, rather than being used merely for novelty or entertainment purposes. The findings from the social validity questionnaire indicate that teachers exhibited a positive attitude towards the incorporation of the LX design in their classrooms. They perceived the implementation as highly valuable in terms of time and effort invested and found it relatively straightforward to put into practice. This supports the notion that appropriate scaffolding and guidance are crucial to maximize the educational benefits of technology while minimizing potential distractions or misuse (Harris et al., 2009).

The second case study focused on the implementation of multimodal learning stations as a core curriculum tool following the LX design, producing significant results. Implementing the LX design improved the academic achievement and cognitive development of kindergarten students. The students were able to achieve the learning objectives, as evidenced by their mastery of the skills practiced on the Kinems learning platform, as well as their excellent performance on the summative math test at the end of the school year. Our findings confirm the assertion made by MacDowell & Lock (2023) that the implementation of immersive technologies should prioritize meaningful and intellectually engaging learning. By considering learning outcomes, pedagogical approaches can be explored and technology can be leveraged to design effective learning experiences. Additionally, the study addresses an open research question regarding the enactment of the movement-based learning games in schools and the need for systematic evaluation studies to assess its potential value in authentic classroom environments, as previously suggested by Kourakli et al. (2017).

Moreover, the case study indicates that the integration of multimodal learning experiences in learning stations is effective, as evidenced by the classroom's high level of concentration and improved academic performance, as most sessions had the highest scores. Moreover the classrooms, demonstrated higher proficiency in the three critical mathematical skills as indicated by their post-test scores compared to their pre-test scores. These findings are consistent with Ainsworth's (2006) emphasis on the importance of using multiple representations for effective learning. Furthermore, teachers had a positive attitude towards implementing the LX design in their classrooms, finding it to be useful and effective for their students. They believed that the time and effort invested in the implementation of these learning experiences was worthwhile. The LX design was found to effectively facilitate the integration of the multimodal learning experiences. This supports the notion that purposeful planning is crucial for successful immersive experiences, as emphasized by MacDowell and Lock (2023). Moreover, during the sessions, students were actively engaged and seamlessly transitioned from one representation/modality to another, as evidenced by the high scores in the teacher’s classroom orchestration quality assessment. This finding supports Mayer, Rose, & Gordon's (2014) assertion that utilizing multiple representations can promote student motivation, foster playful learning experiences, and encourage movement within the classroom.

The third case study explored the potential of the LX design for the design and implementation of educational activities in special education, especially in the context of distance learning. The results regarding students' performance are highly encouraging. According to the assessments conducted by educators, the majority of students exceeded expectations in terms of achieving the learning goals overall, regardless of the duration of their participation. Furthermore, there was a notable increase in motivation and cooperation, as well as enhanced interaction with educators during the intervention, regardless of the students' functional levels. The most significant improvements were observed in children who engaged more frequently with Kinems activities, both during synchronous and asynchronous learning. This suggests that the frequency of engagement with activities, rather than the duration alone, is a robust indicator of successful performance. The results verify findings from several studies that highlight the efficacy of Kinems activities in enhancing academic, cognitive, and motor skills, while also promoting positive emotional well-being among children with special educational needs (SEN) in Greece and Cyprus. (Kosmas et al., 2018; Kourakli et al., 2017).

In conclusion, this doctoral dissertation offers significant contributions to early childhood education by presenting a new LX design model that supports holistic development in kindergarten. Grounded in the principles of UDL and learning trajectories, this model effectively integrates multimodal learning experiences and digital tools to promote cognitive, motor, emotional, and social skills. The empirical case studies conducted in authentic educational settings confirm the model's efficacy, demonstrating its positive impact on student engagement, academic achievement, and classroom behavior. Furthermore, the findings highlight the importance of clear instructional guidance and thoughtful integration of technology to maximize the educational benefits. The LX design also proves to be adaptable across different educational contexts, including special education and distance learning, offering a flexible framework for fostering inclusive and effective learning environments. These insights lay the groundwork for future research and practical applications, emphasizing the need for continued exploration of holistic educational approaches that address the diverse needs of all learners.

6.2 Contribution

The originality of this dissertation is reflected in two key contributions. First, it introduces a well-organized and innovative LX design model tailored to support holistic development in kindergarten through the use of multimodal educational technologies. This model has been positively evaluated in authentic learning environments, demonstrating its effectiveness and practicality. It is designed for easy adoption by educators and learning designers without requiring extensive training, making it a valuable tool for creating effective learning experiences.

Second, the dissertation offers a systematic mixed-methods evaluation approach, utilizing empirical data from both qualitative and quantitative sources to validate the LX model's effectiveness. This evaluation framework not only reinforces the model's credibility but also provides a valuable methodology for assessing other educational models in both general and special education contexts.

In addition to these contributions, the present dissertation offers significant overall value by addressing critical gaps in the current educational landscape, particularly the integration of holistic development in early childhood education. The LX design model's emphasis on cognitive, emotional, social, and motor skill development aligns with the increasing recognition that education must cater to the whole child rather than focusing on academic achievement alone. By introducing a structured and adaptable framework that is easily implemented by educators, this research provides a practical solution to the challenges of modern education, including the need for inclusive, engaging, and technologically enhanced learning experiences. Furthermore, the success of the LX design in both general and special education, as well as in distance learning environments, showcases its versatility and potential for broader application, making this dissertation a valuable resource for educators, policymakers, and researchers aiming to improve educational outcomes across diverse contexts.

6.3 Future work

Building on the findings of this dissertation, future research could extend the application of the LX design to different age groups and educational settings beyond kindergarten. A promising area for further investigation is the adaptation of the LX design for use in primary and secondary education, where holistic development remains crucial. Exploring how the model can be modified to meet the unique developmental needs of older students, including the integration of more complex cognitive and socio-emotional skills, could provide valuable insights. Additionally, expanding the LX design into diverse cultural and socio-economic environments would allow researchers to assess the model's adaptability and effectiveness across varied educational landscapes, contributing to a more inclusive and globally applicable learning framework.

Another potential avenue for future research is the long-term impact of the LX design on student outcomes. While this dissertation has shown positive short-term effects in early childhood education, future studies could track students' academic, emotional, and social development over time to evaluate the sustained benefits of the model. This approach could reveal whether the early gains in motivation, engagement, and cognitive skills persist and how they influence later academic performance and social development.

Another promising direction for future research is to explore the use of the LX design model in special education, particularly for students with diverse cognitive and physical disabilities. While this dissertation touched on the potential of the LX design in special education, a dedicated study could focus more deeply on how the model can be tailored to support the individual learning needs of students with disabilities. This research could assess the effectiveness of customized multimodal learning experiences, investigating how specific modifications—such as adaptive technologies, personalized learning paths, and differentiated instruction—impact student engagement, motivation, and achievement. The study could also explore the role of the LX design in promoting inclusive education, where students with disabilities learn alongside their peers, fostering collaboration and social integration in a shared learning environment.

This study can also serve as a blueprint for other researchers and practitioners involved in designing similar multimodal learning experiences. The systematic approach outlined in this research offers structured steps that can be adapted and refined in various educational contexts. As the study indicates, replication and systematic evaluation with a larger number of participants are necessary to further validate and generalize the findings.

Future work could also investigate the role of teacher professional development in optimizing the use of the LX design, exploring how ongoing support and training can enhance its implementation and effectiveness in diverse classrooms. By addressing these insights and recommendations, future research can build on the foundations laid by this study, contributing to the advancement of immersive learning experiences and enhancing educational practices for holistic child development.

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