CYPRUS UNIVERSITY OF TECHNOLOGY

FACULTY OF FINE AND APPLIED ARTS

Doctoral Dissertation

INVESTIGATING TECHNOLOGY – ENHANCED EMBODIED LEARNING IN REAL CLASSROOM SETTINGS: STUDENTS' PERFORMANCE AND LEARNING GAINS

Panagiotis Kosmas

Limassol, November 2018

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Approval Form

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Limassol, November 2018

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ABSTRACT

In the age of technological imperative, massive efforts are underway to enrich traditional teaching and learning practices with technology. Under the umbrella of Embodied Cognition (EC) Theory, Embodied Learning (EL) is one such approach. EL is a kinesthetic, multimodal and playful process that enriches conventional educational practice and provides ways of integrating the physical body and movement into the classroom setting. In recent years, the use of emerging embodied technologies in educational settings has built upon EL ideas to provide some useful insights into how the active body can influence the function of the brain to drive learning. This dissertation looks at EL in different learning contexts and circumstances to see how it can improve the overall performance of students in real classroom settings for specific learning purposes. The study consists of four sequential phases that use data collection and analysis to explore the impact of EL-driven technology on actual classroom practice. In particular, through a multiphase mixed methods approach, this research focuses on investigating how EL impacts student performance (i.e. motor, cognitive, academic, and emotional performance) in authentic classroom environments within different elementary classrooms, including Special Education and General Education context. Results reveal significant gains in students' cognitive performance -Short-term memory ability (Gsm)- motor skills -Psychomotor ability (Gp) and Psychomotor Speed (Gps)- and academic performance in language and vocabulary acquisition. Findings also show improvements in students' emotional state, resulting in increased students' self-confidence and motivation to participate in learning process. The investigation provides a comprehensive understanding of how EL approaches can be integrated into different real classrooms, allowing researchers and teachers to enrich existing learning environments. To that end, the dissertation concludes with important insights and examples for researchers and educators on how they can implement effectively EL-driven technology in real classroom settings, as a part of the classroom curriculum.

Keywords: embodied cognition, embodied learning, kinesthetic learning, cognitive abilities, academic performance, emotional state, movement, motion-based technology, Kinect-based games, memory, language learning, classroom, school

ΠΕΡΙΛΗΨΗ

Στην εποχή της ραγδαίας τεχνολογικής ανάπτυξης, παρατηρείται μια καθολική προσπάθεια ενίσχυσης και εμπλουτισμού των παραδοσιακών πρακτικών διδασκαλίας και εκμάθησης μέσω διαφόρων τεχνολογικών εργαλείων. Η σύγχρονη θεωρία της Ενσώματης Γνώσης (Embodied Cognition), κάτω από την ομπρέλα της οποίας τοποθετείται και η Ενσώματη Μάθηση (Embodied Learning), είναι ακριβώς μια τέτοια προσέγγιση. Η Ενσώματη Μάθηση αποτελεί μια κιναισθητική και πολυτροπική διαδικασία με ποικίλες δυνατότητες για τον εμπλουτισμό της παραδοσιακής εκπαιδευτικής πρακτικής. Η προσέγγιση της Ενσώματης Μάθησης υποστηρίζει την ένταξη του σώματος των μαθητών και της κίνησης στο περιβάλλον της τάξης. Συγκεκριμένα, αυτό το θεωρητικό πλαίσιο τονίζει την αδιάσπαστη σχέση μεταξύ εγκεφάλου, σώματος και περιβάλλοντος και υποστηρίζει ότι το ενεργό ανθρώπινο σώμα μπορεί να μεταβάλει τη λειτουργία του εγκεφάλου και επομένως τη γνωστική διαδικασία.

Τα τελευταία χρόνια, η χρήση αναδυόμενων τεχνολογιών σε διάφορα εκπαιδευτικά περιβάλλοντα βασίστηκε στις ιδέες της Ενσώματης Μάθησης προσφέροντας μια σημαντική θεώρηση σχετικά με το πώς το ενεργό ανθρώπινο σώμα μπορεί να επηρεάσει τη λειτουργία του εγκεφάλου και να οδηγήσει τελικά στη μάθηση. Η διερεύνηση διαδραστικών μαθησιακών περιβαλλόντων που προάγουν την εμπλοκή της φυσικής δραστηριότητας και του σώματος κατά τη διάρκεια γνωστικών και μαθησιακών εργασιών είναι ο κύριος στόχος αυτής της μελέτης. Ειδικότερα, μέσω μιας παρέμβασης που περιλαμβάνει διάφορες διαδοχικές φάσεις μικτής μεθοδολογίας, η έρευνα αυτή εστιάζει στη διερεύνηση του τρόπου μέσω του οποίου η Ενσώματη Μάθηση επηρεάζει τη συνολική απόδοση των μαθητών στο αυθεντικό περιβάλλον της τάξης κάτω από διαφορετικές συνθήκες και περιστάσεις. Οι εκπαιδευτικές παρεμβάσεις εξετάζουν, συγκεκριμένα, τη συνεισφορά της Ενσώματης Μάθησης στην ανάπτυξη των κινητικών, γνωστικών και ακαδημαϊκών δεξιοτήτων των μαθητών αλλά και τη συναισθηματική τους κατάσταση κατά τη διάρκεια της παρέμβασης.

Αυτή η διατριβή αποτελείται από τέσσερις διαδοχικές φάσεις που αξιοποιούν μικτή μεθοδολογία (ποσοτική και ποιοτική ανάλυση δεδομένων), με στόχο τη διερεύνηση του αντίκτυπου της τεχνολογίας, που βασίζεται στην Ενσώματη Μάθηση, στη διδασκαλία και μάθηση. Τα αποτελέσματα της έρευνας αποδεικνύουν ότι τέτοιου είδους παρεμβάσεις επηρεάζουν θετικά την ανάπτυξη των γνωστικών, κινητικών και ακαδημαϊκών επιδόσεων των μαθητών και βελτιώνουν αισθητά τη συναισθηματική τους κατάσταση. Η εμπειρική έρευνα αποκαλύπτει, επίσης, πώς η Ενσώματη Μάθηση μπορεί να ενσωματωθεί επιτυχώς σε αυθεντικά περιβάλλοντα μάθησης στο πλαίσιο της Ειδικής αλλά και Γενικής Εκπαίδευσης και για συγκεκριμένους μαθησιακούς σκοπούς. Η κατανόηση του τρόπου λειτουργίας της τεχνολογίας στο πλαίσιο της Ενσώματης Μάθησης θα επιτρέψει στους ερευνητές και τους εκπαιδευτικούς να εμπλουτίσουν τα υπάρχοντα περιβάλλοντα μάθησης και διδασκαλίας. Για το σκοπό αυτό, η διατριβή αυτή προσφέρει, μέσα από μια σειρά εμπειρικών ερευνών, μια ολοκληρωμένη εικόνα σχετικά με την εφαρμογή της Ενσώματης Μάθησης μέσω τεχνολογίας σε αυθεντικά περιβάλλοντα μάθησης για συγκεκριμένους εκπαιδευτικούς σκοπούς. Τέλος, τα αποτελέσματα της συγκεκριμένης έρευνας προσφέρουν στους ερευνητές και εκπαιδευτικούς σημαντικές ιδέες, παραδείγματα και οδηγίες για τον τρόπο με τον οποίο μπορεί να εφαρμοστεί αποτελεσματικά η Ενσώματη Μάθηση στην τάξη, ως μέρος μάλιστα του υφιστάμενου προγράμματος σπουδών.

Λέξεις - κλειδιά: ενσώματη γνώση, ενσώματη μάθηση, κιναισθητική μάθηση, γνωστικές δεξιότητες, μαθησιακή επίδοση, συναισθηματική κατάσταση, κίνηση, μνήμη, διαδραστικές τεχνολογίες, εκπαιδευτικά παιχνίδια με kinect, εκμάθηση γλώσσας, τάξη, σχολείο

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LIST OF ABBREVIATIONS

EC:	Embodied Cognition
EL:	Embodied Learning
SE:	Special Education
SEN:	Special Educational Needs
GE:	General Education
HCI:	Human Computer Interaction
RQ:	Research Question
MD:	Multiphase Design
TEL:	Technology Enhanced Learning
EdTech:	Educational Technology
N:	Number
M:	Mean
SD:	Standard Deviation

1 Introduction

This chapter introduces and reviews the background, motive, and scope of this doctoral dissertation. In the following sections, I discuss the relevant past research, which led me to formulate my research questions, as well as the research design and actions taken to address the specific research questions. I also explain why and how this research can be useful for educators in real classroom settings. The chapter concludes with the structure and outline of the dissertation.

1.1 Introduction to the Topic

In the age of technological imperative, massive efforts are underway to enrich traditional teaching and learning practices with technology. Under the umbrella of Embodied Cognition (EC) Theory, Embodied Learning (EL), which builds upon the inseparable link between brain, body, and the world, offers new ways to understand the learning process. The idea that mind and body are closely interlinked (Wilson, 2002) has introduced the involvement of the physical body into the learning process, changing the learning environment, altering learning design, and generating questions about the nature of the relationship between body and mind (cognition).

Existing literature on EC and EL indicates that bodily engagement and movement effects children's cognitive and academic outcomes positively. EL researchers claim that the body next to the mind is a significant factor in the whole learning process, making learning easier through its experiences and interactions with the environment (Foglia & Wilson, 2013; Wilson, 2002). Correctly, the EC theory emphasizes that the brain must be understood in the context of its physical body, whilst, reciprocally, the active body can alter the function of the brain. Through EL, the implications of EC theory have become a significant part of contemporary teaching and learning practices (Foglia & Wilson, 2013; Price, Roussos, Falcão, & Sheridan, 2009; Wilson, 2002).

Embodied Education is the basic concept behind Embodied Teaching and EL (Lindgren & Johnson-Glenberg, 2013). EL places students at the center of the learning process, giving them opportunities for direct physical interaction with learning material (Ayala, Mendívil, Salinas, & Rios, 2013; Chandler & Tricot, 2015) and offering hands-on activities in real classroom environments. EL also provides answers to questions about how knowledge is constructed by students, in so far as bodies are seen as tools for knowledge construction, according to EL (Kalantzis & Cope, 2004). In its role as a tool for knowledge construction, in EL practice the term "body" includes the physical body, the senses, the mind, and the brain, as the whole of the student's personality. According to Lindgren and Johnson-Glenberg (2013), the primary principles underlying the implementation of EL in classrooms are sensorimotor activity, the relevance of gestures to the material that is to be learned, and the emotional involvement of participants in the whole process.

In recent decades, EL has influenced Educational Technology (EdTech), especially Human-Computer Interaction (HCI) and the design of technological environments and objects for learning purposes. Indeed, recent studies in education address the benefits of learning environments designed to incorporate embodied interaction (Dourish, 2001) into children's learning processes (Marshall, Price, & Rogers, 2003). EL has gained such a foothold in education theory that designers and learning scientists can no longer afford not to take EL principles into account when designing mediated content (Trninic & Abrahamson, 2013).

Considering all of this, it is not surprising that the exploration of interactive learning environments that integrate bodily movements into cognitive and academic tasks is gaining traction in the research community. The use of EL technologies like motion-based games, Kinect-based games, Wii and exergames in educational settings builds on the ideas of EC and EL practices and provides insights into how the active body can influence the function of the brain and drive learning. To this end, international studies highlight the positive impact of movement on children's learning, their increased engagement in their lessons and improvement in their abilities to focus their attention. According to Berthhoz (1998), learning takes place through the body and all its senses, whilst movement plays a significant role in how we control our body in space and in relation to others.

Despite the recent growing interest in EC and EL in educational settings, the empirical research focusing on its integration and impact on school settings is limited (Malinverni, Mora-Guiard, Padillo, Valero, Hervás, & Pares, 2016, Kosmas & Zaphiris, 2018). There also aren't many successful case studies to guide educators who want to introduce EL into their classrooms. The overarching goal of this research is to provide new insights, examples, and deeper understanding of using EL as a teaching paradigm. These insights and examples could inform researchers and practitioners who want to integrate EL-driven technology into real classroom environments. To achieve this, in this dissertation, I show how EL-driven technology was implemented successfully in a variety of learning contexts and circumstances and then present findings from four empirical studies conducted in authentic classroom environments.

1.2 Purpose and Research Questions

This dissertation looks at EL in different learning contexts and circumstances to see how it can improve the overall performance of students in real classroom settings for specific learning purposes. The reason for exploring EL in different classroom settings wasn’t to identify or understand similarities and differences between settings or to replicate our findings across them but to inform a set of guidelines for using EL-driven technology in real learning settings that could be useful to educators. In this direction, the findings of this work could advance theory and practice in learning and teaching that is useful to others. The research was conducted in four phases and addresses eight research questions. Phase A and Phase B were conducted in a Special Education (SE) context with Special Educational Needs (SEN) children to see how EL works as a personalized intervention in a special classroom environment with a small group of children. Phase C and Phase D were conducted in a General Education (GE) context - typically developing students- to examine the effects of EL on larger groups of children.

- *Phase A* served as a pilot study for examining EL through Kinect-based games in a small group of SEN children. Specifically, Phase A explored how EL impacted SEN students’ motor performance as a personalized intervention in an authentic SE classroom [RQ1]. We took into consideration not only kinetic analytics but also the teachers’ perceived experiences of the development of their children’s motor skills.
- *Phase B* looked at how EL impacted SEN students’ cognitive and emotional performance in the special classroom. Mainly, this phase aimed to reveal how motion-based EL-driven technology influenced short-term memory skills [RQ2]. Additionally, Phase B examined whether this intervention impacted the emotional performance of SEN students [RQ3].

- *Phase C* focused on applying EL-driven technology in a GE context. In this phase, we examined how EL-driven, motion-based technology improved short-term memory skills [RQ4] and how it impacted specific academic skills like vocabulary and language acquisition [RQ5].
- *Phase D* used the findings from previous phases to implement EL in a class-wide GE context. This last cycle of research looked at the impact of EL using a movement-based intervention called PanBoy, which was developed specifically for this study. Our aim in developing PanBoy was to explore how an EL intervention would impact vocabulary and language acquisition [RQ6] and how it would improve GE students' emotional states [RQ7]. Finally, this phase aimed at addressing how EL could be implemented in an authentic, class-wide GE setting [RQ8].

The following Figure 1 is a schematic representation of the research questions used in the four phases of the investigation.

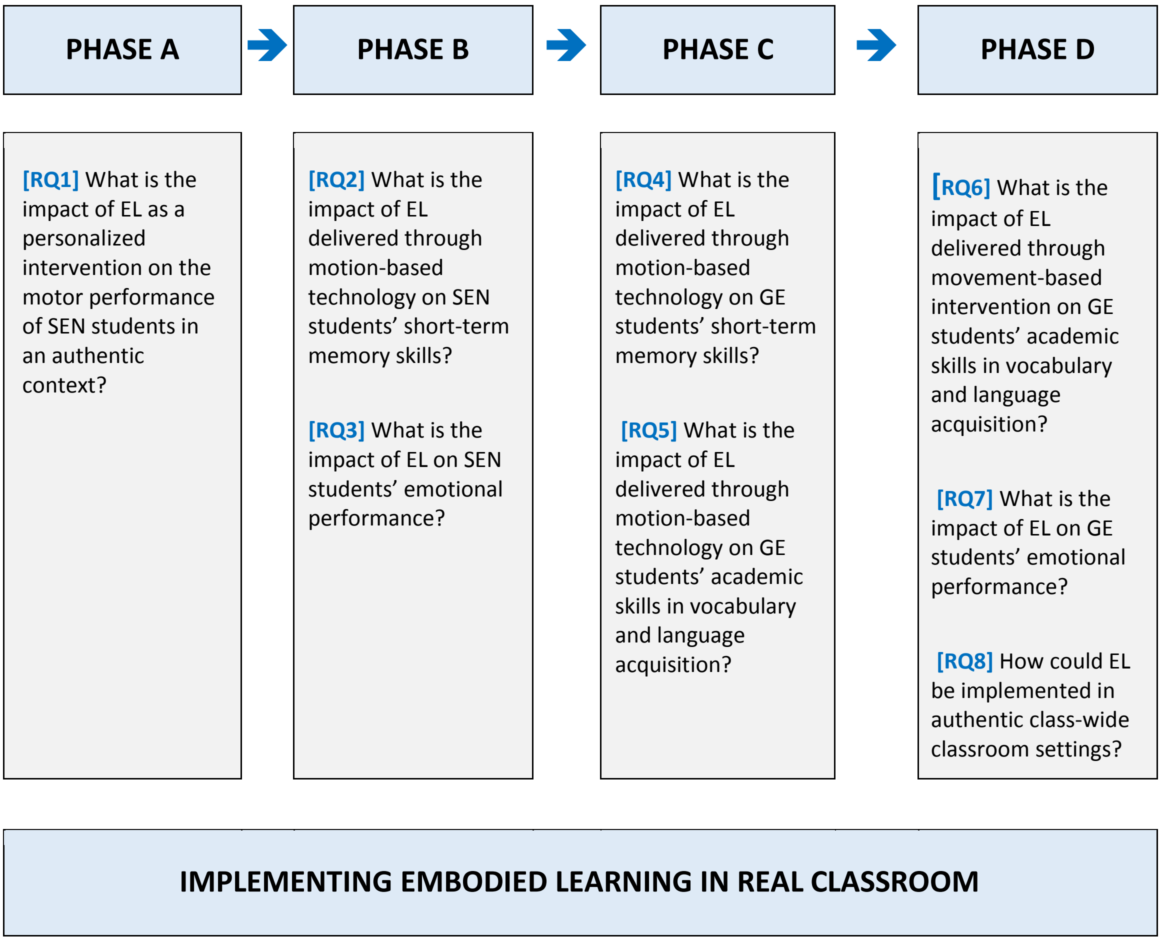


Figure 1: Research questions as divided across the four phases of this dissertation

1.3 Research Design and Context

To implement EL theory in real-world classrooms, this research used a mixed methods research approach. In particular, the dissertation follows the Multiphase Design (MD) strategy, which involves multiple levels of data collection and analysis, as well as multiple case studies (Creswell & Clark, 2007).

The research was conducted in four consecutive phases. Each phase addressed different research questions, but the goal of all the phases was the same: to provide a deeper understanding of EL practice and to offer insights to researchers and practitioners who want to implement EL in the classroom. The first study was exploratory. Using a small group of students, I wanted to determine if EL could be introduced into an actual classroom setting. The other three phases were designed to examine how EL impacted students' overall performance (i.e., motor, cognitive, academic, emotional). This multiphase design allowed me to replicate the method in order to validate my findings across phases with a focus on understanding, explaining, and interpreting student gains in each phase. All four phases were conducted in real classrooms using different participants.

All the interventions were carried out in authentic classroom environments in elementary schools in Cyprus. The first two phases of the study (Phase A and Phase B) were conducted in an SE context with SEN children. SEN students who participated in the research attended special units of mainstream elementary schools and had comorbid difficulties that affected their ability to learn. Given the fact that nowadays most classrooms have heterogeneous mixes of children from different backgrounds and with different abilities, educators need to find ways to engage all their students in the learning process. For that reason, the goal of Phase A and Phase B was to see how EL techniques could be implemented in a special classroom environment with a small group of children. The other two phases, Phase C and Phase D, were conducted in GE contexts with students with typical development in order to see if the ideas from the previous phases (A and B) could be replicated in authentic GE classrooms with similar gains in students' overall performance (see Figure 2). It should be noted that the value of EC was taken as given in this dissertation. The aim was to examine how such a practice can become a reality in authentic classroom environments with significant gains for students.

Phase A
- Special Education Classroom - 10 students

Phase B
- Special Education Classroom - 31 students

Phase C
- General Education Classroom - 52 students

Phase D
- General Education Classroom - 118 students

Figure 2: Classroom context and participants of the four phases of investigation

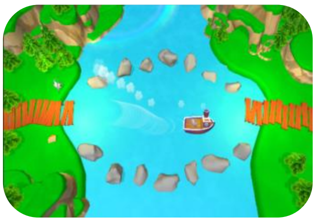
1.4 Using Technology in Embodied Learning

Building on the idea of EL-driven technology, the first three phases of our research (Phase A, B, C) were implemented EL into the classroom via motion-based technology. Specifically, I used the commercial suite of Kinect movement-based interactive educational games called Kinems (www.kinems.com).

Previous research suggests that Kinems games have many positive effects on children and can be used to develop a variety of verbal, math and motor skills (Kourakli et al., 2016; Retalis et al., 2014). Kinems games, which use the Microsoft Kinect camera, engage students in learning through the natural interaction of their bodies and hands. These games are suitable for early elementary or pre-school/ kindergarten-aged children of typical development or for SEN children (Retalis et al., 2014). A unique aspect of Kinems is that children's interaction, performance, and movements during the intervention sessions are recorded on a cloud server, which allows researchers and practitioners to extract conclusions about participants' progress. The Kinems suite includes more than 20 interactive games that target a variety of skills (e.g., motor, cognitive, and academic), based on the Cattell-Horn-Carroll Integrated Model of skills classification, which is the most widely used empirically supported model of cognitive abilities (Cattell, 1971; Schneider & McGrew, 2012).

In each phase of the investigation, games were chosen to match the research questions and interests of the students. It is important to note that these interactive games were integrated into existing lesson plans to enrich conventional learning and teaching. The following Table 1 shows how Kinems learning games were integrating into the classroom to enhance the learning of specific skills. A detailed description of the games used in each phase is provided in the following chapters.

Table 1: The use of motion-based Kinems games in Phases A, B and C

Phase A	**Phase B**	**Phase C**
Motor Skills Psychomotor Ability (Gp) Psychomotor Speed (Gps)	Cognitive Skills Short-term memory (Gsm)	Cognitive Skills Short-term memory (Gsm) Academic Skills Language – Vocabulary (Gc)
 *Walks*	 *Unboxit*	 *Unboxit*
 *River Crossing*	 *Melody Tree*	 *Lexis*

In the fourth and final phase, we developed a movement-based intervention taking into consideration the results from previous phases. The movement-based intervention was created at Get Lab (http://getlab.org/) with the help of researchers Maria Christofi and Christos Kyrlitsias. I called it PanBoy. PanBoy combines bodily movements with target vocabulary used in first and second-grade curriculum (see Figure 3). My aim in creating

PanBoy was to give first and second-grade teachers a simple, affordable tool for enhancing vocabulary and language acquisition using bodily movements. The intervention includes class-wide activities that can be integrated into the individual class curriculum. A detailed description of the development of PanBoy (Phase 4) appears in Chapter 8 (8.3.2).

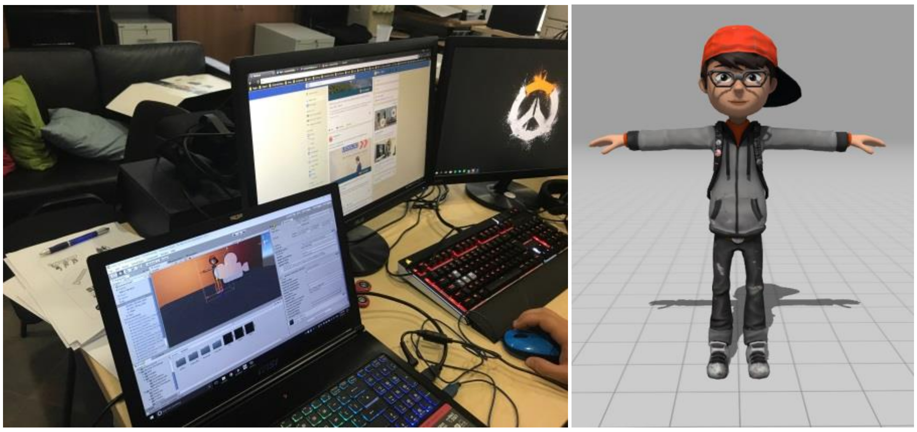


Figure 3: Developing the PanBoy movement-based intervention for Phase D

1.5 The Importance of this Work

The integration of technology into EC theory is an area that is ripe for exploration with so many concerns, unanswered issues and, especially questions concerning how the body can be used as a locus of learning. As Antle and Wise (2013) have pointed out, the embodied theory is still largely empirically unexplored.

There is, however, a large body of literature on the importance of embodied theory to learning and teaching which points to the need to move from abstract teaching and learning to active teaching and learning that uses learners' bodies to learn new skills. Despite the fact that many empirical studies conducted on learning and technology in the last two decades have shown that bodily movement enhances learning, up to now theoretical approaches have failed to explain clearly exactly how the body influences cognition and how it is essential for cognitive work (Glenberg Witt, & Metcalfe, 2013). In addition, there are few educational interventions based on EC and EL principles which combine this embodied view of learning with technology in authentic learning contexts. According to Kirsh (2013), this area of investigation needs theory combined with strong empirical support for how human bodies can enhance cognitive processes.

Furthermore, to date, no one has explored the value of most current EL technologies and the role they might play in facilitating new pedagogies and better learning in formal educational environments. As I mentioned earlier, the importance of EC theory was taken as given in this dissertation. Previous bibliographic and empirical research in the area has demonstrated the positive impact of this practice on the development of the cognitive and academic performance of children. They have even revealed the impact of this framework on improving the emotional state of children by enhancing their involvement in the learning process and by encouraging their motivation for learning. This research attempts to show precisely how EL-driven technology can be implemented in authentic learning environments and examines how such practice can effectively become a reality in the classroom, as a part of the classroom curriculum.

Additionally, the research, through a series of empirical studies in different learning environments, offers a set of new insights or guidelines for the implementation of EL in the classroom via technology in order to develop specific cognitive and academic skills, as well as to improve the emotional performance of the students. The dissertation also provides examples of how EL can be implemented in special and general classroom environments, as a personalized intervention as well as class-wide intervention, offering a more coherent understanding of how technologies can be used as EL tools that would allow learners to engage more deeply in learning processes. As well known, learning spaces-driven technology without properly designed learning activities do not engage students in the process.

It is a fact that many educators and school systems feel that learning only takes place when children are sitting. Usually, teachers aren’t familiar with even the fundamental advantages of being actively engaged in learning through the body (Hynes-Dusel, 2002). But the fact is, children, especially in early childhood, love movement and playing games and usually prefer to stand up to experience and interact with the learning content while learning. In this sense, no one would disagree with Hannaford (2005) when he says that *learning is not all in the head*. But, as we have said, too many educators are unaware of the consequences of divorcing movement from education. Due to lack of movement activities in classrooms children are unable to benefit holistically from the inclusion of movement in the school program. This dissertation suggests the opposite, that not only is movement beneficial to learning, but it is also actually essential.

One important contribution of this work is that it provides empirical evidence for the impact of EL-driven technology in real classroom environments. The fact that this research was conducted in authentic classrooms in different contexts and circumstances would allow researchers and practitioners to pinpoint where, when and how EL could enhance and facilitate learning and what the added benefits are for each situation. Thus, this research provides a holistic view of the implementation of EL, including implementation in SE and GE classroom settings, and giving significant insight on how we can integrate movement in learning contexts considering the body and mind as a whole in the learning process.

The most important contribution of this research, however, is the argument it makes for moving the discussion about EC and EL further in the direction of EdTech, encouraging more empirical research into authentic learning environments. Furthermore, the conclusions we've drawn based on our findings can give educators, researchers, and practitioners a better understanding of the capabilities and particularities of EL-driven technology and how it can be used for learning purposes. This will hopefully lead to new perspectives and directions for its use. Last but not least, the proposed set of guidelines can serve as guiding principles for curriculum design, classroom orchestration and practice, and future teaching methods. The findings of the dissertation can be the starting point for creating a completed theoretical and methodological model for the implementation of such embodied practices in the school environment as part of the curriculum.

1.6 Structure of the Dissertation

The current dissertation is structured into eight chapters, in addition to this introduction, as illustrated in Figure 4:

- *Chapter 2*: Theoretical Framework. This chapter introduces and identifies the mainstream scientific paradigm of EC theory, with a focus on EL and how it relates to EC theory. The synergies between EC, Education, and HCI are also discussed.
- *Chapter 3*: EC and its implications for Education: A review of the empirical research. This chapter explores developments in the field of EC by building a map of the existing research in the area that is based on a review of recent empirical research conducted in the field with a focus on the implementation of EL through technology.
- *Chapter 4*: Methodology. This chapter discusses the methodology and the different phases of data collection and analysis involved in this dissertation.
- *Chapter 5*: Phase A, Piloting EL in an SE Context. This chapter presents the findings of our first EL study, which was conducted with a small group of students within an authentic SE context.
- *Chapter 6*: Phase B, Examining the Impact of EL on Student Performance in an SE context. This chapter showcases the findings of Phase B within the context of SE, examining the potential impact of EL on students' cognitive and emotional performance.
- *Chapter 7*: Phase C, Examining the Impact of EL on Students 'Cognitive and Academic Performance in a GE Context. Chapter 7 presents the findings of the third study, which was conducted in a GE setting where EL was introduced into an actual classroom curriculum using Kinect-based games.
- *Chapter 8*: Phase D, Developing and implementing a movement-based intervention in a class-wide GE classroom. This chapter reports on the fourth and final phase of this dissertation, which implemented a movement-based learning intervention in a classroom. The intervention was developed for first and second graders in authentic GE classrooms. This final study examines

whether EL can enhance the overall performance of students in a class-wide context.

- *Chapter 9*: Discussion. This chapter discusses the findings of the different phases of this research, taking into account results from all previous chapters and providing insights into the use of EL-driven technology in real classrooms.

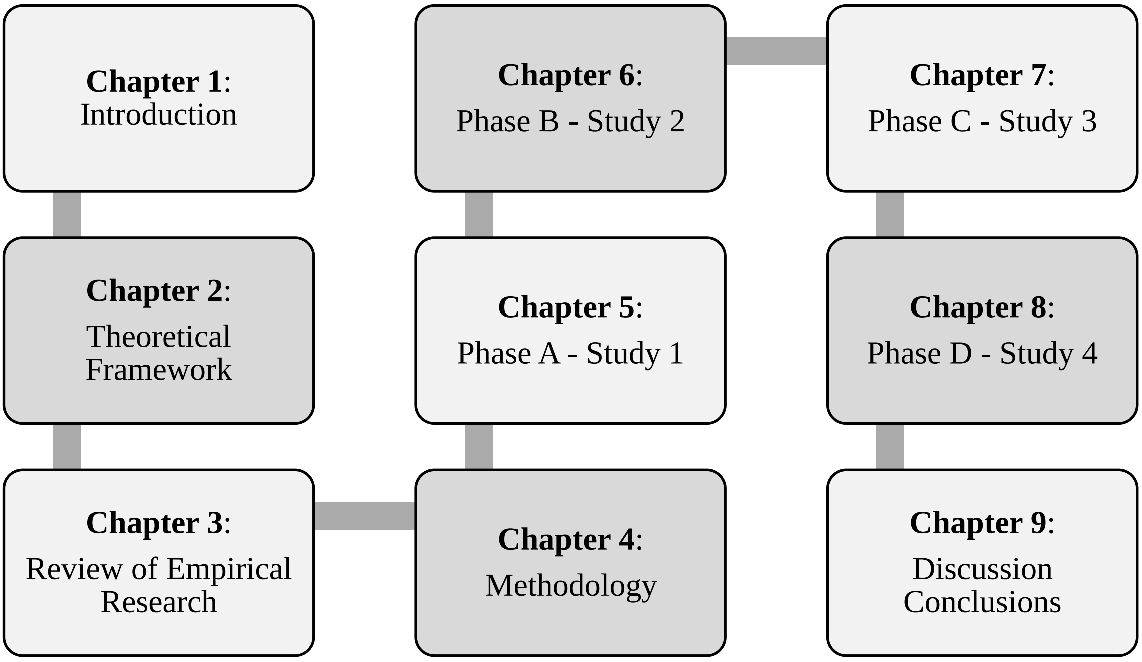


Figure 4: Flowchart of the dissertation chapters

2 Theoretical Framework

This chapter introduces and identifies the mainstream scientific paradigm of EC theory (Gallese, 2005), which is the theoretical basis for this dissertation. EC theory, whose basic assumption is that the body is an integral part of learning, has been a point of interest for contemporary education researchers for decades now (Paloma, 2017) and has a close relationship with many fields, including education and HCI. Foundations, definitions and related theoretical approaches will be discussed as they appear in the literature. In the second part of this chapter, we explore EL, under the umbrella of EC theory, and analyze the relationship between theory, education, and HCI.

2.1 Introduction

Well known discoveries about learning, including learning circumstances and learning achievement, can be systematically combined into so-called Theories of learning (Ebner, Holzinger, & Maurer, 2007). In the history of Pedagogy, a lot of theories have been presented by famous educators and scientists. The theoretical framework of these theories takes into account aspects such as the teacher's role in the class, the innovative learning environments, the interaction between students, the social framework of knowledge and many other related aspects.

In recent years, the theory of EC has brought to the light the involvement of physical body and activity into the learning process, changing the way of learning and creating questions about the role of body in cognitive processes. So far, the implication and the dynamic presence of EC in many different disciplines such as psychology, cognitive science, education, neuroscience, and HCI, indicates the great potential of this theory across many disciplines (Davis, & Markman, 2012; Farr et al., 2012). It bears mentioning that studies around EC rose very fast in prominence towards the end of last century and it seems to be a trend in the research area of the fields mentioned above (Trninic, & Abrahamson, 2013).

The orientation of EC that argues that mind and body are closely interlinked (Wilson, 2002), has obviously many influences in learning and emphasizes the role of bodily experience in education in relation to childhood and adolescence (Paloma, 2017). This section reviews the theory of EC from its appearance in last decades towards its more recent implementations. By examining recent research conducted under the EC theory, this section frames critical ideas of this theory and their evolution over time. At the same time, obstacles, challenges, and critiques towards embodied theory for educational practices are also pointed out.

2.2 Embodied Cognition: Basic Theoretical Underpinnings

EC considers that the body in conjunction with the mind plays a significant role in the cognitive mechanism (Wilson, 2002) and that learning occurs when bodily movements, physical interaction, and sensorimotor abilities are linked with the learning content (Ayala, Mendívil, Salinas, & Rios, 2013; Anderson, 2003). EL practice, as a part of EC theory, constitutes a contemporary pedagogical learning paradigm which emphasizes the use of the body in the educational practice (Wilson, 2002). According to the EC theorists, both body and mind are able to produce the knowledge significantly by integrating the physical interaction in learning. In that way, as Atkinson (2010) states “we experience, understand, and act on the world through our bodies” (p. 599).

EC has now been proved to be a significant part of contemporary theories of cognitive sciences. Generally, the fascinating insight of the EC theory is that behavior is not simply the output of someone's isolated brain (Anderson, 2003; Clark, 1999; Thelen, 1995). The emerging viewpoint of EC holds that cognitive processes are deeply rooted in the body’s interactions with the world (Wilson, 2002). Consequently, in this theoretical approach, the body plays a central role in shaping the mind. Along the same lines, in this perspective, the mind is not only connected to the body, but the body influences the mind.

Lakoff (2012) explains the EC as cognition depending on the body with all its sensorimotor capacities and characteristics and its experiences in that way in which the body is inseparably connected to the mind. In doing so, humans’ cognition is influenced by their experiences in the physical world. In the literature, there are many definitions of EC. Researchers, scholars, and academic authors try to connect the theory of EC with different disciplines and fields.

The common idea about the theory of EC is that the body plays a significant role in shaping the mind. Wilson (2002), trying to determine the general thesis of EC gives the following definition:

> "Many features of cognition are embodied in that they are deeply dependent upon characteristics of the physical body of an agent, such that the agent's beyond the brain, body plays a significant causal role, or a physically constitutive role, in that agent's cognitive processing".

In the same line, from the psychological perspective of cognition, Barsalou (2008; 2010) proposed the theory of EC, stating that the form of the human body can determine the nature of the human mind and that the cognition shaped by aspects of the body including body morphology, sensory-motor capacities, and interactions with the world. This interactivity with the physical world and the essential role of the environment in cognitive processes was mentioned by many researchers from different fields (Hurtienne, 2009; Aizawa, 2014; Anderson, Richardson, & Chemero, 2012; Dijkstra, Eerland, Zijlmans, & Post, 2014; Farr, Price, & Jewitt, 2012; Flanagan, 2013). Especially, psychology researchers draw their attention to the importance of interaction with the environment as the place where thoughts, feelings, and behaviors are grounded in bodily interaction with this (Meier, Schnall, Schwarz, & Bargh, 2012).

Collectively, the literature agrees that the EC refers to the idea that the body influences the mind. Is the belief that humans' ability to gain knowledge, comprehend, remember, judge, and problem-solving are not confined to the brain. In this view, cognition then is influenced, if not determined, by humans' experiences with the world (Wilson, 2002; Atkinson, 2010; Hurtienne, 2009; Klemmer, Hartmann, & Takayama, 2006; Anderson, 2003; Clark, 1999; Barsalou, 2010; Foglia, & Wilson, 2013; Glenberg, Witt, & Metcalfe, 2013; Kiefer, & Trumpp, 2012).

What's more, the emerging viewpoint of EC theory is founded on the idea that the mind must be understood only through its relationship to the bodily interactions in the world (see Figure 5). Wilson (2002, p.626), in order to explain the term of EC in a more meaningful way, suggest six claims, which are considerable in the EC research:

- *Cognition is Situated*: Cognition takes place in the context where the interactivity with the things related to cognitive activity happens.
- *Cognition is Time Pressured*: How cognition functions under the pressures of real-time interaction with the environment.

- *We off-load cognitive work onto the environment*: Because of limits on our information-processing abilities.
- *The environment is part of the cognitive system*. The connection between mind and world is continuous and meaningful.
- *Cognition is for action*: The mind's function is to guide action in the way that behavior and environment are interdependent.
- *Off-line cognition is body-based*: This is the most crucial aspect of EC, as all physical activity feeds into online cognition at some level.

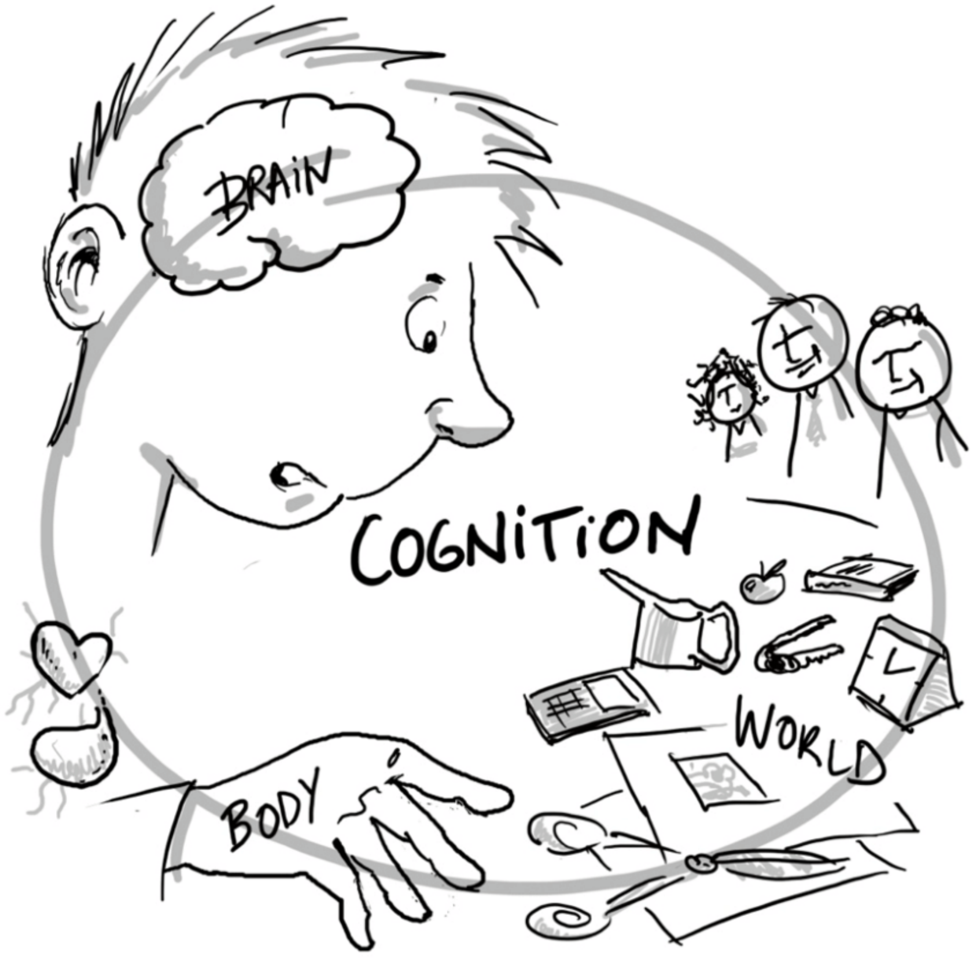


Figure 5: The Embodied Cognition view of knowledge

Resource: van Dijk, Mulder and van der Lugt, (2013) What is more, Spackman and Yanchar (2014, p. 48) in their review on EC proposed four prominent themes in accordance with EC: 1) Embodied Mind, 2) memory is distributed across the body, environment, and tools, 3) language and abstract concepts are understood through situated embodied action and 4) perception and action are inseparable. In the following sections, I reflect on critical theoretical approaches around EC starting from the origins and foundations of the theory.

2.2.1 Origins and Foundations of Embodied Theory

What follows in this section, outlines the basic foundations of the theory of EC very briefly. The theory has a relatively short history in the academic research, and it has only been studied empirically in the last decades.

Theories regarding EC have attracted significant attention in cognitive sciences over the past 20 years; however, have a long and complicated history. The discussion about the relationship between mind and body started from the ancient era of Plato, who has argued that the soul (mind) was separate from the body. This separation remains until the 18th century through the works of the philosophers Locke and Kant, who has noted the vital role of interaction with objects which can affect the people's senses. Afterward, Descartes proposed the mind-body *dualism*, giving more attention to perception and how the mind acquires ideas (Farr et al., 2012).

The origins of the EC can be found in the phenomenology that demonstrates the embodied nature of cognition, including basic perceptual processes (Wilson & Golonka, 2013). Since 1980, Lakoff and Johnson’s in their work titled as “Metaphors we live by” (1980) suggest that our way of reasoning and thinking is derived from our bodily actions. The understanding, according to Lakoff and Johnson (1980), is shaped by our experience on the particular physical form of our bodies and their everyday interaction with the real world. Moreover, on the ongoing research in the areas of EC, Lakoff and Johnson (1999) claim that abstract thinking is grounded in the sensorimotor experience of the physical world.

Different studies at the beginning of the 20th century opposed the dualism of the Cartesian view and proposed instead that the mind and body are intertwined in perceiving and experiencing the world (Bianchi-Berthouze, 2013). As mentioned earlier, the most prominent phenomenological account underpinning embodied theory is the “lived-body” as proposed by French philosopher and psychologist Maurice Merleau-Ponty (Leitan & Chaffey, 2014) in that way that we can say that EC theory has its philosophical roots in Merleau-Ponty’s work. In particularly, Merleau-Ponty views the body as an undivided unity, and she noted that the perceptual process is linked not only to all of the human’s senses but also in the total physical environment in which the body is situated. To date, for Merleau-Ponty, there is no perception without action (Svanæs, 2013). The body is the perceiver and perception involving both sensory and motor processes.

Since 1990 talking about embodiment and situatedness has become increasingly frequent in philosophy (Stolz, 2014; Anderson, 2003; Clark, 2008;), psychology (Aizawa, 2014; Chandler, & Tricot, 2015; Dijkstra et al., 2014; Häfner, 2013; Glenberg et al., 2013; Macedonia, 2014; Willems, & Francken, 2012; Wellsby, & Pexman, 2014), neuroscience (Kiefer, & Trumpp, 2012; Flanagan, 2013; Fors, Bäckström, & Pink, 2012) robotics (Birchfield, et al., 2008), education (Abrahamson, 2013; Ayala et al., 2013; Chandler, & Tricot, 2015; Chang, Chien, Chiang, Lin, & Lai, 2013; Chao, Huang, Fang, & Chen, 2013), cognitive anthropology, linguistics and language learning (Ambrosini, Scorolli, Borghi, & Costantini, 2012; Dove, 2014; Lakoff, 2012; Lan, Chen, Li, & Grant, 2015; Macedonia, 2014; Sandler, 2012; Van Dam, Van Dijk, Bekkering, & Rueschemeyer, 2012; Kuo, Hsu, Fang, & Chen, 2014), and in dynamical systems approaches to behaviour and thought (Spencer, Perone, & Johnson, 2008).

For over fifty years in philosophical debate, there has been a rethinking of the characteristics and the nature of cognition (Anderson, 2003). In philosophy, in contrast to Cartesian ideas where thinking is considered separate from the body, move to the idea that the cognitive functioning is the result of the relationship between mind, body and the environment (Price et al., 2009).

Overall, according to Nunez, (2012) EC has brought forth a diverse collection of theoretical issues starting from the philosophical mind-body problem, to the phenomenology of bodily experience, to the grounding of cognitive development through environmental aspects. The beginnings of EC in the 1980s, conducted by philosophical work in phenomenology (Dreyfus, 1996), and advances in cognitive psychology (Barsalou, 2010) and cognitive linguistics (Lakoff & Johnson, 1980), among others, emerged as the idea of the mind as embodied and situated.

2.2.2 Embodied Cognition: Related Theories and Approaches

Over these years, other relevant theories and approaches have been linked to this theory, explaining in a broader range the prospects and implications of the EC theory. The most common theoretical aspect in literature, with the EC theory, is *embodiment*. As Farr et al. (2012) state, theories of embodiment within cognitive science generally sit under the umbrella of EC. Embodiment theory, like EC theory, views the body inseparable from the mind and emphasizes the role of the external environment in cognitive processes. Dreyfus (1996), discussing the work of Merleau-Ponty, points out three different meanings of the embodiment. The first is the physical embodiment of a human subject; the second is the set of bodily skills and situational responses that we have developed; and the third is the cultural "skills," abilities and understandings that we responsively gain from the cultural world in which we are embedded.

Also, Hung et al. (2014), propose the *embodiment-based learning*, in order to explain how embodiment enhances the performance of comprehending in educational settings. In the same way, Abrahamson and Lindgren, (2014) believe that the embodiment approach can help educators to create more effective learning environments in which learners can work in a disciplinary perspective. The importance of embodiment in the learning environments has also been emphasized by Trninic and Abrahamson (2012), who has talked about its application to Mathematics Education. Rogers (2012), discussing the role of embodiment in HCI, explains that it is about understanding interaction regarding practical engagement with the social and physical environment. Above all, theories of embodiment provide additional theoretical support for understanding how our physical bodies both aid how we interact with and reason about phenomena in the world (Piper, Friedman, & Hollan, 2012).

Furthermore, some scholars distinguish the term *grounded* from the term *embodied*, especially the literature with particular interest to the psychological perspective of EC. Grounded cognition encompasses a variety of theories which support together two assumptions: that cognition involves bodily interactions with the world, and that these interactions are represented in the brain (Barsalou, 2008; Lakoff & Johnson, 1999). Similarly, according to Ionescu and Vasc (2014) "human cognition is fundamentally grounded in sensory-motor processes and in our body's morphology and internal states".

Likewise, De Bruin and Kastner, (2012) talking about the idea of *enactivism*, contend the cognition is grounded in the activities with the environment of an autonomous agent.

The theory that seems to have a direct relationship with EC theory is *Situated Cognition*. Indeed, many times in the literature, embodied goes together with situated cognition. Situated appears as a synonym of embodied, like in the Garg's work (2012), where the viewpoint known as EC treats cognition as an activity that is structured by body and its situatedness in its environment. In other studies, the authors referred to the situated embodied action, which can affect the processing of cognitive procedure (Spackman, & Yanchar, 2014; Kuo et al. 2014; O'Hara, Harper, Mentis, Sellen & Taylor, 2013; Rambusch, 2006). As Wilson (2002) says, "Situated Cognition is cognition that takes place in the context of task-relevant inputs and outputs and involves interaction with the things that the cognitive activity is about" (p.626). Generally, although it is evident that these two theories, Embodied and Situated Cognition, are complementary and closely related (Anderson, 2003), the relation between embodied and situated theory, yet isn't clear or well-defined (Rambusch, 2006). This dissertation adopts the term *embodied* to explain the idea of physical engagement/involvement in the learning process. In the following Figure 6 the relevant approaches/theories to EC are presented.

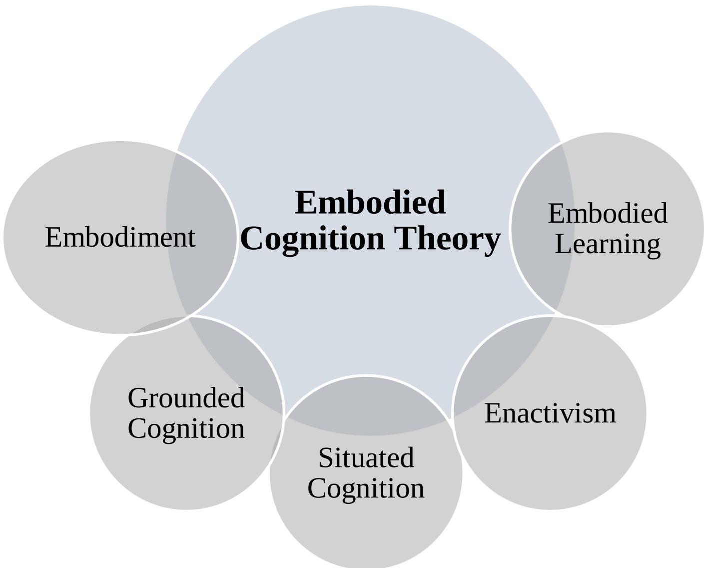


Figure 6: Theoretical Frameworks around Embodied Cognition

2.2.3 Criticism to Embodied Cognition

The critical consideration in debates around EC is the reunification of the body, action, and mind and the development of cognitive abilities and capacities in the interaction with the environmental aspects (Atkinson, 2010; Foglia, & Wilson, 2013; Wilson, 2002; Barsalou, 2010). Many questions of how the mind is embodied have been intensely debated in cognitive science due to a number of criticisms (Hall, & Nemirovsky, 2012; Goldinger, Papesh, Barnhart, Hansen, & Hout, 2016).

Indeed, during the last decades, this point of embodied view has accepted a lot of criticism from the theorists and cognitive researchers (Borghi, & Cimatti, 2010; Smith, & Gasser, 2005; Foglia, & Wilson, 2013). The close relationship between body and mind has revolutionized the field of cognitive sciences because this theory is coming to shake down the fundamental assumptions about the development of human cognition. The big difference from traditional view is that the EC gives attention to the dynamic interplay between bodily shapes and experiences with the whole brain system and their interaction in real-life context and environment (Aizawa, 2014). Goldinger et al. (2016) critically examined the key ideas derived from EC indicating that “EC is often vaguely defined, with various authors attempting to clarify what the field actually entails” (p. 960). They also claimed that however, the theory has an extraordinary level of activity in contemporary research, is still unable to address certain and adequate conclusions due to the lack of enough compelling evidence (Goldinger et al., 2016).

Also, this view of cognitive processes stands in opposition to more traditional notions of internal representation and brain thinking and ability. As Anderson (2003) mentioned, criticism is that EC cannot be right because the physically disabled are apparently able to learn, communicate and acquire concepts. The answer to this claim is that everyone is able to understand and comprehend things, which they have not experienced at all, through imagination, demonstration, and testimony. In that way, the physically disabled are in this regard no different from other people (Anderson, 2003).

According to the theory of EC, the body and mind are dependent on each other. About this dualism, standard cognitive scientists claim that the brain is the only producer of cognition and completely ignore the role of the environment and the dependence of mind on the body (Wilson, 2002). Contrary to this statement of standard cognition principles, the EC theory argues that cognition can occur as a continuous interaction between a mind, a body, and a world.

2.3 Embodied Cognition and Education

During the last century, EC emerged as a new theoretical model, promoting the integration of the body into the general system of cognition and introducing movement into learning and teaching practice. EC is a significant educational development as it provides alternative learning strategies, especially those that take advantage of emerging embodied technologies. In the following sections, we explore how EC and EL have been used up to now in educational settings.

2.3.1 Embodied Education

Embodied Education has been defined as the basic concept which includes Embodied Teaching and Embodied Learning (Lindgren & Johnson-Glenberg, 2013). The characteristics of EL provide answers to questions related to the ways students construct knowledge while they view everyone's body as a tool for knowledge construction (Kalantzis & Cope, 2004). In particular, the term "body" in EL practice includes the physical body, the senses, the mind, and the brain, that is the whole of the student's personality. The idea of the body in education is discussed by Zembylas (2007, p. 30–1) who talked about:

> "An embodied and effective pedagogy which is both a process and a product of particular teaching practices employed in the classroom and how these practices are realized as effects on and in teachers' and students' bodies".

According to Lindgren and Johnson- Glenberg (2013) the primary principles of the implementation of EL are the following: the sensorimotor activity, the relevance of gestures to the theme that is to be reproduced and the emotional involvement of participant in the whole process. The premise of how mind and body are closely interlinked (Wilson 2002) has brought to light the participation of the physical body in the learning process, changing the learning environment, altering the learning design, and generating questions about the nature of the relationship between body and mind (cognition).

Embodied design and learning provide an alternative form of teaching and learning, enriching the conventional educational practice (Abrahamson 2013). As explained by Nguyen and Larson (2015) in embodied learning contexts, students are not only minds but also sensorimotor bodies and social beings. That is, EL, as a teaching method, provides ways of engaging the physical body in multimodal learning experiences aiming to improve the learners' cognitive abilities (Wilson 2002).

In last decades EL has influenced the EdTech field, especially the HCI and the design of technological environments and objects for learning purposes. Indeed, the theoretical approach of EL has informed interaction and user-experience design. Recently, studies in education address the benefits of learning environments designed to incorporate embodied interaction (Dourish, 2001) in children's learning processes (Marshall, Price, & Rogers, 2003). While new technologies are continually being designed, designers and learning scientists should take into account EL characteristics and principles when developing mediated content (Trninic & Abrahamson, 2013).

2.3.2 Embodied Learning

Embodied learning is coming into vogue during the last decades, seeking for how EC theory can help the educational field to benefit from it. For learning scientists, the meaning of EL is the understanding and retention which are affected by sensory input. EL occurs not only in the brain but also through existing and new experiences engaged in by our bodily actions, and thus we can learn new things and content in a more profound impression achieving higher learning and increasing our knowledge retention (Hung et al., 2014; Atkinson, 2010; Riconscente, 2013; Macedonia, 2014; Chang et al., 2013; Kuo et al., 2014). Moreover, learning under embodied circumstances may support active learning (Evans, & Rick, 2014) in which action plays a vital role in the whole learning processes (Davis, & Markman, 2012).

Hung et al. (2014) talk about embodiment-based learning for various learning purposes across many subjects. The role of embodiment in learning is to give a chance for exploration of the learning world and for better comprehension of how things relate to each other and to us in the world (Stolz, 2014). In the EL environment, as Nguyen and Larson (2015, p.342) noted:

> “Learners are simultaneously sensorimotor bodies, reflective minds, and social beings. EL provides a way through which alternative forms of teaching and learning can be integrated and accepted into the classroom”.

As mentioned earlier, the use of the body in practice includes the physical body, the senses, the mind, and the brain and according to Lindgren and Johnson-Glenberg (2013), the characteristics of this embodied approach are the sensorimotor input, the appropriate gestures/movements based on the learning content and the learner’s emotional engagement.

According to the researchers, the human sensorimotor system, which is sensory input, perceptual processing, and muscle control, is capable of finding solutions in the physical environment and understanding general learning tasks such as reading, writing, math, and other subjects (McClelland, Pitt, & Stein 2015). So far, the connection between sensorimotor representations, learning, and control physical actions examined by scholars (see Gallese & Lakoff 2005) and becomes prominent research issue not only in neuroscience but also in linguistics and cognitive science (Boulenger et al. 2006). Researchers in the area claim that the highest percentage of human cognitive ability is based on bodily capabilities to produce knowledge (Wilson 2002; Gallese & Lakoff 2005). The general argument of these theoretical approaches around the body is that physical activity or physical engagement has an impact on cognitive/brain functioning and from this perspective facilitates the learning tasks and goals.

Researchers in EL arena claim that in this type of learning the body, next to the mind, constitutes a significant factor in the whole learning process, while facilitates the meaning of learning through bodily experiences and interactions with the environment (Foglia & Wilson, 2013; McClelland, Pitt, & Stein, 2015). Specifically, the idea of EL places the student in the center of the learning process giving opportunities for physical interaction with the learning material (Ayla et al., 2013; Chandler & Tricot, 2015) and providing hands-on activities in classroom-based environments. From this perspective, different embodied technologies like motion-based games (for example Kinect-based games, Wii, Wii balance, exergames) are only some examples of EL technology which could be used in classroom settings for learning purposes. Researchers and practitioners argue that games such as Kinect-based games require the learner’s interaction both with the technology and learning material, promoting the physical engagement of the learner in the whole learning process (Abrahamson, 2013).

With the emergence of ubiquitous technologies for learning in concepts of embodiment (Price et al., 2009), many researchers have started to rethink about the design of these new technologies in order to create more EL experiences (Riconscente, 2013). Designers, researchers and educators confirm the need to move from abstract - theoretical teaching and learning to embodied teaching and learning, and this indeed is the challenge in education (Ionescu & Vasc, 2014).

2.3.3 Kinesthetic Learning

EL further appears to be a progression of the idea of kinesthetic learning placing the learner in physical interaction with the learning experience (Ayala et al. 2013). For example, in the previous century, Montessori education promoted learning through kinesthetic engagement. Indeed, many views of embodied learning involve kinesthetic and multimodal dimensions to explain the physical involvement of the human body and brain in the cognitive process.

In the EC literature, some studies and papers refer to kinesthetic learning. Kinesthetic is the learning environment in which the learner physically interacts with the learning experience. In the previous century, Montessori education used to promote learning through kinesthetic engagement (Osgood-Campbell, 2015). The word *kinaesthesia* proposed by Merleau-Ponty is the movement sense and in that way the body is the perceiver and human's perception involves both sensory and motor processes (Dreyfus, 1996).

Per scholars (Ayala et al., 2013), kinesthetic learning offers new experiences in education, allowing more clear understanding of concepts, and gives the opportunity to the learner to take action in the learning procedure. The combination of different senses in order to gain new experiences and ideas of interaction and learning offered by the human body and senses, and kinesthetic perception and sensorimotor experiences, are tools to facilitate learning and teaching (Malinverni, Brenda, & Pares, 2012). Furthermore, motion-based learning activities may promote kinesthetic practices for students who learn better when they are physically involved in learning (Bartoli, Corradi, Garzotto, & Valoriani, 2013).

2.3.4 Embodied Interaction and HCI

The ubiquitous computing era is bringing to the people the possibility to interact always and everywhere with digital information. However, the interaction means used to access this information exploit only a few of the human sensorimotor abilities. Most of these interactions happen through a traditional desktop or mobile interface, which often involve just vision and hearing senses and require the movement of only one or few fingers.

Theories of cognition have changed radically over the years upon recent trends in interaction and *embodiment* is the basis for a new foundational approach to HCI. The advent of computers influenced cognitive science and cognitive science influenced how computers were built (Hurtienne, 2009). Researchers in the area of HCI try to find the way to design forms for a wider range of engagements and interactions. Tangible computing and in general Tangible User Interfaces (TUIs) have this concern, to create a new more interactive and innovative context to facilitate the user's experiences (Antle, 2013; Cuendent, Jermann, & Dillenbourg, 2012; Shaer, & Hornecker, 2009). Thus, new forms of interaction such as the use of multi-sensory artifacts, gesture technologies, and whole-body interaction have created for EL purposes (Farr et al. 2012).

As previously noted the EC framework emerged in cognitive science around fifty years ago and had been incorporated in HCI during the last two decades (Antle, 2013). According to this framework, cognition is influenced by physical characteristics, bodily forms (Wilson, 2002) and experiential opportunities. The EC theory and its implications, especially in the HCI arena provide a new interaction perspective that takes account of the way human beings are embodied and where perception and action are embodied (Rogers, 2012).

Indeed, recent developments in the HCI field have moved their attention to the role of immersive and multisensory interaction using multimodal and multitasking interface design (Birchfield et al., 2008). Designing for embodied theory, designers take into consideration embodied skills; focus on bodily movements and interaction with different specific physical or virtual things (Hornecker, & Buur, 2006). Likewise, other technology-based applications can create new opportunities for learning in order to exploit the value of embodiment for learning and interaction (Price et al., 2009).

Embodied theory has brought to the light essential considerations for how we can design for the interactions between people, objects, and spaces (Williams, Kabisch, & Dourish, 2005). In the HCI research, Dourish (2001) coined the term "*embodied interaction*" in order to describe and understand the role of embodiment in HCI. As Dourish (2001) points out, "Embodiment is the property of our engagement with the world that allows us to make it meaningful," and thus "Embodied Interaction is the creation, manipulation, and changing of meaning through engaged interaction with artifacts" (p.3).

In his work, Dourish (2001) states the need for creating new ways of interacting with digital reality, techniques that can better satisfy the people's needs and abilities. For this purpose, context seems to be one of the main issues for HCI design and interactive systems more broadly (Dourish, 2001). According to Garg (2012), the application areas of embodied and HCI are a) Educational and online systems, b) Cognitive design and robotics, c) Autonomous Agents, and d) Cognitive Interfaces.

In conclusion, HCI has an important role regarding the implementation of these new kinds of interactivity based on the EC framework. Given that, with the careful attention to existing practices and procedures, HCI has the key to push the boundaries of new technology, design, and evaluation, for the development of the field (O'Hara, Sellen, & Wachs, 2016). These new promising theories of embodiment, when they can apply to the HCI area, can make cognitive science productive and exciting again (Hurtienne, 2009).

2.3.5 Synergies between Embodiment Theory and Learning

Over the last few decades, education and learning research has been increasingly influenced by EC theory with a great deal of theoretical and empirical implications. In terms of EC's theoretical applications for education, several researchers have proposed frameworks or integration strategies/methodologies to explain how embodiment could work in educational and learning contexts.

One of the first attempts in this direction was Barsalou's (1999) framework of perceptual symbol systems. According to Barsalou, humans or learners develop multisensory representations of their environment using their sensory neural abilities. With a focus on cognitive psychology, Barsalou (1999) claimed that cognition is shaped by aspects of the body, including body morphology, sensory-motor skills, and interactions with the world.

Recently, in the context of mathematical education, Trninic, and Abrahamson (2012) suggested that the use of embodied artifacts (body-based and modular rehearsed actions) can help students perform and understand their material better. The general findings of studies in mathematics also support the notion that the integration of body into learning processes can promote a better understanding of mathematical concepts, graphs, and formulas (Abrahamson, 2013). Similarly, in a language learning context, Zwaan (2014) argued that language use is embedded in the environment and proposed five levels for achieving embeddedness in language learning: demonstration, instruction, projection, displacement, and abstraction.

One important theoretical aspect of EC is *enactment*, which was proposed by Gallagher and Lindgren (2015). Enactment happens when bodily movements are used for specific learning tasks during the learning process. These bodily movements, or enactments, have a significant connection to their concomitant tasks/targets (Gallagher & Lindgren, 2015). Regarding the integration of embodiment into digital learning media, Melcer and Isbister (2016) created a framework that includes seven different categories which facilitate the design and implementation of EL. These categories were developed to clarify EL features for enhancing digital learning media. Particularly, Melcer and Isbister (2016) talked about the following categories: physicality, transforms, mapping, correspondence, mode of play, coordination, and the environment. All of the categories should be taken into account when implementing EL in the classroom (Melcer & Isbister, 2016).

The research of Malinverni and Pares (2014) also discusses the theoretical context of EC theories in conjunction with the user interface and proposes five main categories: theoretical framework, design strategy, educational context, interaction design, and evaluation. Each category includes other related subcategories (Malinverni & Pares, 2014). Another significant contribution to EC theory is the taxonomy for educational EC research proposed by Johnson-Glenberg et al. (2014), which suggests three main factors: motoric engagement, gestural congruency, and perceived immersion. According to Johnson-Glenberg et al. (2014), motoric engagement and gestural congruency (i.e., how a gesture is connected with particular learning task) are both crucial to EL environments. The third factor, perceived immersion, applies specifically to virtual reality and related technological tools (Johnson-Glenberg et al., 2014). Johnson-Glenberg et al. (2014) also believe that their factors have distinct levels of the embodiment, suggesting that the highest level of embodiment in learning contexts requires learning environments with the high degrees of bodily movement, which involve locomotion (Johnson-Glenberg et al., 2014).

Overall, recent research on embodiment offers some essential theoretical ideas for the implementation of EC or EL in educational contexts. However, more research is still needed if we want to develop more comprehensive and empirically supported frameworks for the implementation of EC/EL in those environments.

2.4 Summary

This chapter presented a literature review of the main theoretical underpinnings and directions in EC theory, focusing on the synergy between EC and education. The review showed the implications of EC theory across multiple research fields and disciplines. The next chapter focuses on empirical research conducted within EC and EL frameworks, including evidence from recent empirical studies for the need to use EC and EL in classrooms.

3 Embodied Cognition in Education: A Review of Recent Literature

This chapter explores the development in the field of EC, by building a map of existing research work in the area, based on the results from a review of recent empirical research conducted in the field with particular interest on the implementation of EL - driven technology. The aim of the present review, based on a corpus of 43 manuscripts, is to investigate the potential of EC research in various learning contexts. Notably, the study addresses the research methods and technologies that are utilized, and it also explores the integration of the body in the learning context. A significant finding from the overview is the potential of the theory in different educational environments and disciplines. However, there is a lack of theoretical and methodological guidelines from an educational perspective for an effective EL implementation in various learning contexts. The systematic review on EC and its implication in education is published in International Conference on Education and Technology proceedings (Kosmas & Zaphiris, 2018).

3.1 Introduction

The increasing dependence on technological tools for enhancing learning has brought to light new dimensions in the research area of EdTech, gaining more attention to pedagogical implications of different emerging technologies. In contemporary educational discourse, renewed interest in EC and EL has emerged, in conjunction with the exploitation of technologies, which provide new teaching approaches and interactions.

Simply stated, EC has brought in the light the involvement of physical body and activity into the learning process, changing the way of learning and creating questions about the role of body in cognitive processes. So far, the implication and the dynamic presence of EC in many different disciplines such as psychology, cognitive science, education, neuroscience, and HCI, indicates the vast potential of this theory across many disciplines (Davis & Markman, 2012; Farr, Price, & Jewitt, 2012). The fundamental idea of EC argues that mind and body are closely interlinked (Wilson, 2002) and thus influences the way we learn and teach. From this perspective, EC is one contemporary learning paradigm with a potential impact in educational settings.

This chapter examines the EC theory, by reviewing existing research work in the field. Based on a corpus of 43 manuscripts, published between 2013 and 2017, it sets out to describe the development and implementation of EC theory. In particular, the present review addresses: a) The research methods used in educational settings for EC research, b) the learning subject/content, c) the technological tools are utilized for the implementation of EC, d) the collaboration in EL environments, e) the kinesthetic and multimodal approaches in learning, f) the integration of body into the learning process, g) the design strategies, and h) the role of the environment in EL.

3.2 The methodology of Systematic Review

The purpose of this review is to map the current research issues and directions in EC through a systematic literature review. Following the similar methodology described in previous systematic overviews (Xu & Ke, 2014; Sheu & Chen, 2013), this is characterized by initial selection, filtering and classification processes. The review includes studies published in scientific journals, proceedings of conferences and book chapters. The methodological procedure followed for this review (see Table 2) consists of three stages:

In stage 1 (first database search), the initial search was based on searching terms "embodied cognition" and "embodied learning," with the keywords: education, embodied interaction, embodiment, technology, full-body interaction, kinesthetic learning, multisensory, motion-based interaction, school, classroom. From this initial database research, the total number of papers was 147.

In stage 2 (selection of papers), the selection was based on the following criteria: 1) Containing an embodied cognition theoretical orientation such as "embodiment-based learning", "embodied interaction", "kinesthetic approach", whole-body interaction", "gesture-based learning", and other relevant theoretical approaches. 2) Containing technological tools and devices such as "gesture-based devices", "motion-based devices", "embodiment technologies", and other "multi-sensory tools". In this selection of the corpus of 147 papers, only 82 papers remained in the pool after applying the above two rules.

In stage 3 (final selection of papers), the final choice was made by focusing on empirical work in learning contexts and environments, both formal and informal. Only empirical research papers conducted across learning settings were included. During the final selection, other types of papers were excluded such as papers that provided "product reviews", "introductions to special issues", "theoretical/ position papers", "reports", and "commentary sections". This resulted in a final list of 43 papers published between 2013 and 2017.

Table 2: The methodological procedure of systematic review

	Description	**No of manuscripts**
Stage 1	Database Search	147
Stage 2	Selection of related papers based on criteria	82
Stage 3	Final selection	43

3.3 Review Outputs: Thematic Areas

The overview of EC literature shows that theory has many implications in different fields and contexts, specifically in a setting related to learning comprehension and process. The results of this systematic literature review have revealed some important themes/ topics which are discussing in the following sections. These themes are the research methods used in these studies, the learning subjects, tools and learning outcomes acquired the collaboration within EL context, the multimodal approach to learning, the effective integration of body in learning, and the design strategies.

3.3.1 Methods for Embodied Cognition Implementation

The design of the research and the methods that were used in reviewed studies are categorized and analysed. The majority of papers applied experimental research (24) and design-based research (15). The rest of the studies focused on case studies, qualitative research and location-based research. Research methods used for data collection were also analysed. It should be noted that each type of research addresses different purposes. In almost all the studies, the primary goal was to examine the hypothesis that embodiment technologies may have an impact on the learning process, and indeed all reviewed studies show a positive impact related to learning outcomes. In addition, some other studies aimed to explore relevant issues, to gain a better understanding, and to promote design guidelines for developing learning conditions involving EC theory and related technologies.

Many different methods are utilized in order to accomplish the goals mentioned above and respond to those research questions. A combination of methods was utilized including usability tests, user studies, pre-post-tests, questionnaires, and traditional qualitative strategies such as interviews, video and audio recording, and observations.

Depending on research purposes, some researchers focus primarily on user studies adopting related techniques like usability tests, and observations protocols in order to evaluate the interaction with the devices and technologies. Some others take particular approaches, such as grounded theory and action research.

3.3.2 Learning Subjects

The majority of research papers were in the domain of math education (14 papers), followed by Higher Education topics (10 papers). This second category encompasses studies with different topics/ content applied all in university settings. Some of the topics include language learning, psychology, medicine, and communication. In science education (physics, chemistry) there were seven papers, and in language learning and second language acquisition, there were also five studies. Other subjects consist of different topics in school education. Three studies were conducted in Special Education on children with special needs, including physical disability, autism, blindness, and other impairments. The rest of the papers were from other fields such as environmental education, reading, manufacture, medicine, dancing, music, and behavior development. Furthermore, the users and a sample of these studies were categorized into two categories: 1) children (infants, K-12, high school), and 2) adults (over 18 years old). Most studies were conducted with children (30 studies) in the K-12 system. All the other studies utilized adults for their data collection. Table 3 shows the distribution of learning subjects, participants and learning outcomes across the reviewed articles.

Table 3. Distribution of learning domains, participants, and outcomes (N=43 papers)

Discipline/domain/content/subject	Participants	Outcomes	No
Mathematics	Adults K-12	- Understanding of mathematical concepts - Math skills - Executive functions - Emotional engagement - Motivation	14
Multiple topics in Higher Education (presentation skills, language, communication, politics, psychology, design, neuroscience)	Adults	- Memory performance - Understanding of abstract concepts - Creativity - Collaboration - Motivation	10
Science (physics, chemistry)	Adults K-12	- Academic acheivements - Multimodality in learning - Learning gains	7
Language learning	Adults K-12	- Comprehension - Vocabulary acquisition - Listening comprehension - Oral fluency - Retention	5
Other	Adults K-12	- Thinking skills - Collaboration - Design skills	4
Special education	K-12	- Emotional outcomes - Attention - Motor Skills - Motivation - engagement	3
Total			43

3.3.3 Technological Tools for Embodied Cognition

New technologies, based on embodied user's integration, can add value in learning because they offer chances for communication through gesture, with interactive surfaces, supporting not only individual but also collaborative work. By using these interactive educational technologies, learners can manipulate digital information directly with their body. So, there are significant implications for learning and teaching (Kiefer, & Trumpp, 2012).

Researchers, towards the last decade, have investigated how sensory and kinesthetic activities have influenced students' learning with particular interest on Mathematics and science (Abrahamson, 2013; Ayala et al., 2013; Kellman, & Massey, 2013; Hall, & Nemirovsky, 2012; Quek, & Oliveira, 2013; De Freitas, & Sinclair, 2012; Abrahamson, Lee, Negrete, & Gutierrez, 2014; Hannula, 2012), as well as language and reading comprehension (Osgood-Campbell, 2015).

Contemporary educational research has published a significant amount of studies about gestures as a fundamental role in children's learning. Gestures, according to Piper et al. (2012) play an essential role in teaching and learning discourse. Gesture-based technologies, which involve gestures or body movements, have been widely used to support the physical interaction on learning (Chang et al., 2013; Chao et al., 2013).

It is no wonder that gesture-based devices and tools have opened up new possibilities for kinesthetic learning (Sheu, & Chen, 2014). The use of gestures can lead to a clearer understanding of children learning language and thinking in general (Ionescu & Vasc, 2014). Moreover, when students use their gestures achieving something or while trying to understand an idea, learning is enhanced (Ozcelik, & Sengul, 2012). Except for gesture technologies, there are other body sensory technologies, such as Microsoft Kinect, that provide designers with new approaches to innovatively facilitating learning (Xu, & Ke, 2014).

The technology listed, as it appears in Figure 7, includes the devices used for the EL environment based on the reviewed papers. Most articles utilized Tangible User Interfaces (18 studies), including desktop computers, interactive tabletops, iPad, tablet, MoSO, gesture-based devices. The second popular technology is Microsoft Xbox Kinect, which was found to be the main device in 12 studies. Only one study in this category used the WBB (Wii Balance Board). Five cases are using some embodied artifacts or objects such as 3D pictures and objects, cameras, virtual reality objects, and Mathematics Imagery Trainer for Proportion (MIT-P). Three articles used biosensor technologies such as haptic glove interface, remote-sensing technologies, and other related devices. Only two studies using embodied interaction video games like Second Life. The last category, as shown in Figure 7, refers to studies using multiple devices (e.g., eye tracker, LEGO, and Embodied Mixed Reality Learning Environment-EMRLE).

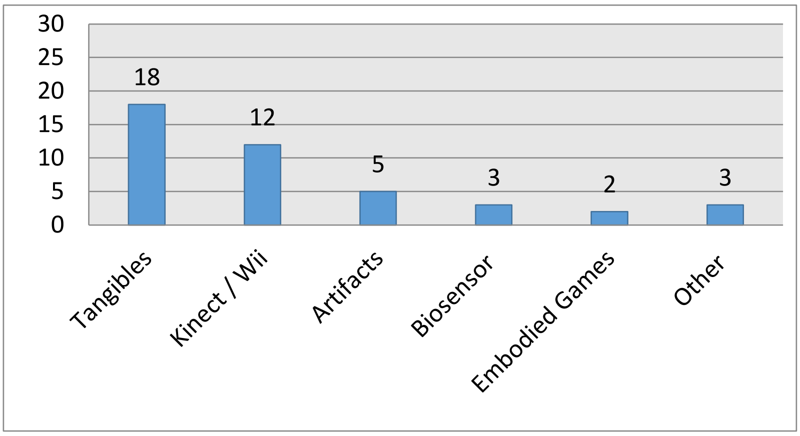


Figure 7: Technologies for Embodied Cognition in Education

All these technologies offer new ways to engage with learning and teaching. However, apart from their potential use, there are also challenges, in particular to those who have physical disabilities and those who experience difficulties with physical or bodily movements. Thus, it is necessary to take into consideration all the possible users in order to avoid frustration and unsuccessful learning (Shaer, & Hornecker, 2009).

3.3.4 Collaboration in Embodied Learning Environments

One aspect which emerged from the literature about EL is collaboration. EL environments seem to promote the collaboration between learners creating opportunities of working together using their body and senses. Many technologies with embodied skills provide collaboration and cooperation of all the people involved in learning processes (O'Hara et al., 2013; Antle, 2013; Eisenberg, & Fischer, 2014).

Ultimately, there is ongoing interest in creating technologies to support communication and collaboration between people who work in different physical locations (Luff, Jirotka, Yamashita, Kuzuoka, Heath, & Eden, 2013). An example is TUIs (Tangible User Interfaces) which can promote and support collaborative work in learning settings and for learning purposes (Antle, 2013). As Klemmer et al. (2006) noted, the role of tangibility and in general the role of artifacts in collaboration is to facilitate all the collaborative aspects between learners. These technologies can also offer teachers opportunities to "orchestrate" or prepare the collaboration settings inside and between groups (Evans & Rick, 2014).

Consequently, collaboration is one important factor associated with embodied learning. It has been shown in studies conducted in embodied environments by SMALLab (a mixed-reality environment where students collaborate and interact with sonic and visual media through full-body) that collaboration is essential for learning outcomes providing learners' engagement in all the activities for solving a problem (Birchfield, 2008).

3.3.5 Kinesthetic and Multimodal Learning

To start with, in the EC literature some studies and papers refer to kinesthetic learning, except for EL. Kinesthetic is the learning environment in which the learner physically interacts with the learning experience. "Kinesthesia" is the movement sense and in that way, the body is the perceiver and human's perception involves both sensory and motor processes (Wilson & Golonka, 2013). The importance of such learning is that abstract things and contents can grow up with activities of the body (Evans, & Rick, 2014).

One embodied environment must provide opportunities for activities such as walking, running, hearing, seeing, touching, smelling, tasting. In that way, all our senses participate in the learning processes, and this continuous process of action and reaction comes to our attention. According to Ayala et al. (2013), kinesthetic learning offers new experiences in an educational setting, allowing more clear understanding of concepts, and gives the opportunity to the learner to take action in the learning procedure. The combination of different senses in order to gain new experiences and ideas of interaction and learning offered by the human body and senses, kinesthetic perception and sensorimotor experiences are tools to facilitate teaching and learning (Malinverni Brenda, & Pares, 2012). Furthermore, motion-based learning activities may promote kinesthetic practices for students who learn better when they are physically involved in learning (Bartoli et al., 2013).

Studies in line with EL and kinesthetic learning provide the term "multimodality" with focus on examining the use of multiple semiotic resources and explaining the collection of visual, aural, embodied, and other aspects of interaction and environments and also the relationships between these (Price, & Jewitt, 2013). Birchfield et al. (2008) say that multimodality means students' interactions and full sensory capabilities including visual, sonic, haptic, and kinesthetic. Along similar lines, Han (2013) argues that human cognition is developed based on the "multimodal representation that we acquired from our bodily experiences through sensory modalities (such as eyes, ears, nose, hands, and mouth) while interacting with the environment" (p.43).

The role of human's body abilities and senses is essential for the HCI designers, in order to create new novel interactions and experiences. Kinesthetic interaction with technology has led to many ways in which whole-body interaction may be invaluable (Farr et al., 2012). Designers should be able to promote the better exploitation of new tools in the ubiquitous computing era with the aim of developing new methods and devices for evaluating and understanding learning in embodied interaction and map future design directions. In recent years, researchers in the educational field have developed many interactive surfaces and environments (tablets, tabletops, whiteboards, smart rooms, 3D sensing systems), which promises significant opportunities to support kinesthetic learning (Evans, & Rick, 2014).

3.3.6 The Integration of Body in Learning: Empirical Evidence

Many empirical studies, in the last two decades, on learning and technology have shown that bodily movements and actions enhance learning positively. Chang et al. (2013) examined the learning effectiveness of a Kinect-based environment for college students' understanding of verbal information. The collected data indicated that the embodied approach facilitate students' cognitive learning outcomes and give opportunities for more active learning experiences. Along the same line, in the study of Chao et al. (2013) Kinect-based condition has actual effects on encoding and later recall providing a better understanding of action phrases.

Moreover, applying EC theory in mathematics instruction has been prevalent in many studies in very recent years (Flanagan, 2013; Have, 2016; Quek, & Oliveira, 2013; De Freitas, & Sinclair, 2012; Abrahamson et al., 2014; Trninic, & Abrahamson, 2012). The general findings of these studies show that embodied approach and methods provide not only better understanding of mathematical concepts, graphs, and formulas (Ayala et al. 2013; Novack et al., 2014; Trninic, & Abrahamson, 2013), but also help students in mathematical achievement (Have, 2016; Abrahamson et al., 2014). Some other studies with empirical evidence indicate that the involvement of the body in doing math help students to solve easier mathematical problems by improving their self-confidence (Riconscente, 2013).

Additional studies have examined embodiment from different academic perspectives. An important aspect is the role of embodiment in information processing. Lee et al. (2012) applied the Microsoft Kinect to capture gestures like hand raising, waving, and pointing, facilitate conversational language learning for 39 non-English speaking college students. The findings from this review have shown that gestures attract the attention of learners and stimulate their thinking. In addition, VanDam et al. 2012 showed that the embodied approach could result in language comprehension indicating that word meaning is linked to sensorimotor experience.

Synthesizing the findings of articles, it is evident that motor and bodily activities can facilitate both learning processing and comprehension. Physical movements also help to attract attention, encoding information, and promote the communication and interaction between learner, technology, and environment. To conclude, all the studies point out the effectiveness of integrating bodily movement and technology learning environments.

3.3.7 Designing Embodied Learning Technologies

One of the main issues that arose from the review it has to do with the design strategies, approaches, and choices. However, since HCI is an applied science, it is necessary to analyze how findings in EC research can be used to design more efficient embodiment technologies for learning purposes in learning environments. Many studies claim that a design methodology is needed in order to create interaction opportunities between actions, objects and digital representations (Chen, & Fang, 2014). As Hung, Lin, Fang, and Chen (2014) ascertain, although there is a lack of a comprehensive design based on EC theory, it is suggested that many embodiment-based tools can facilitate the comprehension of learning content during the learning procedure.

What is more, designers should know how to develop technologies for learning environments taking into account contemporary pedagogical approaches around EC and the role of embodiment. It is essential to integrate such technologies into practical learning contexts (Evans, & Rick, 2014), based on the interactive technology design (Loke, & Robertson, 2013).

Svanæs (2013), propose modality as important element designing for embodied interaction and perception. It is also important to carefully design the movement feedback provided by the interface (Bianchi-Berthouze, 2013), in order to achieve better performance and gain more learning outcomes.

In an embodied-based learning environment where learners can interact physically with any discipline using their bodies, three key characteristics should be considered when designing a learning environment: a) activities, b) materials and c) facilitation (Abrahamson & Lindgren, 2014). Activities and materials should be designed in a way that engages students in learning taking advantage of their bodily abilities and capabilities.

Therefore, the problem is how such technologies can best be designed. Designing more effective multisensory and embodied devices requires strategic methodological approaches for developing, evaluation and implementation. In recent years, it always raises the need to create useful applications for learning and develop appropriate frameworks for designers in order to maximize the use of embodied and sensory mechanisms across various learning contexts and environments.

3.3.8 The Role of Environment

Another important issue in the EC literature is the role of the environment among different learning contexts (Schaper, Malinverni, & Pares, 2014; Kim, & Lim, 2013). Researchers concern about the impact of the physical environment in learning, the integration of the digital environment and the relationship between these two in the learning process. Particularly, Flanagan (2013) simply states that the physical environment plays an important role not only in learning but also in the formation of knowledge. Along the same lines, other researchers express their question about how sensory-motor bodily movements can interact with the environment in learning (Kuo, Hsu, Fang, & Chen, 2014; Have et al., 2016).

On the other side, Abrahamson and Lindgren (2014) talk about the *orchestrated environment* in which learning activities should be situated. In doing so, that environment should be designed in a way that facilitates the interaction and interrelation with the environment. More complicated situations are when learners have to manipulate both the physical and virtual environment (Wong, Castro-Alonso, Ayres, & Paas, 2015).

3.4 Discussion and Future Directions

In the short presence of EC in research, a good deal of studies in various fields has shown the potential of the theory in different environments and for different purposes. Increasingly ubiquitous sensing technology and multisensory tools are being used in multiple HCI areas of health, psychology, neuroscience, arts, games, and education. However, the focus differs between areas. An attempt to bridge the gap in EC field is to bring together researchers from different areas, such as HCI, education, and psychology to investigate appropriate methods, frameworks, and tools applied for a multidisciplinary perspective.

The EC field provides compelling evidence that cognition is affected by different systems and should clarify these cognitive areas as separate from one another (Anderson et al., 2012). As Antle and Wise (2013) point out, the embodied theory is mostly empirically unexplored, especially in a way to identify how the design of mappings between activities, objects and digital representations in conjunction with embodiment approach may enhance learning and understanding of abstract concepts.

In this regard, new challenges around embodiment and learning require new solutions. Through technological advances, educators should rethink the role of the body in learning environments and also should consider the body's role in digital education (Nguyen, & Larson, 2015). In order to understand the embodied possibilities that educators can utilize, require demonstrating more explicit connections between perception, cognition, and learning (Kellman, & Massey, 2013).

It is worth investigating, as Kuo et al. (2014) believe, which are the factors that may affect students' learning performance and retention, like gender, prior knowledge, and collaboration activities, and what might be the effect of Kinect's integration into collaborative problem-solving activities. Similarly, Chao et al., (2013) propose the examination of the educational implication of Kinect usage in the classroom enhancing students' engaging in a more active, physical and emotional way during the lesson. Researchers should do more experiments to find the effects of EL on higher-order thinking skills (Chao et al., 2013). In addition, theoretical research is limited about these applications concerning the cognitive learning strategies and little research is published on the Kinect's effectiveness in gesture-based learning (Xu, & Ke, 2014).

Furthermore, more research is also needed to ascertain if educational content with gestures promotes an effective method for learning compared to more traditional methods and this can be examined by gathering metrics on movement (Johnson-Glenberg et al., 2014). Few studies have investigated the impact of gestures on students' cognitive learning outcomes, and thus more studies are needed to explore what type of tools or materials are suitable for embodied learning environments (Chang et al., 2013). For future studies, Chen, and Fang (2014) propose to examine the effects of different types of gestures on learning outcomes and the learner variables to explore whether there is an interaction between learner variables and gesture types in the gesture-based learning environment.

Due to the fact that Tangible User Interfaces (TUIs) research is still in its infancy, there are many unanswered questions and issues regarding the practical value of TUIs. Extensive empirical research is required for better understanding of the implications and relationships between physical and digital worlds for more effective design of tangible interaction techniques that could bridge the digital and physical environments (Shaer, & Hornecker, 2009).

Osgood-Campbell (2015) states that future research should show evidence about the link between sensorimotor action and cognition in classroom activities; it should also examine how academic skills can have improved such as language comprehension, mathematics, and scientific thinking. Future research needs to be more specific on how sensory-motor abilities are involved in language comprehension (Willems, & Francken, 2012). Studies should focus on teaching and learning to investigate how designers can build new understandings of embodied mathematical cognition in learning environments (Hall, & Nemirovsky, 2012). Trninic and Abrahamson (2012) suggest that in future work, researchers must investigate the embodiment of mathematical concepts by developing theories of EL, and designing suitable educational technologies.

Additionally, future research should explore the value added of EL in game-based environments. Some directions are the exploration of how embodied devices can support learning, and how the embodied learning apps, can influence the relationship between learner characteristics and game features (Riconscente, 2013). Due to the lack of a comprehensive design based on embodied cognition, it is suggested by Hung et al. (2014) that more investigation is needed to demonstrate how games can be integrated in learning content along with the embodiment-based methodologies. Empirical research is limited also in the field of embodied interactive games for healthcare and special education (Altanis, Boloudakis, Retalis, & Nikou, 2013).

Further studies, according to Wellsby, & Pexman, (2014) need to be conducted to examine how sensorimotor processes interact with the developing linguistic and conceptual systems. Moreover, it's important to include in the research methodology not only the learners but also the educators, teachers, and instructors to identify profoundly the learning problems in embodied environments (Malinverni, Brenda, & Pares, 2012). Also, an interesting future direction would be to explore how to use different types of feedback in the same activity (Cuendent et al., 2012).

An extraordinary number of empirical studies have investigated many claims regarding the role of embodiment in learning, using various methods, from gesture studies to psycholinguistic experiments (Núñez, 2012). Particularly, in education, it is essential, according to Evans, and Rick (2014), to examine how embodied technologies could be integrated into real classrooms and which is the best way to design and prepare learning environments that take full advantage of such tools. It is also important for the future research to show how these new tools can influence learners' attention and collaboration, and whole-classroom orchestration (Evans, & Rick, 2014).

All things considered, taking into account evidence and theories arising from embodied cognition and interaction, developments in computing technologies, and evidence from research, the future for education is set to change. Research effort and proof are needed exploring effective ways for teachers to know how to use and adopt technologies, which provide the body engagement and movement in the learning environment (Price et al., 2009). As Clark (1999) said, the implications and understanding of these embodied methodologies and approaches remain to be determined, and inevitably there are a lot of difficulties that continue to be resolved. A future research path is the promotion of educational methodologies and design guidelines, which are important for better system design, development, and implementation (Sheu, & Chen, 2014).

It is evident that previous research in the area has demonstrated the positive impact of this practice on the development of the cognitive and academic performance of children. This dissertation comes to reinforce the embodied approach, expanding the body of knowledge through empirical data in authentic learning environments. Specifically, the research aimed to offer examples of how EL can be implemented in special and general classroom environments, as a personalized intervention as well as class-wide intervention to develop specific cognitive and academic skills, as well as to improve the emotional performance of the students. My research also aimed to move the discussion in the direction of EdTech promoting the creation of a completed theoretical and methodological model for the implementation of such practices in the school environment as part of the curriculum.

3.5 Summary

This literature review focused on EC theory applied in learning environments. The results of this analysis show that EC research is a growing field in education. It is also confirmed that EL is an exciting and exciting area of investigation (Lindgren, & Johnson-Glenberg, 2013), because of many existing challenges in various aspects and because of many unanswered questions in accordance with the design, teaching, learning, and environment in EL context. In summary, from EC perspective, the bodily movement is the protagonist in the learning procedure, and it can be seen “as a sort of sixth sense” (Paloma, 2017). With this in mind, this research focuses on the investigation of EL in different real contexts, informing practitioners and researchers regarding the implementation of EL in authentic learning environments, as a part of the classroom curriculum. This would be a first step in the development of the synergy between EC and education.

4 Methodology

This chapter explains the research method used for this dissertation. It also reflects on the data collection process, with a focus on the research design of the four studies we conducted in schools.

4.1 Introduction

To investigate how using EL approaches can improve overall student classroom performance in real classroom contexts for specific learning purposes, the mixed methods methodological framework was used as an overarching paradigm for educational inquiry. In particular, the dissertation follows the Multiphase Design (MD) strategy, a mixed methods approach which involves multiple levels of data collection and analysis, as well as multiple studies (Creswell & Clark, 2007). The MD approach also supports educational interventions in real-life environments, combining sequential and concurrent aspects of mixed data collection (Creswell & Clark, 2007). For this research, educational interventions were made in real classroom environments in four phases. The implementation was conducted in mainstream schools using both quantitative and qualitative data based on the MD mixed methods approach. This approach gave me a rich overview of the learners' experiences during the intervention period in each phase of research.

4.2 Mixed Methods Research

For the implementation of EL theory in actual classrooms, we used the mixed methods research approach. For many years, mixed methods approaches have been widely used in educational research and practice. With mixed methods, the researcher can look at multiple aspects of real learning environments, collecting and analyzing both quantitative and qualitative data (Punch & Oancea, 2014). Indeed, experienced researchers have blended both qualitative and quantitative data collection and analysis to evaluate and understand human interactions with social and cultural components. The resulting rich dataset allows researchers to understand and interpret human behavior in a given context (Morgan & Shmircich, 1980). Even more common is the use of mixed methods design to describe and explain the impact of different technological learning tools (see Kourakli et al., 2017; Enyedy, Danish, Delacruz, & Kumar, 2012; Kosmas, Ioannou, & Retalis, 2017; Kosmas, Ioannou, & Retalis, 2018). For example, according to Kosmas, Ioannou, and Retalis (2018), the use of mixed methods that use quantitative statistical elements and qualitative data showed how Kinect educational games positively impacted students' memory performance and emotional state.

According to Punch and Oancea (2014), the mixed methods approach has the following basic principles: a) the use of qualitative and quantitative approaches within a single research project; b) a focus on the link between approaches; c) an emphasis on practical approaches to research problems, and d) the triangulation of data collection. As many researchers claim, using mixed methods methodological approaches provide a comprehensive result, and a clearer understanding of the research problem since using different methods and different kinds of data results in a more in-depth investigation (Punch & Oancea, 2014; Creswell & Clark, 2007). The mixed methods strategy also offers researchers many other possibilities and advantages, such as a) validation of their findings, including threats to their validity, and a fuller and deeper understanding of their subjects; b) more comprehensive, accurate and more precise results, and (c) richer and more meaningful and useful answers to research questions (Punch & Oancea, 2014).

4.2.1 Multiphase Design (MD)

As mentioned above, for the implementation of the EL theoretical approach in real-world classrooms, the mixed method research approach was employed. Mixed research methods are designed for use in social and educational settings (Greene, Caracelli, & Graham, 1989) where researchers gather, analyze, combine, and explain both quantitative and qualitative data collected for a long-term project to address specific research questions. There are six different mixed methods design strategies: 1) convergent parallel design; 2) explanatory sequential design; 3) exploratory sequential design; 4) embedded design; 5) transformative design, and 6) multiphase design (Creswell & Clark, 2007).

This dissertation uses the Multiphase Design (MD) strategy, which is appropriate for a multiyear study with multiple phases. This multiphase approach "examines a topic through an iteration of connected quantitative and qualitative studies that are sequentially aligned, with the purpose to address a set of incremental research questions that all advance one programmatic research objective" (Creswell & Clark, 2007, p.100).

More specifically, a MD mixed methods approach can be used when a researcher wants to combine a set of multiple studies that all contribute to an overall research objective. As such, MD is an ideal research paradigm for a multi-year project that requires multiple stages to address an overall research plan. As Creswell and Clark (2007) argue:

> "The multiphase design incorporates the flexibility needed to utilize the mixed methods design elements required to address a set of interconnected research questions and to provide an overall framework for conducting multiple iterative studies over multiple years" (p.101).

The MD approach is based on the use of a sequence of approaches (qualitative, quantitative, or both) that build up to an overarching aim. This allows researchers to show how each phase of their studies is built on earlier findings and results, where each phase addresses a specific set of questions that will eventually address the overall objective. This methodological strategy usually has two or more sequential phases that produce a long-term or even multi-year study with a practical outcome. Researchers and practitioners/educators are involved in data collection and analysis, contributing both their knowledge and practical experience.

Additionally, each MD follows its own structure or plan. For instance, often MD studies have an organized structure with particular research questions from the initial phase of the research. In some cases, MD design research is based on the results of the previous phases and re-defines the questions as they emerge throughout the interconnected studies. For these reasons, MD design principles offer an ideal research paradigm for multi-year projects and studies. That said, researchers also face some challenges during the implementation and design of the interconnected phases/stages. Some of the challenges researchers must consider when going forward with MD design are: a) the amount of resources, time, and effort the research takes, because it involves several phases over multiple years; b) effective collaboration between researchers and practitioners for the duration of the research; c) the difficulty of connecting and interpreting the individual studies, and d) the difficulty of mixing all the data collected from both the quantitative and qualitative strands within phases (Creswell & Clark, 2007).

4.2.2 Appropriateness of Multiphase Design for this Research

MD Design, a mixed methods approach, was used for this dissertation. The study was implemented in multiple phases, and the quantitative and qualitative methods were conducted sequentially across phases and also concurrently within some phases. The analysis focused on the triangulation of data in order to "obtain complementary quantitative and qualitative data on the same topic, bringing together the different strengths of the two methods" (Creswell & Plano Clark, 2007, p.62). MD is appropriate for this study, as the goal is to examine EL across multiple studies using the strengths of both quantitative and qualitative data.

The research was conducted in four consecutive phases. Each phase addressed different research questions, but all phases were intended to complete and answer the primary aim of the study (to provide useful insights and deeper understanding on how we can implement EL-driven technology in authentic context). The first study was exploratory and identified if the EL approach could be used in real settings for the development of specific skills. The following three sequential phases were implemented to look at how EL, as a part of the classroom curriculum, impacted cognitive, academic and emotional student performance. This multiphase design allowed us to replicate our method so that we could validate our findings across phases with a focus on understanding and interpreting student gains in each phase. All four stages were conducted in different classrooms using different participants. Last but not least, the overarching goal of this work was to inform practitioners/educators on how they can implement EL- driven technology in their daily practice.

4.3 Research Design

In this dissertation, educational interventions were implemented in four different classroom settings using mixed methods for data collection. As mentioned above, these different classroom settings were not explored in order to identify and understand similarities and differences between them or to replicate findings across cases, but to inform a set of guidelines for using EL-driven technology in different learning contexts, which we hope will be useful for advancing education theory and practice. Considering the needs of this research, and the strengths mentioned above and challenges of the MD research approach, I structured a multiphase mixed methods design to address my research objectives.

4.3.1 Research Questions

This study examines the EL approach in different learning contexts and circumstances to investigate how using EL can advance overall student performance in real classroom contexts for specific learning purposes. Specifically, it examines how the body's physical integration into classroom activities impacts the learning process, with a focus on the development of motor, cognitive and academic skills within authentic learning environments.

The main purpose of this research is to provide some guidelines that will ground and expand the use of EL technology in the classroom. The results will hopefully offer those guidelines for researchers and practitioners by providing the basic principles for implementing EL in authentic classrooms environments. The research was implemented in different learning contexts and circumstances in four phases and addresses eight research questions (see Figure 8).

- *Phase A*: [RQ1] What is the impact of EL as a personalized intervention on the motor performance of SEN students in an authentic context?
- *Phase B*: [RQ2] What is the impact of EL delivered through motion-based technology on SEN students' short-term memory skills? [RQ3] What is the impact of EL on SEN students' emotional performance?
- *Phase C*: [RQ4] What is the impact of EL delivered through motion-based technology on GE students' short-term memory skills? [RQ5] What is the impact of EL delivered through motion-based technology on GE students' academic skills in vocabulary and language acquisition?
- *Phase D*: [RQ6] What is the impact of EL delivered through movement-based intervention on GE students' academic skills in vocabulary and language acquisition? [RQ7] What is the impact of EL on GE students' emotional performance? [RQ8] How could EL be implemented in an authentic class-wide classroom setting?

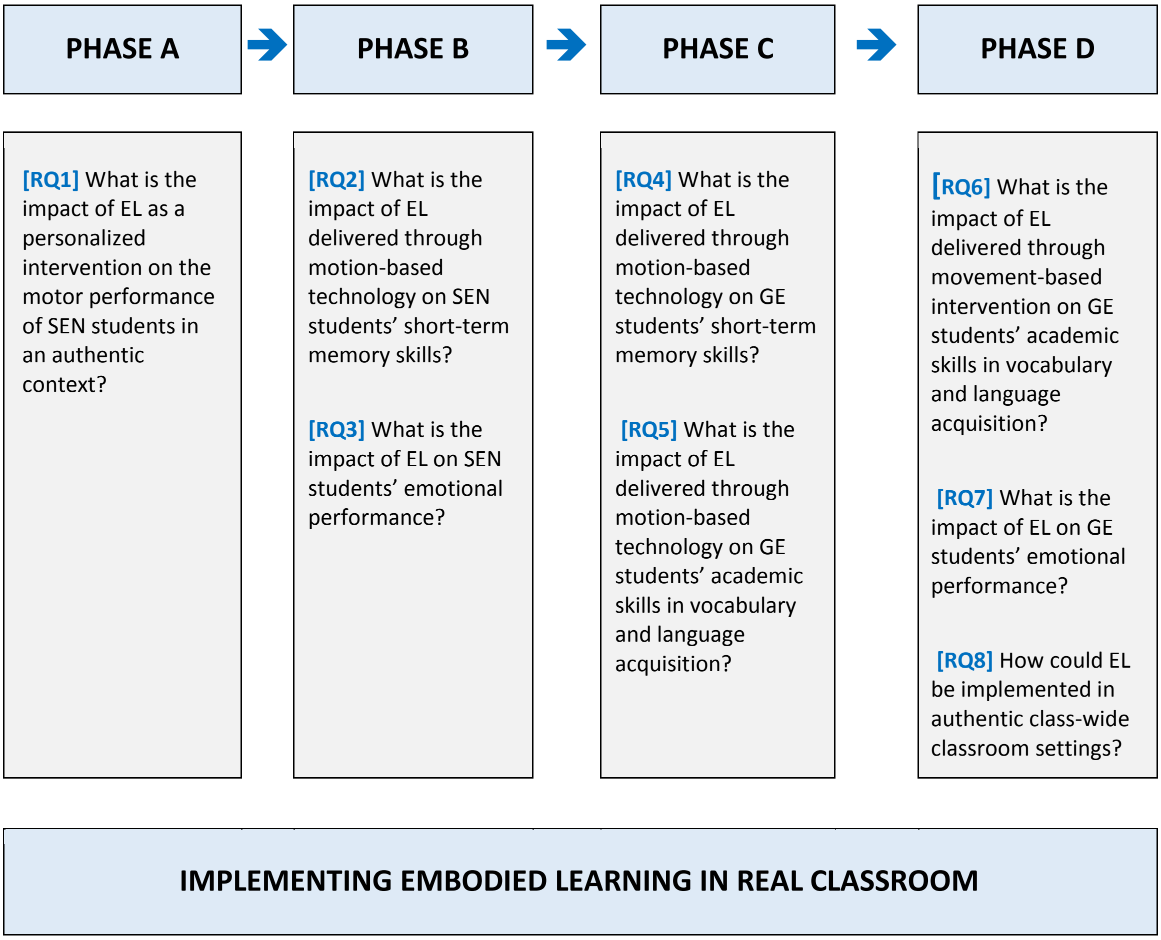


Figure 8: The Research Questions of the dissertation divided into four phases

Phase A and Phase B were conducted in a SE context. Phase C and Phase D were conducted in a GE context in order to see if the ideas tested in previous phases (A and B) were valid for authentic GE classrooms and if overall student gains in performance could be replicated. In the first three phases, EL was implemented using Kinems educational games, a motion-based technology. In the fourth and last phase, a movement-based intervention called PanBoy was developed for use in the classroom.

4.3.2 Participants in Four Phases/Studies

4.3.2.1 Participants in Phase A

Ten elementary students (seven boys and three girls) with special education needs and motor impairments participated in Phase A. Students were 6-12 years old and attended mainstream elementary schools with special education units. The participants had comorbid learning disabilities and disorders which influenced their motor performance. Inclusion criteria for this phase were the age of children and their ability to use the games, even from a seated position. In Phase A, ten special education teachers, who were responsible for implementing the interventions over a five-month period, were involved in the study.

4.3.2.2 Participants in Phase B

31 children (21 males / 10 females) with special educational needs and learning difficulties from five mainstream elementary schools participated in Phase B. 18 students attended schools with special education units, while 13 students attended schools with no special education unit, but with in-class support when needed. The complete sample included 31 children 6-12 years old, of which 68% were boys diagnosed with one or more special educational need. As in Phase A, inclusion criteria were the age of the children and their ability to use games. Ten special education educators (the same teachers who participated in Phase A) also voluntarily agreed to participate in Phase B, which again lasted five months.

4.3.2.3 Participants in Phase C

Phase C was conducted in four different elementary GE classrooms in two primary schools. A total of 52 second and third graders (N=52) aged 7-9 participated in 13 intervention sessions of 45 minutes each over a four-month period. Five teachers were involved in the research process. Selection of children was by virtue of them being in the school class that was invited to participate.

4.3.2.4 Participants in Phase D

In Phase D, the final phase, a total of 118 students (M = 6.92 years, SD = 0.66; 80girls) from six GE classrooms participated in a three-month movement-based intervention in lessons. 52.5% of the students (or 62 students) were first graders, while 47.5% were second graders (56 students). All attended public mainstream classrooms. In Phase D, six teachers were responsible for delivering the movement-based language activity (L1).

To sum up, all participants were elementary students attending mainstream public elementary school in Limassol, Cyprus. Before the study started, all the necessary release forms from the Ministry of Education were obtained (see page 176). Both teachers and children participated in the study after providing proper consents (see page 180). Table 4 shows the participants involved in the four studies.

Table 4: Summary of participants in this dissertation

	Summary of Participants
Phase A	Students: 7 males and 3 females (N=10) – Age: M=9.8 Teachers: 10 Context: Special Education unit
Phase B	Students: 21 males and 10 females (N=31) – Age: M=8.1 Teachers: 10 Context: Special Education unit
Phase C	Students: 25 males and 27 females (N=52) – Age: M=8.2 Teachers: 5 Context: General Education classroom
Phase D	Students: 38 males and 80 females (N=118) – Age: M=6.92 Teachers: 6 Context: General Education classroom

4.3.3 Technology for Implementing Embodied Learning

4.3.3.1 Kinems Games

In Phase A, B and C, EL was implemented through Kinect, a commercial suite of movement-based interactive educational games, also known as Kinems (www.kinems.com). Kinems was the right tool for my research because it engages students in learning through natural interaction, using only the hands and body, via the Microsoft Kinect camera. It includes several games which combine motor, academic, and cognitive goals with high adaptability for a different curriculum. These games can be used in early elementary classrooms with children with special educational needs as well as with young children of typical development (Retalis et al., 2014). A unique aspect of Kinems is that children's interactions, performances, and movements during the intervention sessions are recorded on a cloud server and can be accessed via the program's analytics, which allows the researcher or practitioner to draw conclusions about participants' progress. All the Kinems games allow the teacher to change settings (e.g., duration, level of difficulty, number of words, categories of words, etc.) and save sessions for use in subsequent sessions. To address the research questions of this dissertation, I used five different games across phases (see Figure 9).

Phase A focused on games which can enhance children's motor performance, in particular, their psychomotor abilities (Gp) and psychomotor speed (Gps), based on the Cattell-Horn-Carroll Integrated Model, which is the empirically supported model for assessing cognitive abilities (Cattell, 1971). The games used were 'Walks' and 'River Crossing'.

Phase B used two games from the suite designed to address short-term memory skills (Gsm), according to the Cattell- Horn-Carroll Integrated Model (Cattell, 1971; Schneider & McGrew, 2012): 'Unboxit' and 'Melody Tree'.

Phase C used two games to investigate how the EL approach helps children improve memory and language skills, the 'Unboxit' game for short-term memory skills (Gsm) and the 'Lexis' game for vocabulary and linguistic development.

Each game is described in detail in the next three chapters, where each phase is fully analysed (see Chapter 5, 5.3.2 for Phase A; Chapter 6, 6.3.2 for Phase B; Chapter 7, 7.3.2 for Phase C).

Walks River Crossing Unboxit

Melody Tree Lexis

Figure 9: Screenshots of Kinems games used in this dissertation

4.3.3.2 PanBoy, a Movement-based Intervention

In Phase D, the final phase, we used a movement-based EL intervention we developed ourselves. We called it PanBoy. PanBoy was based on the EL learning paradigm and according to current scientific evidence on what prevents effective learning. Our aim with PanBoy was to enhance the vocabulary and language acquisition of first and second graders by creating a simple and easy-to-implement intervention that could be used in classrooms by the teachers themselves. The intervention was intended to be a class-wide intervention in mainstream classrooms that could be adapted to fit the curricula of different classes. Specifically, PanBoy pairs bodily movements with specific words chosen from first and second-grade vocabulary acquisition curricula.

Unity® software was used to record character movements. Once the movements were recorded, 10 PowerPoint presentations with 80 movement-words with animations were created for the intervention in the classroom. Each session/intervention was designed to be implemented in a playful, collaborative way with increased difficulty across the sessions. See Chapter 8, 8.3.2 for a detailed description of the development of the PanBoy intervention.

4.3.4 Procedures and Settings

All the research phases were conducted in authentic classroom environments in schools. The first two phases (Phase A and B) were conducted in an SE context, in special units of mainstream schools. The other two phases (Phase C and D) were conducted in different mainstream schools in a GE context. The research lasted three years (2015-2018) so we could see how our EL practice evolved across multiple groups of students over time. All the educational interventions were carried out in the classroom with the class teacher present.

In all the phases, before actual implementation in the classroom, participating teachers were invited to take part in a training workshop where they could learn to play Kinect-based educational games—Kinems for Phases A, B and C, and PanBoy for Phase D—so they could implement the intervention in the classroom effectively. Furthermore, this workshop provided teachers with the skills necessary to identify, customize, and enact interventions that would address the specific needs of their students.

In Phase A, the intervention was conducted over a five-month period. In mainstream elementary schools with a special education unit, the interventions took place within the unit. In this case, the teacher prepared a personalized Kinems intervention based on the needs of their students. Students participated in two 40-minute Kinems sessions per week. They did not play the games in the same order, for the same duration or with the same games settings. Personalised game settings were selected by the children's special education teacher/therapist.

In Phase B, the intervention was conducted over a five-month period using Kinems games. During this period, students participated, on average, in two 40-minute Kinems sessions per week and completed between 12 and 40 sessions for the duration of the study. The interventions took place within the unit. As with Phase A, the teacher prepared personalized interventions based on the special educational needs of each student. Children did not play the two Kinems games, 'Unboxit' and 'Melody Tree', in the same order, for the same duration, or with the same settings each time; the personalized program of each child's game settings were selected by the child's special needs teacher.

In Phase C, the study was implemented over a four-month period. During this period, children completed 13 Kinems game sessions in their own classroom with their teacher once per week for 45 minutes. In this phase, all teachers prepared and organized class-wide intervention sessions, selecting the games (in this case ‘Unboxit’ and ‘Lexis’) and configuring the settings, increasing the difficulty over time. Children played at different times. While some children were playing, other children completed worksheets and activities based on the lesson plan. In all cases, the lesson plan, game settings, and procedures were the same. Games were fully integrated into lessons in such a way as to benefit all the children and enriched their knowledge of the subjects they were designed for.

In Phase D, the 30-minute PanBoy intervention sessions were delivered to the whole class once a week for ten weeks over a three-month period during language/literacy lessons, using ten video-based PowerPoint presentations. Classroom activities started out simple at the start of the program and built in complexity over the weeks. Students participated in 12 sessions of movement-based learning. Each session had a short video component with movements, words, and pictures, giving the children explicit visual instruction on how to perform each movement. This way the children taught themselves the necessary skills they needed to complete the interventions. The equipment needed for Phase D included a computer, speakers, and an interactive whiteboard/projector.

The following Figure 10 shows the procedures of the four phases of investigation in the classroom.

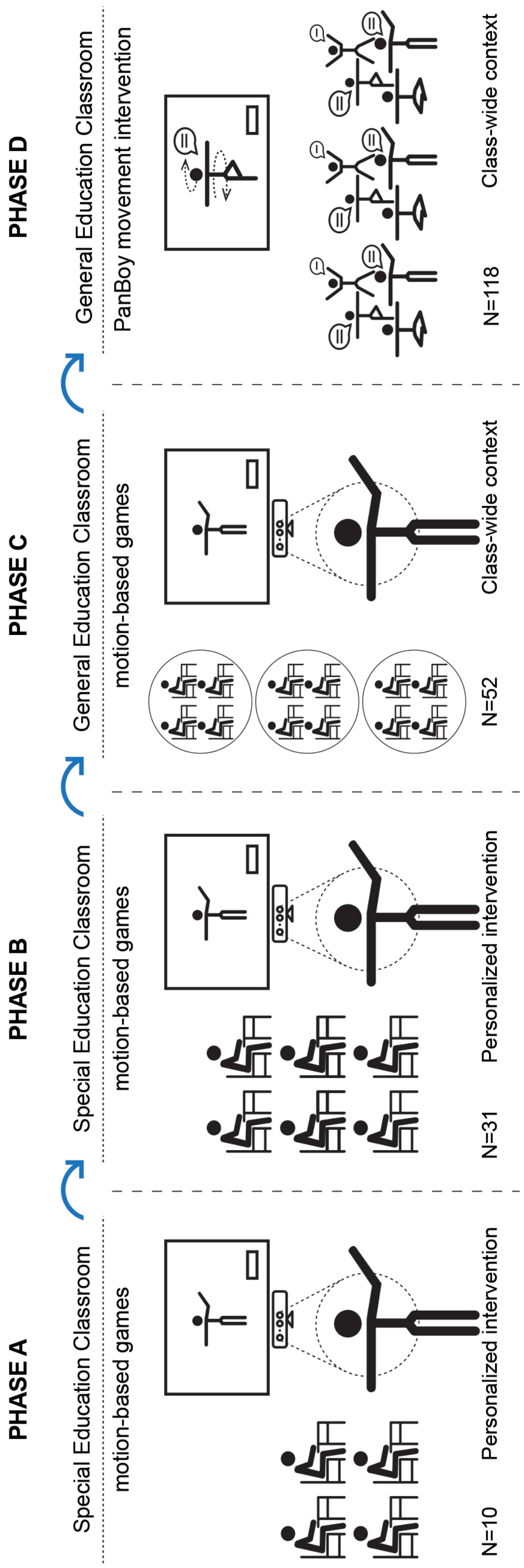


Figure 10: Visualizing the interventions in the classroom across the four phases

Finally, it is worth mentioning that in all four phases, the interventions were designed to promote children's physical engagement in the lessons, specifically their bodily movements and gestures. The Table 5 summarises how the four phases were carried out.

Table 5: Summary of procedures in four phases of the research

	Intervention period	**Completed Sessions**	**Intervention**	**Setting/ Technology**
Phase A	5 months	12 – 40	Personalized	Kinect games
Phase B	5 months	12 – 40	Personalized	Kinect games
Phase C	4 months	13	Class-wide activities	Kinect games
Phase D	3 months	12	Class-wide activities	PanBoy intervention

4.3.5 Data Collection of the Four Phases

Following the MD approach, I collected data using various methodologies. During all the phases I followed a mixed methods approach, with simultaneous quantitative and qualitative data collection approaches. Both quantitative and qualitative data were gathered in order to examine learners' overall performance in the classroom using technology, learners' perceptions of the EL teaching method, teachers' perceptions of the EL implementation in the classroom, the ways in which technology supported EL, and the possibilities of using EL in authentic learning contexts. The strategy for data collection was similar for Phases A, B, and C. For Phase D, I focused more on qualitative measures, using a video recording of all the sessions. The following sections describe each data collection method used for this research.

4.3.5.1 Assessment measures

The pre-post memory test was adapted from Gonida and Iossifidou's (2008) Psychometric Criterion of Cognitive Adequacy for Children and Adolescents. The particular pre and post-assessment test I used to assess the children's short-term memory skills (Gsm) is called 'Recall Word'. 'Recall Word' is based on Catell's (1971) classification and has 27 questions which measure sequential processing and short-term memory (Gsm) through audio-visual and auditory-motor activities. The test I used was a Greek version adapted from the Kaufman Assessment Battery for Children, second edition (KABC-II) (Kaufman & Kaufman, 2004). This test was appropriate for the purpose of the study as it validated and standardized in Greek language for measuring the short-term memory ability of students.

To measure language skills (e.g., expressive vocabulary), I used the standardized Greek version of the Word Finding Vocabulary Test (Renfrew, 1997), normed on Greek preschool and school-aged children (Vogindroukas, Protopapas & Sideridis, 2009) and used by researchers in the area of language learning (Kambanaros, Michaelides, & Grohmann, 2015). This test is designed to measure the extent to which pictures of objects, arranged in order of difficulty, can be named correctly. The test includes 50 line-drawn pictures. Both psychometric memory and language tests were given by the teachers after they had been trained and with the presence of specially trained staff. Children who did not complete all pre-post tests were not included in the sample.

In Phase D, I used a test based on vocabulary introduced by the PanBoy intervention (see 4.3.3.2) in order to see how many new words the children actually learned from the intervention. In this test, each child had to write the words associated with the bodily movements they performed in the intervention. The test was personalized for each student and included 50 randomly selected words from the PanBoy vocabulary (see all the psychometric and assessment tests on page 182).

4.3.5.2 General Games-usage Analytics

In Phases A, B and C, the learning analytics automatically recorded by the Kinems software were used to chart the progress of students participating in five games ('Walks', 'River Crossing', 'Unboxit', 'Melody Tree' and 'Lexis'). The analytics revealed student growth across sessions as the study unfolded. This data enabled teachers and researchers to pinpoint exactly how their children were progressing by isolating variables of interest. In my analysis, I focus on general analytic details, such as the time spent playing, the speed of completing the session and the number of errors in each session. These analytics were linked to our variables of interest and were analyzed in conjunction with other quantitative and qualitative measurements in order to examine the overall performance of students.

4.3.5.3 Students' short attitudinal scale

At the end of the intervention period, a short attitudinal Likert scale (see page 191) was administered to students participating in Phase B and Phase D to assess their overall experience and perceptions of the learning approach. The questionnaire focused on the children's emotions and feelings during the intervention period.

4.3.5.4 Semi-Structured Interviews

All teachers participating in the four phases were interviewed at the end of the intervention. Semi-structured interviews (see page 192) were then conducted with all teachers (N=21) who participated in all phases (from Phase A to Phase D) to assess their overall experiences and perceptions of EL in authentic classroom environments. The qualitative data from semi-structured interviews were transcribed and coded as described in Saldana (2009) and following the analysis procedure of Chi (1997). The analysis started with an open coding and grouping of codes under higher-order categories. The next step was the review of the emerged categories and subcategories and then the interpretation for finalizing the categorization. Coding was done by two researchers. One was an independent researcher who participated in the data analysis process to allow a check for inter-rater agreement.

4.3.5.5 Teachers' observation notes

Teachers made comments during each intervention session in the form of a reflective diary. In Phases A, B, C, teachers' notes were saved on the Kinems platform. In Phase D, teachers made comments in observation protocols (see page 196) given by the researchers. The comments focused on monitoring how the students perceived the game and how well they met the specific goals. My analysis of teacher comments concentrated on 1) learning benefits as perceived by the teachers, and 2) students' overall appreciation of the learning method as perceived by the teachers.

4.3.5.6 Video recording of movement-based sessions

In the final stage of the research, Phase D, all classroom sessions using the PanBoy intervention were video recorded. The cameras were positioned in two different places in the classroom and captured most of the students' movements. In the end, 40 minutes of material was recorded for each classroom per session. The video material was intended to yield rich information about the physical engagement and interaction of the students and to show just how EL worked in the classroom. Collecting video material also allowed me to view what users actually did in the learning setting, capturing behavior that would otherwise have gone unreported.

Table 6 summarizes the types of data collected in the four phases of this investigation.

Table 6: Summary of data collection across four phases

	Phase A	**Phase B**	**Phase C**	**Phase D**
Psychometric test for memory ability		+	+	
Test for Vocabulary acquisition			+	+
Games-usage Analytics	+	+	+	
Students' attitudinal scale		+		+
Teachers' Semi-Structured Interviews	+	+	+	+
Teachers' Observation notes	+	+	+	+
Video Data				+

4.4 Trustworthiness of the Research

One challenge conducting qualitative studies (i.e. part of a mixed-method investigation) is the way to ensure the trustworthiness of a naturalistic study. In existing literature, there is a debate between positivist and naturalistic investigators on the concepts of validity and reliability in qualitative research. Guba (1981) to ensure trustworthiness of a naturalistic study, proposed the criteria -among others- of validity, reliability and generalizability.

Regarding the validity of the research (i.e. how well the study was conducted), according to Shenton (2004), one way to ensure the credibility of a study is to adopt well established research methods and theories to base our interpretations. Therefore, in order to strengthen the bonding between raw data and findings we followed an existing theoretical model of EC and EL (Wilson, 2002). The validation of EC theory was taken as given in this dissertation. Furthermore, EC has been also applied in various research studies and outside from educational practice. This research attempts to show precisely how EL-driven technology can be implemented in authentic learning environments, improving our understanding regarding the use of an EC framework in education.

To achieve this and in order to avoid students' out of normal behaviour, we carried out four phases of investigation in different classrooms with different participants. We also extended our observation over a five-month period in Phase A and B, a fourth-month period for Phase C and three-month period for Phase D. This persistent observation helped in waving the novelty effect off the participants, and measuring the real experiences of the learners within the EL approach.

Moreover, the research was conducted in Special Education context (Phase A, B) and in General Education context (Phase C and D) ensuring the replicability of our findings and the transferability of our results. This idea, based on EL can be replicated in other educational environments as the investigation provides comprehensive description of different empirical implementations in the classrooms. In that way, our examples we allow researchers and practitioners to make decisions about the fittingness of our study in their real settings.

In each phase of investigation, we triangulate our findings, employing different methods for data collection to ensure our results. Interviews were analyzed building the basic coding scheme for our study and then data from observations and video recording were used as a validating tool, comparing and evaluating our findings and interpretations. Furthermore, one of the ways that we also employed to overcome novelty effects and be sure of the repeatable character of our findings is by running four phases of data collection and analysis which enable the documentation of patterns that could not be identified within a single-study design.

Overall, using multiple data sources in each phase such as questionnaires, learning analytics, interviews, observations, and video recordings, we ensured that what is reported is objective and unbiased. In addition, in the qualitative data analysis procedures, a second independent investigator examined a representative part of the data analysis and ensured a high degree of inter-rater agreement, before proceeding to the full analysis of the collected data.

4.5 Summary

This chapter outlined how MD research design was used by this dissertation and elaborated on the context, participants, procedures, and settings of the four phases of research, including data collection methods and tools. The following chapters will explain in detail how data were processed during each phase so as to answer the research questions outlined in Section 4.3.1.

5 Phase A: Piloting Embodied Learning in the Classroom

This first Phase of investigation served as a pilot study with a small group of students within authentic SE context. This first cycle of research aimed to explore the possibilities of integrating EL approach using multimodal, motion-based games mediated by sensors like a Kinect camera, in the real classroom (in this case in a special unit within mainstream school) as a personalized intervention with SEN students. More specifically, as shown in Figure 11, Phase A addresses one research question.

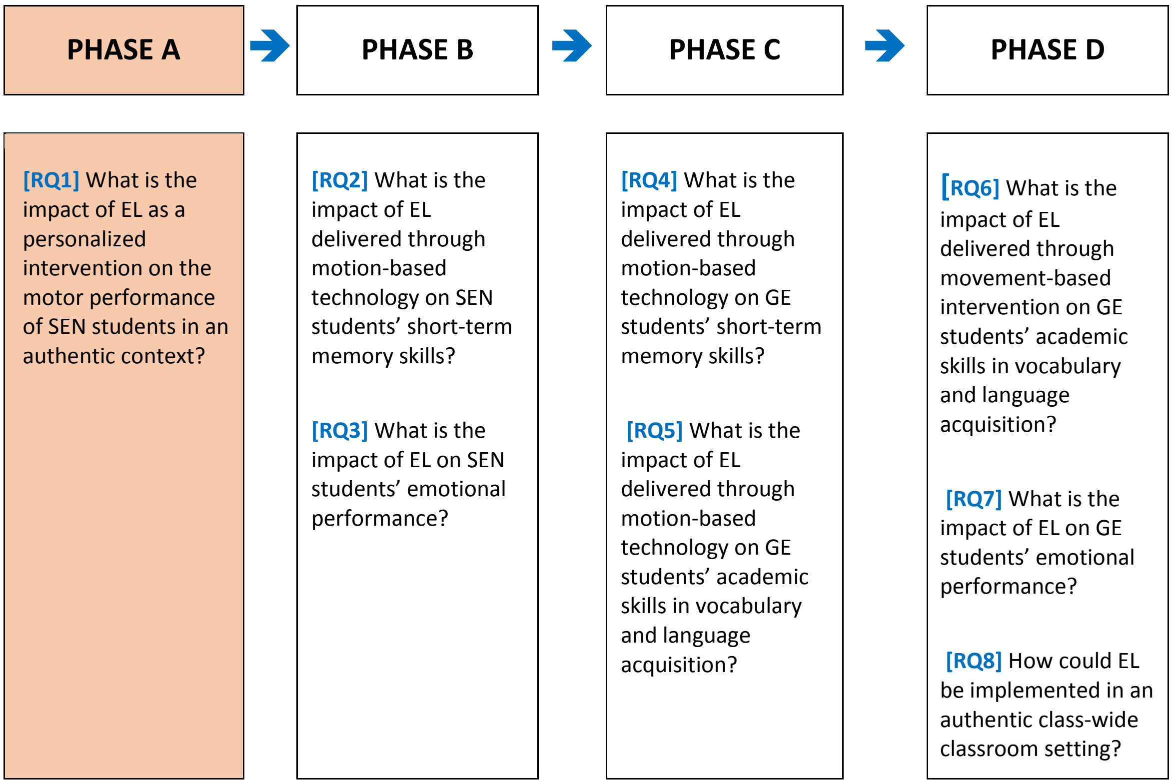


Figure 11: Research question of Phase A

Findings from this investigation revealed improvements in children's motor performance, particularly Psychomotor Ability (Gp) and Psychomotor Speed (Gps), based on the classification of Cattell (1971). Results of this study are published in Proceedings of European Conference of Technology Enhanced Learning (ECTEL) 2017 (Kosmas, Ioannou, & Retalis, 2017).

5.1 Introduction

This chapter investigates how EL practice with the use of embodied touchless interactive games can advance the motor performance of children with learning disabilities and motor impairments. This study focuses on the motor performance of children, particularly:

Gains in (a) Psychomotor Abilities (Gp) - the ability to perform physical body motor movements with precision, coordination, or strength, and (b) Psychomotor Speed (Gps) - the speed and fluidity with which physical body movements can be made, based on the Cattell-Horn-Carroll Integrated Model classification of skills, which is widely accepted as the most comprehensive and empirically supported model of cognitive abilities (Cattell, 1971).

5.2 Related Work

In the last few years, innovative embodied interaction technologies are replacing the traditional human-computer interface modalities like mouse and keyboard (Leitan & Chaffey, 2014). Motion-based, interactive games such as Wii, Wii Fit or Wii Balance Board, Kinect-based games and exergames have received the researchers' attention investigating their potential for learning. These types of interactive games require active participation and physical engagement by the participants. In doing so, players can practice their motor skills in addition to others (e.g., cognitive skills depending on the goals of the game).

Within the limited empirical evidence in special education, motion-based interactive games appear to enhance the motor skills of children with disabilities (Barnhart, Davenport, Epps, & Nordquist, 2003; Chang, Chen, & Huang, 2011). For example, in a relevant study (Sandlund, Waterworth, & Häger, 2011) a total of 15 children with cerebral palsy with limited motor control of arms, experienced increased physical activity during the interventions with motion-based interactive games, compared to children in the control group. In another study conducted with 40 children diagnosed with cerebral palsy spastic diplegia, the practice with Nintendo Wii Fit games showed significant improvement in children's motor performance, when the control group exhibited no significant changes in the respective measures (AlSaif & Alsenany, 2015).

Moreover, a study conducted with ten children with motor impairments using Nintendo Wii (Wii), showed significant improvement in upper limb functions for children in the intervention group (Sajan, John, Grace, Sabu, & Tharion, 2016). It should be noted that all studies mentioned above used motion-based interactive games in home settings (rather than in school environments or therapy centres) with children with motor impairments.

Along the same lines, a series of studies have been conducted to support both children and adults with attention problems and motor impairments (Deutsch, Borbely, Filler, Huhn, Guarrera-Bowlby, 2008; Hsu et al., 2010; Joo et al., 2010; Loureiro, Valentine, Lamperd, Collin, Harwin, 2010; Saposnik et al., 2010). In one study (Altanis et al., 2013) children with gross motor skills problems were actively engaged in learning and, as a result of playing, improved their motor performance. In another recent study (Kourakli et al., 2016), a total of 20 children with special educational needs used a suite of Kinect-based learning games for a number of weeks; results showed significant improvement in children's motor, cognitive and academic skills. Moreover, previous findings from research on exergames suggest that their use in rehabilitation interventions is pleasant in addition to being effective in helping people to improve their motor skills (Vernadakis, Papastergiou, Zetou, & Antoniou, 2015). Yet, other studies have shown limited effects of exergames on participants' performance (Hsu et al., 2010).

All things considered, a few empirical studies in the last decade have shown that bodily movement can enhance learning and motor performance, while it appears to help with attention levels during the task. In all studies, researchers have emphasized the need for conducting more work to provide compelling evidence for the effectiveness of motion-based, multimodal interactive technologies for EL.

5.3 Method

This Phase A, as well as the following phases, employed an MD mixed method research design that incorporated both qualitative and quantitative data collection and analysis.

5.3.1 Participants

This first exploratory study involved ten elementary SEN students (seven boys and three girls) with motor impairments. All of them (N=10) attended mainstream elementary schools with special education units. The participants had comorbid learning disabilities and disorders which influenced their motor performance, such as dyspraxia, brain paralysis, Down syndrome, and ADHD. Five children were diagnosed with brain paralysis, spastic diplegia or quadriplegia which is subsets of spastic cerebral palsy that affects arms and legs. One child was diagnosed with dyspraxia which is a disorder that makes it hard to plan and coordinate physical movement. The rest four children had motor impairments combined with other disorders such as Down Syndrome, autism and ADHD (see Table 7). Inclusion criteria were age (6–12 years old) and ability to use Kinect-based, multimodal interactive games, even from a seated position. Exclusion criteria included a severe motor or mental disorders to the extent that no engagement with the activities would be possible, according to the participating educators/therapist. Ten special educators were involved in the study, who were responsible for implementing the interventions during a five-month period.

Table 7: Children participating in Phase A

Child	Age	Diagnosis
1	8	Motor impairments (seated on a wheelchair)
2	8	Down Syndrome and motor impairments
3	11	Brain paralysis
4	8	Motor impairments and ADHD
5	9	Dyspraxia and motor impairments
6	8	Autism and motor impairments
7	10	Brain paralysis - Spastic diplegia
8	12	Brain paralysis -Spastic quadriplegia (on a wheelchair)
9	14	Brain paralysis -Spastic diplegia (on a wheelchair)
10	14	Brain paralysis and motor impairments

5.3.2 Motion-based Games for Embodied Learning

In this first study, I used the commercial suite of Kinect motion-based interactive educational games, known as Kinems. In this Phase A, I focused on games which can enhance the motor skills of children, particularly Psychomotor Ability (Gp) and Psychomotor Speed (Gps), based on Cattell-Horn-Carroll Integrated Model classification of skills (Cattell, 1971). These are the "Walks" and "River Crossing".

To provide a better picture of the motion-based learning games of this Phase, "Walks" is a game that takes place in an imaginary farm. A farmer should walk along a path and collect carrots, without straying off the path into the mud or colliding with moving critters. The game can be made more/less challenging by selecting various path directions (horizontal, vertical, diagonal or zigzag) or by adding/removing obstacles to be avoided (see Figure 12 left).

On the other hand, in "River Crossing" (see Figure 12, right), the child undertakes the task to lead a boat in a river and transfers animals and items of the food chain from one shore to the other. The child should be very careful so as not to crash the boat on rocks that exist. Sometimes the passage for the boat becomes narrower or wider, depending on the difficulty level of the game that the teacher can adjust.

Figure 12: "Walks" game (left) and "River Crossing" game (right)

5.3.3 Procedures

Special education teachers with their students were invited to participate in the study, upon ethical review of the proposed work. Before the implementation, a training workshop was conducted for teachers/therapists to practice the use of Kinems games and understand how to implement the method effectively. The intervention was conducted over a five-month period. In this phase, the interventions took place in the special education unit of mainstream schools. The teacher prepared a personalized intervention based on the needs of their students. On average, students received two sessions of 40-minutes Kinems interaction per week and completed between 12 and 40 sessions in the duration of the study. Children did not play the games in the same order, duration, or configuration settings; the personalized programme of each participating child involved different game settings (see Figure 13).

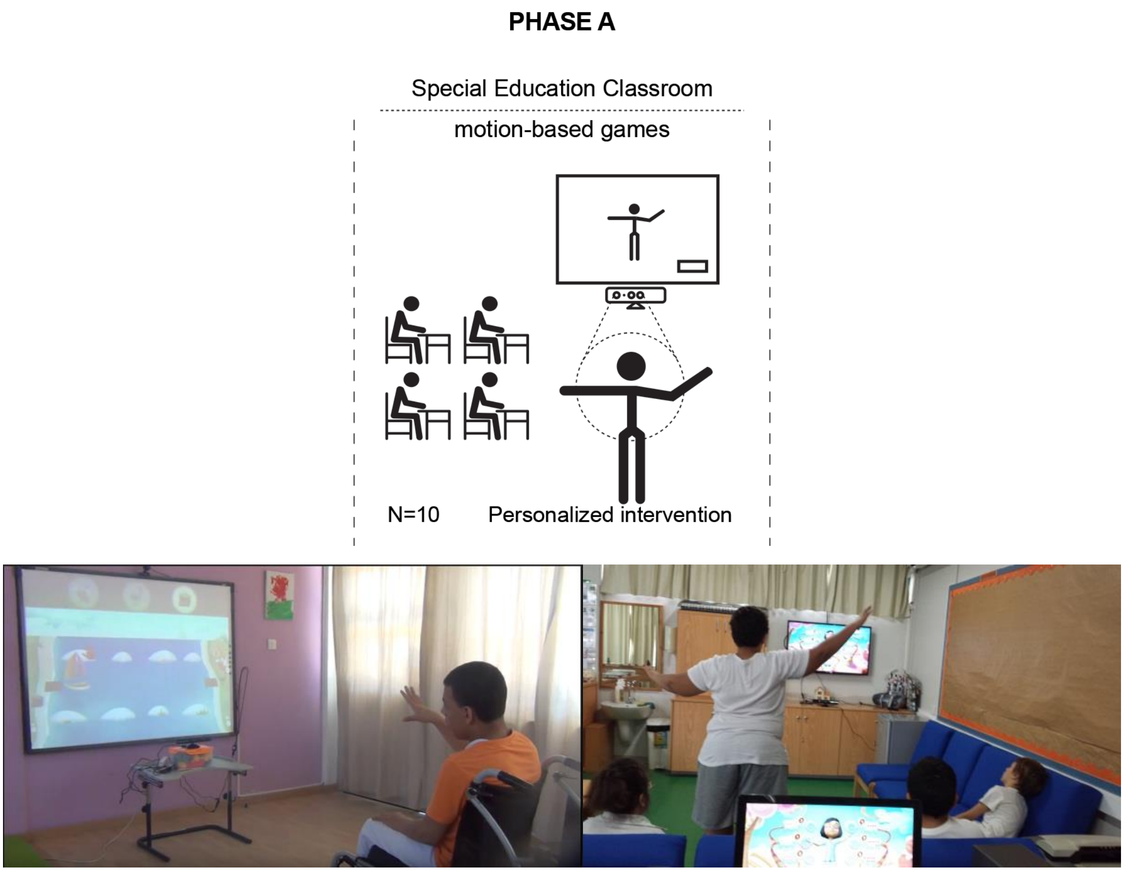


Figure 13: Intervention in the classroom with SEN children – Phase A

5.3.4 Data Collection in Phase A

In terms of data collection, system log-file data of children's interaction were automatically recorded in the Kinems platform. For example, depending on the game, the system recorded hand movements and stability, number of times the child completed the game, number of obstacles avoided (e.g., snakes and worms in "Walks" and rocks in "River Crossing" game) and speed of completing the game. In other words, the Kinect sensor recorded tracking data as the game progressed to enable the teachers' and researchers' understanding of children's progress on the variables of interest, in this case, Psychomotor ability (Gp) and Psychomotor speed (Gps).

The dataset also included teachers' typed observations regarding children's performance, behaviour, and participation in the learning process; per researchers' instructions, these observations were noted by teachers at the end of each session in a specific notes-area for typing within the Kinems software. Furthermore, at the end of the programme, semi-structured interviews were conducted with all participating teachers. As shown in Table 8, questions focused on teachers' perceptions of students' improvement through their participation in the programme and the value of the Kinems games for EL for SEN students with motor impairments.

Table 8: List of some questions asked in semi-structured interviews

Question	
1	How was the mood and motivation of the children during the sessions?
2	How children increase or not their participation during the intervention?
3	In what ways did the games support children's motor needs and learning needs?
4	Were the games hard, easy, and usable for the children and the teacher/therapist?
5	Please describe the general performance of children across sessions (motivation, completion time, body and hand movement, etc.).
6	How do you see embodied games helping children to improve their skills?

5.4 Findings of Phase A

5.4.1 Advancement of motor performance – Statistical Analysis

Initially, the analysis focused on understanding how the use of embodied touchless interactive games can enhance children's Psychomotor Abilities (Gp) and Psychomotor Speed (Gps). Based on the Cattell-Horn-Carroll Integrated Model classification of skills (Cattell, 1971), Psychomotor Ability (Gp) is the ability to perform physical body motor movements with precision, coordination, or strength, operationalized in this study as the motor stability of the hand. Psychomotor Speed (Gps) is the speed and fluidity with which physical body movements can be made, operationalized in this work as the time for successful completion of the task.

With regards to Gps, we examined the speed-related analytics recorded in "Walks" which was used by all 10 participants for a different number of sessions, using configuration settings within the personalized programme of each child.

Table 9 presents sequences of "Walks" usage by each child with the same configuration settings. As shown in Table 9, the overall completion time of the game improved across intervention sessions. In fact, there was a statistically significant difference on children's speed ($t(9) = 4.35$, $p = .002$), with children completing the task in shorter time in their last session ($M = 1.67$, $SD = .78$) compared to their first session ($M = 3.57$, $SD = 1.85$), with a large effect size (Cohen's $d = 1.37$) suggesting the practical significance of this finding.

With regards to Gp, we present the case of two children, while similar gains were evident across the majority of children of Table 9. Child 2 played "Walks" for four consecutive sessions with the same configuration settings. As Figure 14 shows, this child progressively improved his hand stability along with a combination of horizontal and vertical movement, in only four sessions. Also, as the child was increasingly more capable of performing more accurate hand movement, success in completing the task was achieved in progressively shorter time (see Table 9). This child did not play other consecutive sessions of Walks with more advanced configuration settings.

Table 9: Completion time from the first to the last session in "Walks"

Child	Time in Walks Session 1	Time in Walks Last Session	Number of Sessions with same settings
1	2.37	1.4	4
2	5.1	2.12	4
3	7.33	2.39	6
4	5.8	3.34	8
5	1.58	1.3	4
6	2.19	1.51	7
7	3.19	1.29	4
8	2.42	1.7	4
9	3.34	1.18	9
10	2.4	0.49	7

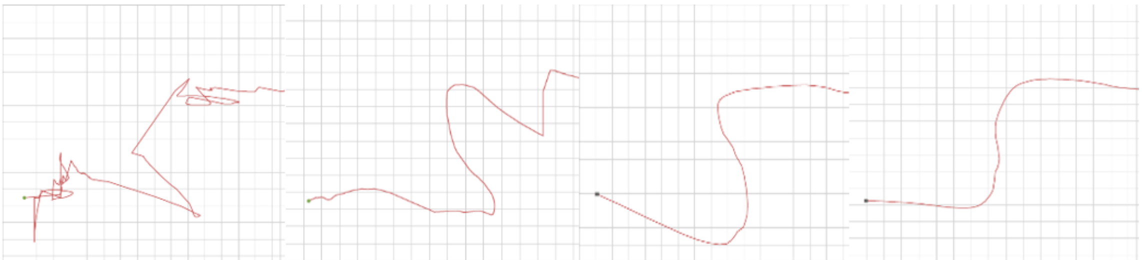


Figure 14: The progressive improvement of the child's hand movement in 4 sessions of Walks

In “River Crossing,” we present the case of Child 9 who played the game for twelve consecutive sessions with the same configuration settings. Figure 15 shows progressive improvement of the horizontal movement of his hand for four different routes from left to right during the game. Specifically, the charts of the first session (left side), show that child faces kinetic instability during the execution of the right to drive left. Instead, looking at the figures of the last session (right side) one can see the child’s improvement in comparison with the hand movement of the respective first session.

Overall, the child’s Gp ability for hand movements from left to right improved over time. Meanwhile, the game completion time of the child (Gps ability) was improved across sessions. In the first session, the child finished the “River Crossing” game in ten seconds; in the fourth session, he finished the game in four seconds and maintained this speed for the remaining sessions in “River Crossing.”

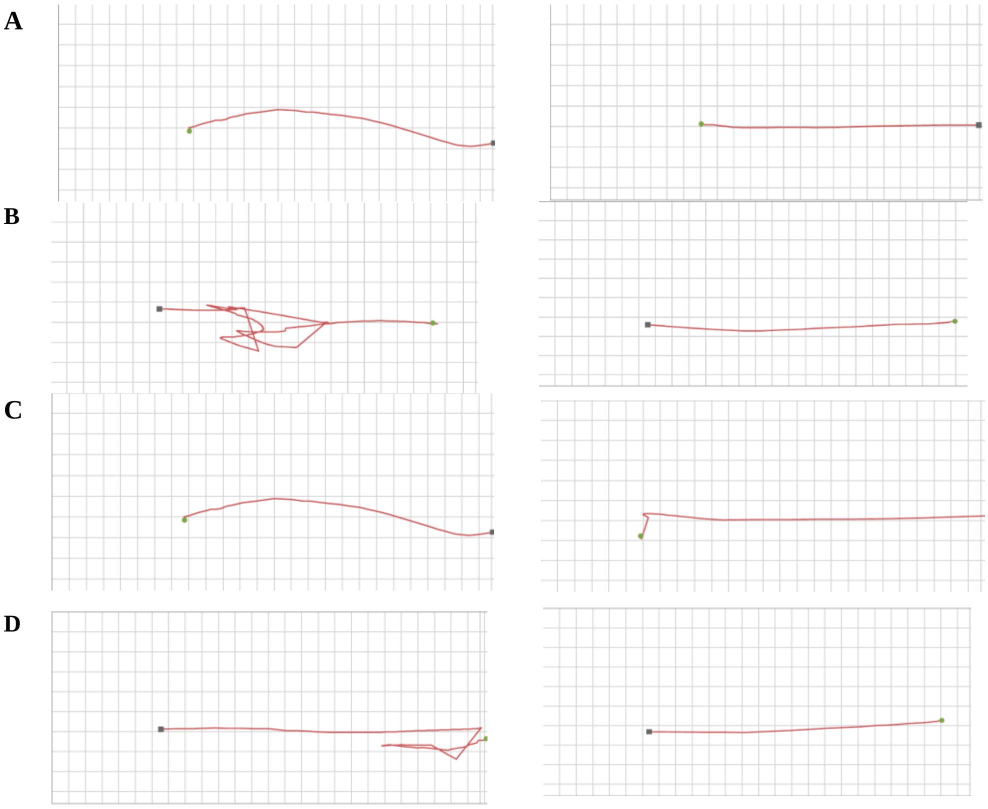


Figure 15: A: Hand movement from 1st session to 12th session in - route 1; B: Hand movement from 1st session to 12th session - route 2; C: Hand movement from 1st session to 12th session - route 3; D: Hand movement from 1st session to 12th session - route 4.

5.4.2 Teachers' Perceived Experiences - Qualitative data

Teachers' observation notes taken upon each intervention session were analyzed in conjunction with the semi-structured interviews conducted at the end of the five-month period. The interview data were transcribed and coded as described in section 4.3.5.4, following an iterative coding approach (Saldana, 2009). Coding of the interview transcripts was done by two researchers while considering the observation notes of the respective teachers. Next, we report on one theme – "Improvement of motor skills" – which is directly linked to variables of interest in Phase A– Gp and Gps.

According to the teachers, EL enabled children to engage in physical activity improving their body-hand movement. The clear majority of teachers discussed progress in vision-motor coordination, hand stability, and speed improvement, as illustrated in Table 10.

Table 10: Teachers talk about visual-motor coordination, hand stability and speed

Participant	Visual-Motor Coordination	Hand Stability	Speed Improvement in task completion
p1	+	+	+
p2	+	+	+
p3	+		+
p4	+	+	+
p5	+	+	+
p6	+		+
p7	+	+	+
p8		+	+
p9	+	+	
p10	+	+	+

A few teachers went on to discuss that the embodied interaction with the games helped the children improve their gross motor and fine motor skills, body position in the space and ability coordinate thought and movement. Some indicative quotes on the matter are presented below to express the depth of the experience:

(p1) "*With the interactive games, I saw that [child's name] was more concentrated* and *improved her movement. I think that this interactivity is very helpful especially for these children who have a lot of disabilities which affect their movement*."

(p2) "*In the beginning, it was very difficult for my students to play the interactive games, but after a few sessions, they became much more confident in their movements.*"

(p4) "*I saw a significant improvement in the gross motor skills of my students. I saw that during the intervention my children could coordinate their hands better as well as their body position in front of the game*."

(p9) "*I believe that this learning experience helped the children to coordinate their thinking and how to materialize it; thought - movement coordination for these children is very important.*"

(p5) "*One of my students has issues with his balance and hand-movement coordination. He also has a lot of difficulties in physical activities and for this reason he cannot participate in the gym class. However, this student managed to complete all the interventions. I saw significant improvement in his balance, hand stability and hand-movement coordination. I think that the games helped him a lot*."

(p7) "*I saw improvement even with children who do not have severe mobility problems. Children with severe motor impairments had stress at the beginning, but during the programme, they became capable of controlling their movement and their balance.*"

(p10) "*My children were seated on a wheelchair while playing. I saw an improvement especially in hand movement. I saw, for example, improvement in their hand stability and in their visual-motor coordination in the game. Playing these games, which require physical effort, I helped my students practice and learn to control their movements by improving the fluidity of their hand and fingers movements*".

Some yet more promising feedback was related to the transfer of motor skills. One of teachers reported improvement in his student's writing, although the study did not have the data to triangulate this finding. In the teacher's own words:

(p9) "*During the programme, I noticed that one of my students improved the way of his writing; his graphic-kinetic skill improved significantly. Before the intervention, his movements were more steel and often without control; I noticed that after these sessions his movements are more limited around the body and are more controlled*".

Overall, the teachers' perceptions were fully consistent with the findings from the Kinetic analytics reported earlier. All the participating teachers felt that the embodied learning games can have an impact on children with motor impairments and special educational needs.

5.5 Discussion - Addressing RQ1

A few studies in the field of educational technology have recently focused on exploring the potential of engaging the body in the learning process. This Phase A presents the findings from an empirical investigation of using embodied touchless interactive games, within the context of EL, to enhance motor performance for children with learning disabilities and motor impairments.

In sum, analysis of system analytics data from the Kinems embodied learning sessions revealed that children experienced significant gains in (i) psychomotor abilities (Gp) operationalized as the stability of hand movement and (ii) psychomotor speed (Gps) operationalized as the time needed to complete the task successfully. These findings were consistent with the experiences and impressions of the teacher-participants.

In general, the results of the study are encouraging as they not only support our initial expectations driven by the theory of EC but also, confirm results of previous works making use of motion-based technologies to achieve learning goals including motor performance for children with special needs and learning disabilities (Leitan & Chaffey, 2014; Bartoli et al., 2013; Sandlund et al., 2011; AlSaif & Alsenany, 2015; Loureiro et al., 2010; Altanis et al., 2013). Moreover, although many previous works make use of EL technology in (isolated) home settings, the present study suggests that such methods can be used in traditional educational settings, including special schools, mainstream schools with special units and personalized education programmes, enriching the way of teaching and learning and enhancing the motor performance of children.

Nonetheless, empirical research in the field of embodied interactive games in SE for children with developmental coordination disorders is still limited (Altanis et al., 2013; Kourakli et al., 2017), not allowing for firm conclusions to be drawn. Therefore, the results of the present investigation are encouraging and could inform scientists about the value of embodied experiences linked to specific (learning) goals (in this case motor skills and purposes). Phase A serves as a pilot study. Next we explore the use of EL in different intervention settings such as, receiving personalized intervention in special units in mainstream classrooms or being part of class-wide EL interventions in GE.

5.6 Summary

Overall the findings of Phase A provide a better understanding of the potential of using EL technology, as a personalized intervention, in the SE context. The study suggests that the use of motion-based interactive games can help enact EL and result in the advancement of motor performance for SEN children with motor impairments. The findings from this Phase A can inform and further encourage us on the integration of EL experiences mediated by motion-based technology in different learning environments not only in SE but also in GE. Next chapter presents the findings of Phase B within the context of SE examining the impact of EL on cognitive and emotional skills of SEN students.

6 Phase B: The Impact of Embodied Learning in Special Classroom

This chapter presents the findings of Phase B within the context of SE. As in Phase A, Phase B conducted in an authentic special unit of mainstream schools with SEN students. The investigation focuses on the use of a series of Kinect motion-based educational games by 31 SEN elementary students during a five-month intervention study. This cycle of research aims to further examine the potential of EL on students' cognitive and emotional performance. More specifically, Phase B addresses the following research questions (see Figure 16).

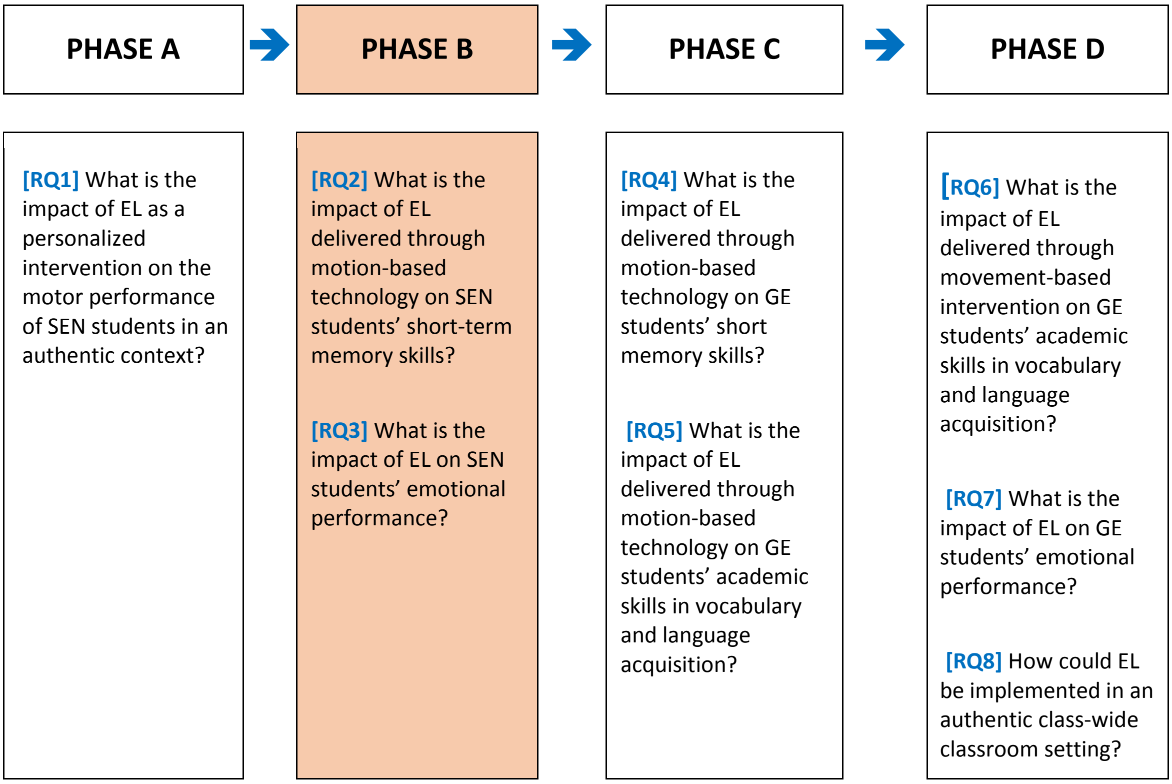


Figure 16: Research questions of Phase B

Findings from this investigation demonstrated the positive impact of the games on children's short-term memory skills and emotional state. Results of this study are published in the Tech Trends journal (Kosmas, Ioannou, & Retalis, 2018).

6.1 Introduction

EL, as a teaching method, provides ways of engaging the physical body in multimodal learning experiences aiming to improve the learners' cognitive abilities (Wilson, 2002). One way, EL can be achieved is via the use of motion-based technology (e.g., Kinect-based games, Wii, exergames, etc.), which requires the learner's physical engagement in interacting with the technology and playing the games. Such games are characterized by motion and movement activities, such as clicking, grasping, pointing, walking or balancing (Altakrouri & Schrader, 2012; Iacolina, Lai, Soro, & Scateni, 2010). Thus, motion-based technology, and particularly the use of Kinect-based games, can be framed as one such example of EL activity.

Despite the recent growing interest in EL and motion-based technology, there is a lack of empirical research focusing on its integration and impact in school authentic settings (Malinverni et al., 2016). The issue becomes of paramount importance when one considers the rise of children with special needs in mainstream schools worldwide (McConkey, Kelly, Craig, & Shevlin, 2016), vis-à-vis the under-utilization of technology in the classroom (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013).

Phase B investigates the use of EL in authentic SE environment. We examine the use of a series of Kinect-based educational games by 31 children in special education, during a five-month program. This second cycle of investigation focuses on short-term memory gains and emotional outcomes, particularly:

1. Gains in short-term memory ability (Gsm), i.e., the ability of encoding, retention, and immediate use of information from memory, based on the classification of cognitive skills of the Cattell-Horn-Carroll Integrated Model (Cattell, 1971; Schneider & McGrew, 2012).

2. Outcomes related to children's emotional' stage, e.g., joy, self-confidence, motivation.

6.2 Related Work

In the last decades, researchers and learning scientists have explored how kinesthetic activities and sensorimotor abilities have influenced student learning with particular interest on mathematics and science (Abrahamson 2013; Ayala et al. 2013; Kellman and Massey 2013; Hall and Nemirovsky 2012), as well as language and reading comprehension (Cassar and Jang 2010). For example, Chang et al. (2013) examined students' understanding of verbal information using a Kinect-based activity; their results indicated that the embodied approach facilitated learning. In the study by Gao et al. (2013) with 32 university students, the Kinect-based condition had positively influenced encoding, understanding, and recall of information, compared to a control condition. Van Dam et al. (2012) showed that the embodied approach improved the language comprehension of 20 students, indicating that word meaning is linked to sensorimotor experience.

Along the same lines, the study of Lee et al. (2012) demonstrated that the Kinect-based activity facilitated conversational language learning for 39 students, attracting their attention and stimulating their thinking. In the context of mathematics education, Have et al. (2016) examined 505 elementary children in a 9-month intervention integrating physical activity into the math lessons; the authors revealed the positive impact of children's physical engagement on mathematical achievement and executive functions, compared to a control group. Moreover, Trninic and Abrahamson (2012) suggested that the use of embodied artifacts (body-based and modular rehearsed actions) can enable students to achieve better performance and understanding. The general findings of these studies support that the integration of body in the learning process can promote understanding of mathematical concepts, graphs, and formulas (Abrahamson 2013) and can improve students' overall mathematical achievement (Have et al. 2016).

In the context of special education, the use of technological tools that activate multiple senses as well as the kinesthetic and the sensorimotor experience have been considered to facilitate learning (Malinverni et al. 2012). Researchers have investigated different motion-based technologies that are based on natural user interaction such as Wii, Wii Fit or Wii Balance Board, Kinect-based games, and exergames. A few studies have shown their positive impact on learning (Bartoli et al. 2013, 2014; Malinverni, Mora-Guiard, Padillo, Hervás, & Pares, 2014), mainly being used in home settings or in therapy centers for children with special needs. For example, the study by Bartoli et al. (2013), with five elementary autistic children playing Kinect-based games at a therapeutic center for a period of two and a half months, revealed positive improvement on children’s attention skills. Another exploratory study with ten elementary autistic children at a therapeutic center demonstrated the effectiveness of a Kinect-based game in promoting social initiation (Malinverni et al. 2014). Other studies have shown that the increased physical activity is linked to improved academic performance (Donnelly and Lambourne 2011; Gao et al. 2013), concentration and memory skills (Monti et al. 2012; Chao et al. 2013; Budde et al. 2008), and motor performance (Kosmas et al. 2017). For example, a study of the value of BDance Dance Revolution (Gao et al. 2013) showed that the 4th-grade students’ physical engagement enhanced their academic performance compared to a control group. Another study by Kourakli et al. (2017) examined 20 elementary children with special educational needs attending mainstream schools with special units, using a suite of commercial Kinect-based interactive educational games, namely the Kinems suite. Their analysis of data gathered via pre-post testing, interviews, and kinetic/learning analytics showed that the Kinems games had a positive impact on children’s academic performance, cognitive, and motor skills. Additionally, Altanis et al. (2014) conducted a one-month intervention study at the premises of the Attention Deficit Hyperactivity Disorder (ADHD) unit of the children’s university hospital; 11 four-eight years old ADHD children played a series of Kinect-based educational games demonstrating significant improvement on their executive functions and cognitive skills (Retalis et al. 2014).

Overall, EL appears to be an emerging research field with promising findings from a few empirical studies in various domains. The present chapter focuses on presenting findings related to memory and emotional performance of SEN children through EL.

6.3 Method

6.3.1 Participants

Participants were 31 children with special educational needs in five mainstream elementary schools in Cyprus. Most of them (N=18) attended schools with special education units. 13 students (N=13) attended schools with no special education unit (i.e., in-class support when needed). The complete sample included children 6-12 years, 68% boys. According to the confidential school records, the participating children were diagnosed with one or more special educational needs, as shown in Figure 17. Participants were also ten special educators (same teachers with Phase A), who voluntarily agreed to participate in the study implementing a five-month program with their children.

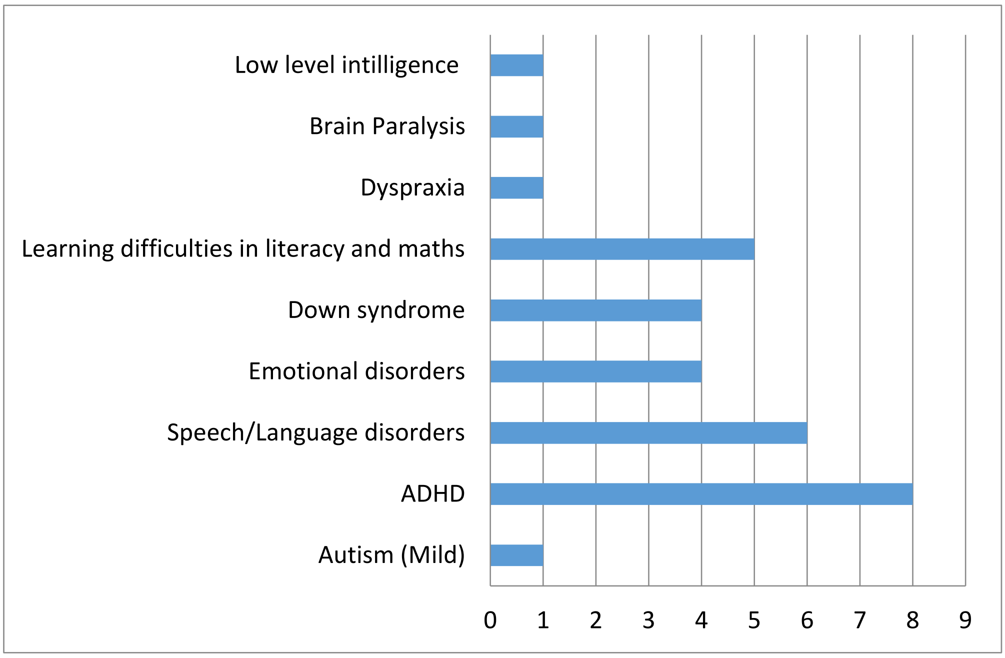


Figure 17: Range of participants' special educational needs (N=31)

6.3.2 Motion-based Games for Embodied Learning

As in the previous phase, we used the commercial platform of Kinect motion-based educational games, Kinems, which is specifically designed for children with special educational needs as well as, for young children of typical development in early elementary or pre-school/kindergarten (Retalis et al., 2014). In this second phase of the investigation, we focused on the use of two games from the suite, both designed to address short-term memory skills (Gsm), per Cattell-Horn-Carroll Integrated Model classification of skills, which is the empirically supported model of cognitive abilities (Cattell, 1971; Schneider & McGrew, 2012):

1. "Unboxit" game (see Figure 18, left), which is based on the concept of typical flashcards for improving visual memory and recognition, enhancing children's visual-spatial working memory, attention, concentration, and processing speed. In this game,

the child concentrates on finding pairs of objects that are hidden in boxes. To select an object, the child places his/her hand over the object and keeps the hand motionless for a few seconds in order to select it. The teacher/researcher can set the category of objects including animals, letters, fruits, etc.

2. “Melody tree” game (see Figure 18, right), which is focused on sounds, thus aiming at the improvement of audio-visual memory, attention, and concentration. In this game, the child concentrates on finding pairs of sounds that are hidden in melody keys. Again, to select an object, the child places his/her hand over the object and keeps the hand motionless for a few seconds in order to select it. The teacher/researcher can set the category of sounds including animals, weather, instruments, melodies, etc. and can add visual and/or audio distractors in order to increase the difficulty level.

Figure 18: “Unboxit” game (left), “Melody tree” game (right)

6.3.3 Procedures

The participating special teachers in Phase B, like in Phase A, attended a mandatory workshop on the philosophy of the study and hands-on use of the Kinems games. The workshop provided teachers with the skills necessary to identify, customize, and enact games to address specific needs for their students, i.e., memory skills in the case of the present study.

The intervention was conducted during a five-month period. During this period, students received, on average, two sessions of 40-minutes Kinems interaction per week and completed between 12 and 40 sessions in the duration of the study (see Figure 19).

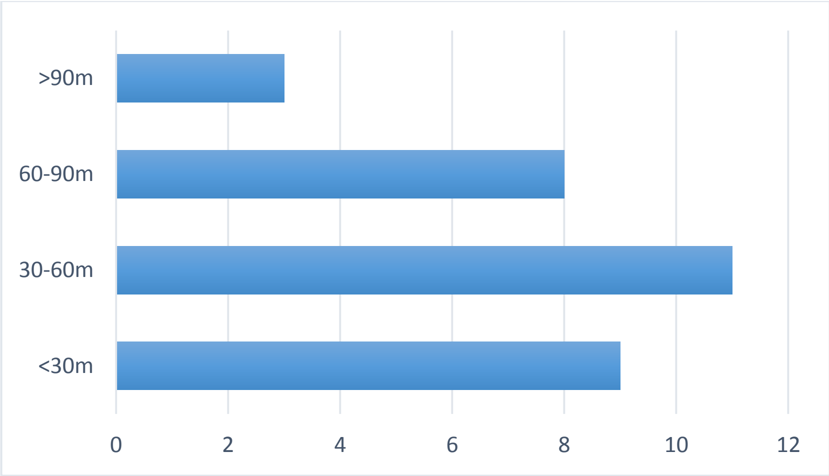


Figure 19: Average usage time of the games by children (N=31)

In schools with a special education unit (N=18 students), the interventions took place in the unit. In this case, the teacher prepared personalized intervention-sessions based on the special educational needs of each student. In schools with no special education unit (N=13 students), the teachers prepared class-wide intervention-sessions, designed on the bases of the participating special needs student; in this case, the participant played the games together with other children of typical development. Figure 20 visualizes the intervention in the classroom during Phase B.

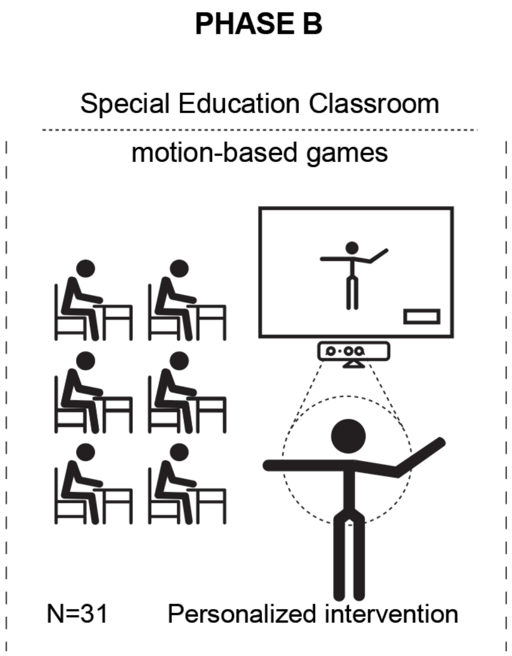


Figure 20: Intervention in the classroom – Phase B

Children did not play the two games in the same order, duration, or configuration settings; the personalized program of each participating child involved different game settings as decided by the child's special teacher. In all cases, the interventions were designed to promote children's physical engagement, namely students' bodily movements and gestures (see Figure 21).

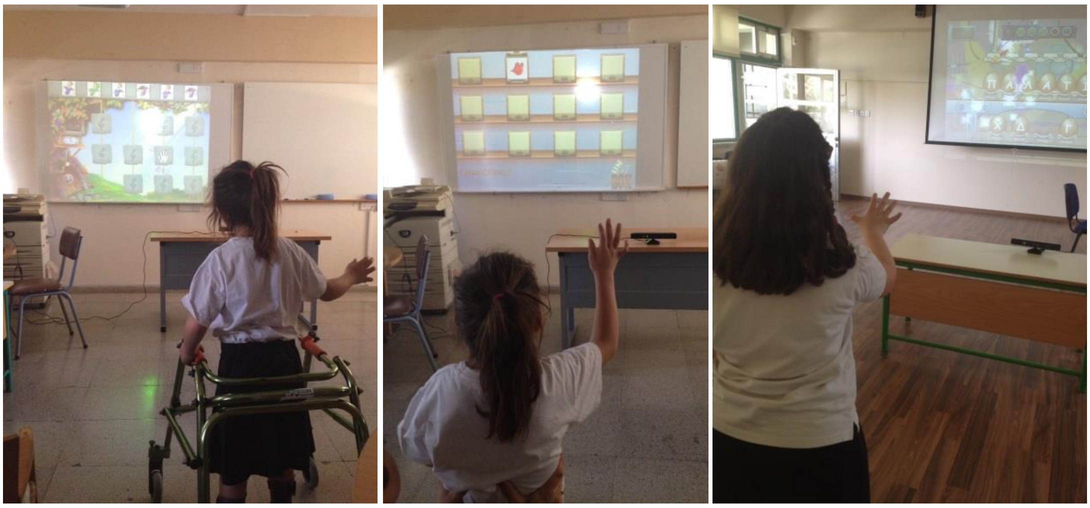


Figure 21: SEN students in action in the special unit setting

6.3.4 Data Collection and Instrumentation in Phase B

Data collection was based on psychometric pre-post testing, games-usage analytics, a student attitudinal scale, teachers' reflection notes, and teacher interviews.

Our pre-post memory (Gonida & Iossifidou's (2008) "Psychometric Criterion of Cognitive Adequacy for children and adolescents"), evaluates the short-term mnemonic capacity since the child must repeat all the words in the same order. The administration of a memory pre-test was conducted by the SEN teachers, with the help of the researchers, the week before the interventions began. The administration of post-test was done by the teachers, with the support of the researchers, the week after the interventions were completed for each participant. A short attitudinal scale was also administered to the students, by the teachers, at the end of the intervention period.

Additionally, analytics data were automatically captured and stored in the Kinems platform, regarding children's interaction and progress in each game (e.g., time spent on using the game, number of times the child completed the game, speed of finishing the game, number of errors, etc.).

Moreover, the participating SEN teachers were asked to note their observations and reflections upon each session, guided by two specific questions: what the specific learning goals for the session were and how the child's performance in relation to these goals was. Finally, all SEN teachers participated in a personal interview session with one of the researchers, regarding their overall experience.

6.4 Findings of Phase B

6.4.1 Gains in Short-term Memory (Gsm)

A Paired sample t-test was conducted to examine mean differences from pre-to-post testing on "Word Recall"; there was a statistically significant increase (p value < .05), from pre (mean performance score = 18.90 out of 31) to post-testing (mean performance score = 20.84 out of 31), with medium effect size (Cohen's d =0.60); see Table 11.

Table 11: Differences in Word Recall skills from pre-to post-testing (N= 31)

Cognitive Skill	Mean Performance Pre-test	Mean Performance Post-test	Maximum Possible Score	P value	Cohen d
Word Recall (Gsm)	18.90	20.84	31	.002**	0.60

**p<.01 = Indicates significance

We noticed that there was variability in the use of the "Unboxit" and "Melody tree" games across children, ranging from 12 minutes of play (min value) to 122 minutes of play (max value); see Figure 19. We, therefore, performed post-hoc correlations to understand if time-on-task (i.e., duration of playing the games) was related to the child's performance difference (gains). In particular, the total time-on-task in Unboxit” and “Melody Tree” was correlated with the child’s gains on the Gsm measure. We found a statistically significant positive correlation between time-on-task and Gsm performance (see Table 12). In other words, the more the child played “Unboxit” and “Melody tree”, the better s/he performed on the memory test.

Table 12: Correlations between Time on Task and Gsm (N=31)

	Word Recall (Gsm)
Time on Task (“Unboxit” and “Melody Tree”)	.0417*

*p<.05 = Indicates significance

The teachers’ perspective was fully consistent with these outcomes. The teachers’ interview data, in conjunction with teachers, recorded reflections, were transcribed and coded by two researchers, then ideas were classified into broader themes, as described in Saldana (2009). We found evidence of cognitive gains as perceived by the teachers. The teachers argued that the experience improved the memory skills of the participants, particularly their ability to execute a series of tasks and the ability to make choices toward solving a problem.

As one of the teachers (p9) explained:

“*I saw that these educational Kinect-based games enhance children’s attention, memory, and concentration. Through the sessions, my children improved their memory performance and their concentration. They could remain careful and pay attention to the task throughout the session. They also learned how to follow directions and how to make appropriate choices to reach a goal*.”

Additionally, the teachers argued that the experience could be beneficial not only for special education students but also for the general population of first and second graders in mainstream schools, in terms of supporting cognitive skills in a space that activates the senses.

As stated by a teacher (p6):

"*I would think these are also appropriate learning activities, not only for SEN students but also for the general population of first and second grades to strengthen their coordination of thinking and memory! The technology and these activities can complement traditional classroom courses, offering new incentives, increase active participation, and activate the children's senses which enrich learning*."

6.4.2 Outcomes on Emotional Aspects

Quantitative data derived from children's responses to the attitudinal scale demonstrated that the experience was fully endorsed by the participants. As illustrated in Figure 22, most students thought that the lesson was more enjoyable (79%) and that they would like to use this method in more courses (74%).

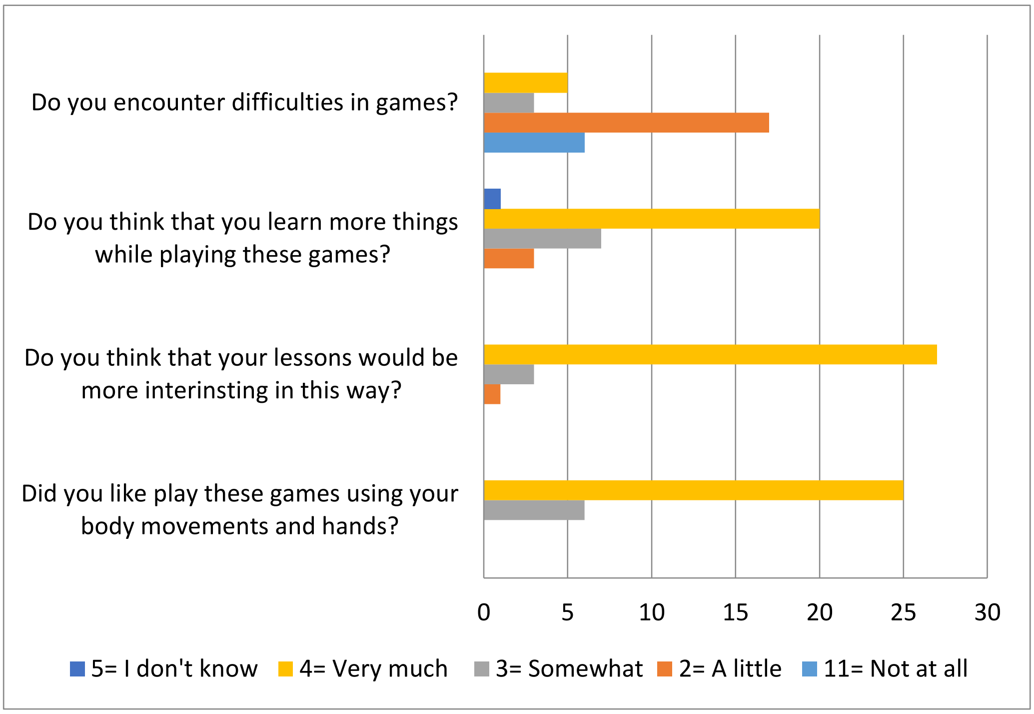


Figure 22: Children's perceptions of the experience (N=31)

Again, the teachers' perspective was fully consistent with these outcomes. As teachers explained, motion-based interaction enabled children to improve the emotional stage of the participants demonstrated in the form of increased self-confidence, joy, enthusiasm, calmness, and motivation to participate in the learning process. As shown in Figure 23, the participating teachers mentioned several variables linked to the improvement of the children's emotional stage. Specifically, eight out of ten teachers reported that children improved their self-confidence during the interventions, while all ten participants stated that during the experience children were motivated to participate in the lesson. Calmness was mentioned by six participants, who claimed that children with emotional disorders and behavioral problems were calm playing the games.

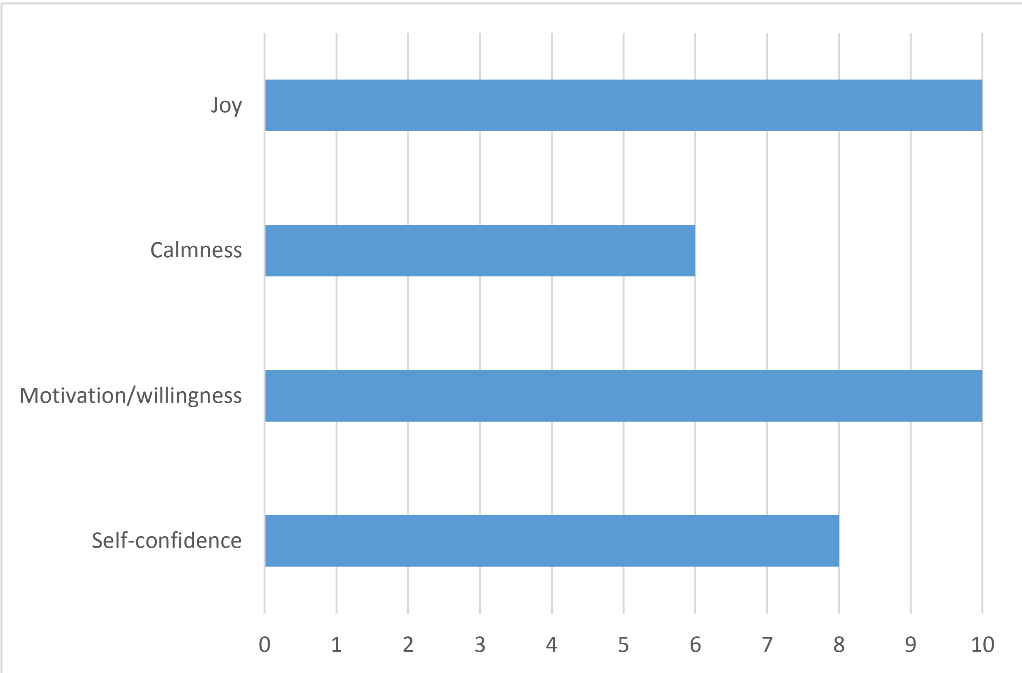


Figure 23: SEN teachers (N=10) talk about children's improved emotional stage

Finally, all the teachers confirmed that all the students were happy during the intervention period. In a teacher's own words (p3):

"*This kind of activity with body movement and gestures motivates children and activates their mind. I realized that through these activities children increased their participation because the game was an incentive for them and of course technology always inspires them. These activities seem to have an indirect positive effect on learning because they* *help students to improve their self-confidence, to improve their emotions, and to feel free to express their thoughts and feelings*".

Moreover, according to the teachers, the method of motion-based interaction was very engaging and motivated the children to participate in the learning activities and to achieve better performance from session to session.

A couple of indicative quotes include:

(p1) "*Children were always happy playing the game and motivated to participate in the lesson. My students had a great desire to play the games. They were happy and enthusiastic, and their attention was high until the end of the game waiting for the next time to play*".

(p6) "*Interacting with motion-based games was a tremendous incentive for children to engage in learning, and their improved emotional stage lasted not only during the sessions but also, for the duration of the day*."

6.5 Discussion - Addressing RQ2 and RQ3

In Phase B the motion-based technology served as one example of implementing EL in SE classroom. Yet today's access to motion-based technology creates new opportunities for EL, shedding light on new dimensions for teaching and learning. In this study, children's activity using motion-based technology is framed as an example of EL. We focus on the use of a series of Kinect-based educational games by 31 children with special needs in mainstream schools, during a five-month intervention study. There is a lack of work addressing the impact of such technology in SE. The present study improves our understanding of EL via motion-based technology in teaching and learning with SEN children, enriching and confirming the findings from Phase A.

Findings from this study suggest that EL via the use of motion-based educational games can help improve children's short-term memory (word recall test); we found medium effect sizes, indicating the difference is meaningful and may have practical importance for education (Lecroy & Krysik, 2007). Also, there was a relationship between "time on task" and gains on the test. These findings agree with the results of previous studies on the value of using motion-based games in learning for children with multiple learning difficulties (Altanis et al., 2014; Bartoli et. al, 2013; Bartoli et al, 2014; Retalis et al, 2014, Kourakli et al., 2017; Kosmas et al., 2017). Future studies could work on the investigation of the long-term effects on short-term memory of elementary students using motion-based games in their daily school learning activities.

Furthermore, findings support that EL activities can help SEN children to engage with the learning tasks, exhibiting motivation, enthusiasm, joy, and an improved emotional state overall. This was the major reason why the experience was fully endorsed by students and SEN teachers participating in this study. It becomes evident that motion-based technology holds promise in allowing teachers to engage children in EL experiences (Chen, & Fang, 2014). At the same time, we acknowledge that the enthusiasm might be suggesting a novelty effect, which can be confused with the true impact of the intervention. Future longitudinal studies should be able to eliminate a potential novelty effect to detect the true effect of EL via motion-based technology with special education students.

Indeed, all the teachers confirmed that all the students were happy during the intervention period. As teachers argued, motion-based interaction enabled children to improve their emotional stage demonstrating increased self-confidence, joy, enthusiasm, calmness, and motivation to participate in the learning process.

6.6 Summary

Judging by the encouraging results of this phase, we can argue that the enactment of EL using motion-based technology (e.g., Kinect-based educational games) holds promise in supporting SEN students in mainstream education. Explicitly, the Phase B confirms that the implementation of EL in the classroom enabled students to advance their cognitive abilities in short-term memory (Gsm) and to engage them emotionally in the learning process. Yet to address the impact of the EL in education, our findings require replication with a larger population of students in other contexts. The next chapter presents the Phase C of this investigation, reporting on results of EL implementation through technology in GE classroom.

7 Phase C: The impact of Embodied Learning in General Classroom

Previous phases (A and B) were conducted in SE context showing significant impact on students' motor performance (see Phase A – Chapter 5), memory performance and emotional performance (see Phase B – Chapter 6). Following the encouraging findings of previous phases, Phase C was conducted in General Education in order to examine if that significant impact of EL can be enacted as well in authentic classrooms of GE and replicate gains in students' overall performance. In particular, the third cycle of investigation implements EL as a part of the classroom curriculum in a real classroom environment using motion-based games. Phase C was aimed to answer the following questions, as illustrating in Figure 24.

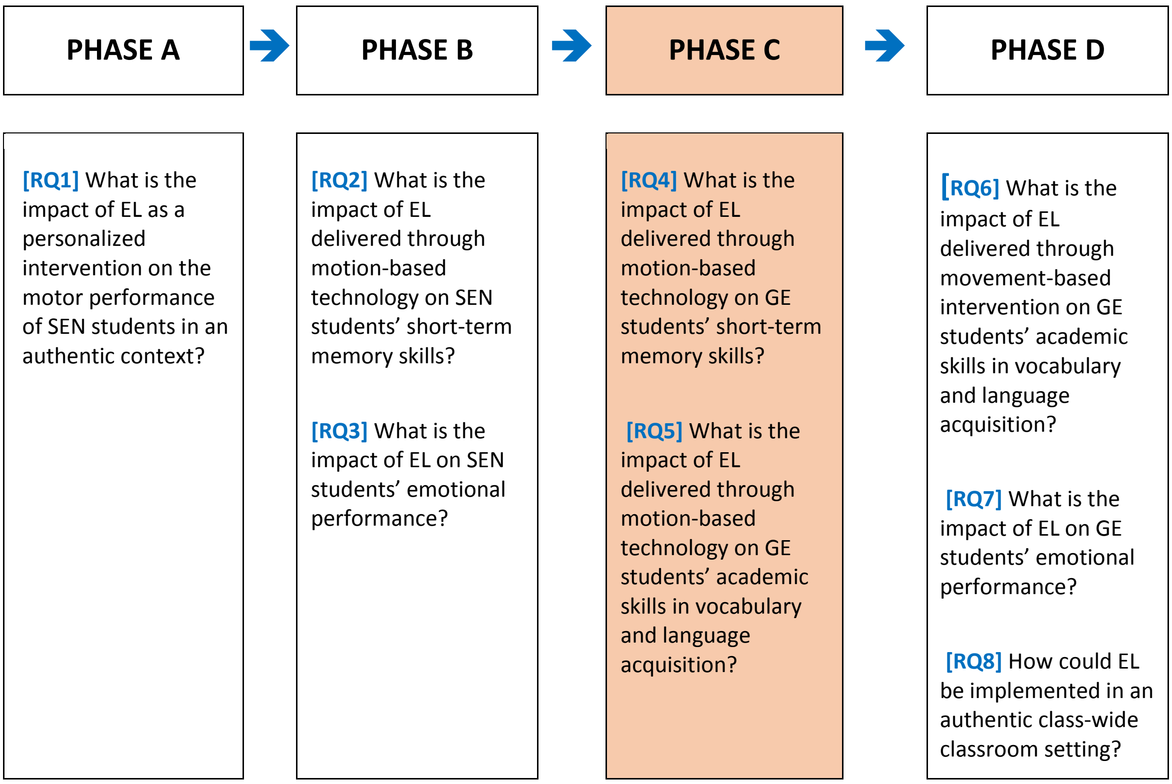


Figure 24: Research questions of Phase C

Findings showed significant effects both on children's cognitive abilities (i.e., short-term memory skills) and academic performance (i.e., expressive vocabulary). The empirical results of Phase C are published in the Educational Media International journal (Kosmas, Ioannou & Zaphiris, 2018).

7.1 Introduction

Existing literature on EC and EL shows promising effects of bodily engagement and movement on children's cognitive and academic outcomes. As mentioned earlier, despite the potential use of such games in various educational settings, there is still limited empirical evidence on their impact in real school settings (Malinverni et al., 2017).

Little work has explicitly examined the integration of different EL technologies in authentic classroom environments. To this end, Phase C presents findings from an empirical investigation of using motion-based educational games, as one example of implementing the EL approach in a GE classroom context. The research relies on the collection and analysis of multiple forms of data using mixed methods to study such embodied activities and games. This study considers the potentials that these games provide for implementing EL in authentic classroom settings, with an emphasis on:

1. Effects on children’s cognitive skills, particularly in short-term memory ability (Gsm), based on the classification of cognitive skills of Cattell-Horn- Carroll Integrated Model (Cattell, 1971).

2. Effects on children’s academic performance, particularly in language skills (i.e., linguistic development and vocabulary acquisition), based on results of Word Finding Vocabulary Test (Renfrew, 1997).

Phase C served as a validation of previous studies aiming to provide a deeper understanding of children’s interaction with motion-based technology in a different authentic classroom environment and discuss the potential impact of EL technologies for specific learning purposes (in this case memory and language skills) in GE context.

7.2 Related Work

Previous research in the area making use of embodied technologies for learning has shown that this kind of interventions and interactions with the technology can improve cognitive functioning and academic performance for children (Kosmas et al., 2017). For example, a recent study with 21 children showed that the engagement with Kinect-based educational games was beneficial not only for children's cognitive abilities but also for academic performance in math and language (Kourakli et al., 2016). Similarly, the study of Lieberman et al. (2011) discussed the potential health benefits of active-play video games in education.

Further, studies in the field suggest that there is a strong correlation between physical movement and learning. That is, the human sensorimotor system, perceptual processing, and muscle control is capable of finding solutions in the physical environment and understanding specific learning tasks (McClelland, Pitt, & Stein, 2015). A great deal of studies has revealed that increased physical engagement during the learning process has the potential to positively impact cognitive ability, memory and academic achievement (Chao, 2013; Donnelly & Lambourne, 2011; Gao et al., 2013). For example, a recent empirical study revealed significant gains in 31 children's short-memory ability after playing Kinect-based games in the classroom (Kosmas et al., 2018). Likewise, in the study of Chao et al. (2013) the Kinect-based learning environment facilitated memory performance of 32 university students, compared to the control group. In the same line, the study of Donnelly and Lambourne (2011) showed that the physical engagement in lessons improved children's overall academic performance based on a standardized test of academic achievement. Also, findings from an empirical investigation in physics showed significant progress in learning physics based on the pre- and post-test assessment (Enyedy, Danish, Delacruz, & Kumar, 2012).

Additionally, several studies have also shown the positive impact of EL activities for language development and language comprehension. For instance, the study of Cassar and Jang (2010) showed that a games-based approach enhanced the improvement of literacy skills in elementary children with reading disabilities. Other related studies indicated that the use of EL activities in the classroom facilitated the verbal information of students (Chang et al., 2013), influenced their understanding and recall of information (Gao et al., 2013) and improved their second-language comprehension (Lee et al., 2012). Other studies in the embodied education field have shown that kinesthetic approaches and embodied activities can enhance academic achievement in mathematics and science (Abrahamson, 2013; Chen & Fang, 2014; Kellman & Massey, 2013).

Overall, motion/Kinect-based games, under the umbrella of EL practice, can provide engaging activities for students in classrooms, enriching the conventional way of teaching and learning. However, there is a lack of sufficient research on the implementation of EL as a part of a classroom curriculum in authentic classroom environments.

7.3 Method

This phase adopts an MD mixed method approach, as in the three previous phases, in order to utilize the strengths of both quantitative and qualitative research findings. Specifically, the methodological approach is based on pre-post standardized testing, general learning analytics details, direct classroom observations and semi-structured interviews with the participating teachers. In this way, a rich evidence of the children's experiences was gathered during the intervention period.

7.3.1 Participants

The study was conducted in four different elementary classrooms in two primary schools. A total of 52 second and third graders (N=52) aged 7-9 participated in 13 intervention sessions of 45 minutes during a four-month period. Five teachers were involved in the research procedure. All sessions were conducted in the classroom with the teacher in the class who was trained to implement the motion-based educational games with his/her students. Before the study, all the ethical approvals from the Ministry of Education were obtained. Selection of children was by them being in the school class that was invited to participate. Both teachers and children involved in the study after providing proper consents.

7.3.2 Motion-based Games in General Education classroom

As in the Phase A and Phase B, Kinems games suite was used. For this cycle of study, I used two particular Kinems games to investigate how the EL facilitates the improvement of memory abilities and language skills of children. These were the "Unboxit" game for short-term memory skills (Gsm) and the "Lexis" game for vocabulary and linguistic development.

By conception and design, "Unboxit" (see Figure 25, left) aims to improve children's visual-spatial working memory and attention. The child must find the pairs of objects that are hidden in boxes, using his/her hand to select the appropriate objects. “Lexis” (see Figure 25, right) is a missing letter game designed to allow children to practice their skills on the spelling of words of different length. At an egg-packing plant, the child has to create “egg-words”, i.e., words that consist of letters written on eggs; the child has to grab the correct missing egg-letter from a set of given egg-letters, place it carefully and appropriately in order to fill it in so that the “egg-word” is packed (www.kinems.com). The “Unboxit” game was used in the Phase B. The difference in this Phase C regarding this particular game is the adjustment of “Unboxit” on classroom curriculum.

Figure 25: Screenshots of the Kinems games, “Unboxit” game (left) and “Lexis” game (right)

7.3.3 Procedures

The students attended the sessions in four different classrooms in two primary schools. The teacher of the classroom was trained in the use of these games in the classroom for specific learning purposes (i.e., memory skills, language skills). All teachers prepared and organized class-wide intervention sessions, selecting the game (in this case “unboxit” and “lexis”) and configuring the settings increasing the difficulty.

Then, the children played the games, one by one, while other children did related worksheets and activities based on the lesson plan prepared by the teacher (see Figure 26). In all cases, the lesson plan, game setting, and the procedures were the same. In practice, children were organized into a queue, and each child was waiting his/her turn to play the game while working on another activity. It is important to note that the teaching material was designed in such a way that it serves the delivery of specific learning subject. The material was linked to the games played by the children each session in the classroom according to the curriculum of the class.

Therefore, the game was fully integrated into the lesson in such a way that all children could benefit from it and enrich their knowledge in that particular subject. For example, in the chapter on nutrition, the teacher chose the related category in "unboxit" and "lexis" game to give children the opportunity to consolidate what they learned but also to enrich their knowledge on this specific subject.

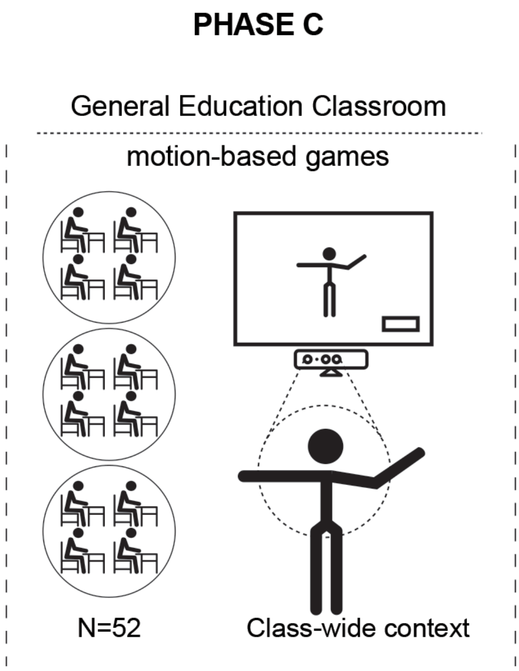


Figure 26: Intervention in the classroom – Phase C

The study was implemented in a four-month period. During this period, participating children completed 13 game sessions in their classroom with their teacher, once per week for 45 minutes (see Figure 27).

Figure 27: Episodes from embodied learning activities in the classroom

7.3.4 Data Collection in Phase C

7.3.4.1 Assessment measures

To assess the children's short-memory skills (Gsm), I used the "Psychometric criterion of cognitive adequacy for children" (Gonida, & Iossifidou, 2008) as pre and post-assessment test – same test used in Phase B. For language skills (in this case expressive vocabulary), I used the standardized Greek version of Word Finding Vocabulary Test (Renfrew, 1997) normed on Greek preschool and school-aged children (Vogindroukas, Protopapas, Sideridis, 2009).

Both psychometric tests of memory and language were given by the teachers, after relevant training and with the presence of specially trained staff. The pre-test was given at the beginning of the school year (particularly two weeks before the start of classroom interventions). The post-test was administered at the end of the 13-week intervention (in particular one month after the end of the last intervention). Children who did not complete all pre-post tests were not included in the sample.

7.3.4.2 General Learning Analytics

The learning analytics, automatically recorded in the suite of games, were used to examine in depth the progress of each child in the two games ("Unboxit" and "Lexis"). In our analysis, we focused on general analytic details such as the time spent on using the game, the speed of completing the session and number of errors in each session. The analysis of learning analytics concentrated on the 1) children's memory performance in the case of Unboxit and 2) children's performance and speed in the case of "Lexis".

7.3.4.3 Qualitative Dataset

Additionally, teachers noted their comments upon each intervention session in the form of a reflective diary; these were saved in the Kinems platform. The comments focused on monitoring how the students perceived the game and how was the children's performance in relation to the specific goals. The analysis of teacher's comments concentrated on 1) learning benefits as perceived by the teachers and 2) overall students' appreciation of the method as perceived by the teachers.

Finally, at the end of the intervention, semi-structured interviews were conducted with all participating teachers to assess their overall experience and perceptions of EL in this authentic classroom environment.

7.4 Findings of Phase C

Next, we present findings regarding the children's interaction with the motion-based educational games focusing on their overall learning gains in language and cognitive performance in short-memory ability.

7.4.1 Effects on Children's Short-term memory Skills

To examine differences and gains in children's cognitive skills (i.e., Gsm-short memory skills), according to the classification of cognitive abilities of Cattell-Horn- Carroll

Integrated Model (Cattell, 1971), based on children’s scores in pre to post-testing, a Paired Sample T-Test was conducted. There was a statistically significant difference (p_value = <.001), from pre to post-testing, with strong effect size (Cohen’s d = 1,01), as shown in Table 13.

Table 13: Effects on memory skills from pre-to post-testing (N=52)

	Pre-test (mean)	Post-test (mean)	P value	Cohen d
Short-memory ability	15.04	19.00	,000**	1,01

**p<, 01 = Indicates significance

Given the statistically significant differences in memory skills, the general learning analytics recorded per child in “Unboxit” were further considered to evaluate the improvement of children's memory performance during the educational intervention. It seems that, as they progressed in the game, the participating children made less effort to find the right answer (in this case, to match the objects). The “unboxit” game requires that children are concentrated in order to remember all the visual objects and make progress. In the beginning, the children made a lot of wrong trials to remember where each object fit. Moving into play, the wrong attempts/trials were greatly reduced, which proves that the children began to improve their memory ability and thus found the right answer quickly.

It is worth mentioning that although in each session the difficulty of the game increased, the children continued to improve their performance in the game. As shown in Figure 28, the majority of children (N=42) performed very well in the memory game, with an average number of only two wrong trials, while the rest of children had only one trial (N=7) and three trials (N=3) to complete the game successfully. The children’s memory performance progressively improved, completing the game with fewer wrong trials compared to their first sessions.

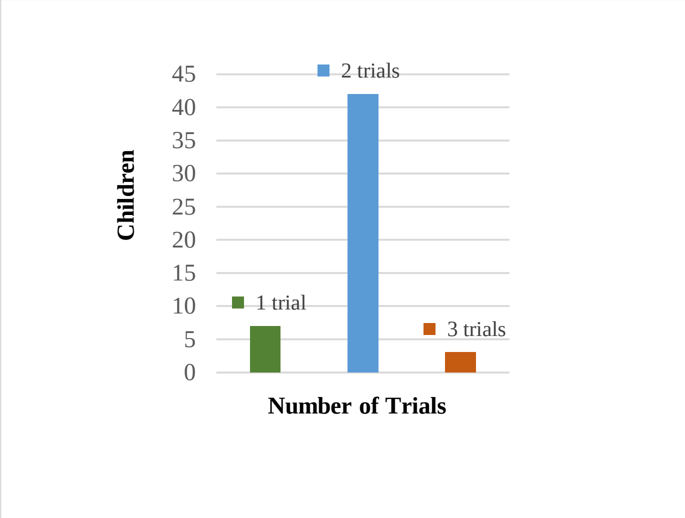


Figure 28: Children's average number of wrong trials in "Unboxit" in 13 sessions (N=52)

The teachers' perceptions were fully consistent with these gains in memory skills. The teachers' interview, in accordance with teachers' observations notes, were coded and analyzed, as described in Saldana (2009) – as in Phase A and B. The teachers discussed cognitive gains of children, gains explicitly in short-memory skills during the intervention period. The teachers claimed that the "unboxit" game enhanced the memory abilities of the children, particularly their ability to recall words and to practice their memory skills.

In particular, the analysis of observation data concentrated on the 1) children's memory performance, 2) children's academic performance, and 3) overall appreciation of the method. The teachers' comments and reflections, upon each intervention session, showed that children had progressively improved their memory adequacy by playing the game. It is clear from the teachers that after the first two sessions the children began to improve their performance significantly in the game. In fact, the teachers' comments for the first two sessions, mention words such as "*embarrassment*," "*a lot of wrong trials*," "*lack of certainty for the right answer*," "*difficulty in remembering the object*".

Then, according to the teachers' comments, the children began to unconsciously apply some "*techniques*" so as not to forget the objects they had to match. The majority of the teachers' comments in the last three sessions mention "*absolute concentration*," "*focus on the game*," "*structure and organization of objects*," "*think aloud*" and "*use of body* *and especially of hands*." In other words, based on teachers' observations, children managed to improve their memory performance by finding alternative ways to remember the visual objects and complete the game.

Similarly, the semi-structured interviews complement the teacher's observations and they provide valuable insights regarding the improvement of students' memory performance during the intervention period.

As one of the teachers (T3) argued:

"*This game was really good for second graders! It helps the children with practicing their mnemonic capacity and I really saw that children improved their memory across sessions, even those with very low memory skills*".

Along the same lines, a teacher (T1) explained:

"*The highest improvement that I saw during this period was the improvement of children in performing the memory [unboxit] game. It was absolutely great to see that children managed to improve their memory skill and coordinate their thinking with action and movement. In the first 2-3 sessions children made a lot of effort to remember the objects correctly. As the game progressed over time, the children managed to complete the game with fewer wrong trials, and this was great!*"

7.4.2 Effects on Children's Language Skills

In order to find out if there any improvement in children's language skills and particularly in expressive vocabulary, we examined the data from pre to post testing. In this case, we report the results from a Paired Sample T-Test (see Table 14) in which there was a statistically significant difference (p_value <.001), from pre to post-testing, with large effect size (Cohen's d = 0,28).

Table 14: Effects on expressive vocabulary from pre-to post-testing (N=52)

	Pre-test (mean)	**Post-test (mean)**	**P value**	**Cohen d**
Expressive Vocabulary	17.40	19.92	,000**	0,28

**p<, 01 = Indicates significance

Then, given the analytics recorded in “Lexis”, we performed post-hoc correlations between time-on-task (i.e., duration of playing the games) and child’s academic performance. In particular, a Pearson product-moment correlation was conducted to determine the relationship between test scores in language testing and time-on-task in “Lexis” game during the intervention (see Table 15). There was a positive, strong correlation between scores on a vocabulary test and time-on-task, which was statistically significant (r = .675, n = 52, p <.001).

Table 15: Correlation between completion time in Lexis and students’ test scores

		Children’s Scores
Time-on-task in “Lexis”	Pearson Correlation	,675**
	Sig. (2-tailed)	,000
	N	52

** Correlation is significant at the 0.01 level (2-tailed)

Moreover, the teachers’ perspective was fully consistent with these learning gains. All the teachers argued that this motion-based interaction with the technology facilitated the children’s academic achievements in language and vocabulary acquisition. Indeed, they stated that the engagement in these gaming sessions enabled the children to increase their academic performance in the language in the form of increased spelling skills, new vocabulary acquisition, and comprehension.

The teachers’ observations in the classroom during the game mention “*many new words only after three sessions of Lexis game*,” “*the visual help of the word facilitates the acquisition of new words*,” “*children find the appropriate word immediately*,” and “*children spell the word correctly*.”

Equally, the data from semi-structured interviews gave us detailed important insight regarding the children’s experience with Lexis.

As one teacher (T1) explained:

"*In practicing with Lexis game, the children acquire new vocabulary and at the same time improve their language comprehension as they combine words with the picture*."

In another teacher's own words (T2):

"*The Lexis game helped my students to understand the meaning of new words from different categories available in the game. All the children were playing Lexis very concentrated, and thus almost all of my pupils completed the session successfully. In the end, I realized that my second graders enriched their vocabulary*".

7.5 Discussion - Addressing RQ5 and RQ6

As previously mentioned, a few studies in the fields of educational technology have recently focused on exploring the impact of engaging the body in authentic classroom environments. The value of EC/EL was taken as given in this work based on both empirical evidence from Phases A - B in SE and evidence from the literature. The aim was to examine how such a practice (which implemented in SE as a personalized intervention) can become a reality in an authentic classroom environment with documented gains for students. Indeed, from the data analysis it becomes evident that the EL approach, as a learning method in real classroom environment, supported and mediated by motion-based games (in this case Kinect-based educational games), can have positive impacts on children's cognitive skills (i.e., short-term memory ability-Gsm) and on children's academic performance (i.e., linguistic development and vocabulary acquisition).

Notably, this cycle concentrated not only on statistical analysis of data but even more on ideas and hints coming from the teachers' observations and interviews. By analyzing both quantitative and qualitative data, we found full consistency between them. The meaningful differences and significant effect sizes in measures of our two variables of interest - memory skills and language skills - agree with the teachers' perceptions, notes, and reflections regarding the overall children's experience. Moreover, our results agree and confirm findings from previous studies conducted in different educational settings (Kosmas et al., 2017; Kourakli et al., 2016; Kosmas et al., 2018; Bartoli et al., 2013).

Statistical analysis of pre-post testing in short-memory ability revealed statistically significant difference (p_value = <.001), with strong effect size (Cohen's d = 1,01). This significance becomes stronger taking into account the general learning analytics recorded per child in "Unboxit" game. The in-depth analysis of learning analytics showed improvement of children's memory performance during the educational intervention. Moving into play, according to time spent and wrong trials in "Unboxit" game, participating children improved their memory ability finding the right answer easily.

Another interesting finding was that we found progressive improvement of cognitive performance (short-memory ability) across time (13 sessions in four months) and increasing difficulty of the game. The learning analytics confirm that the participating children progressively improved their memory performance and managed to complete the games with 100% success during the intervention period. Nonetheless, by looking across all our sessions, it is clear that children were fully engaged in the learning process providing their maximum effort to complete the game successfully and acquiring academic achievements over the intervention in the classroom.

A qualitative analysis based on teachers' interviews and observations, confirm students' gains in memory skills. The teachers discussed significant students' gains in short-memory abilities during the intervention period. The teachers argued that the EL activities enhanced the memory abilities of the children, particularly their ability to recall words and to practice their memory skills. Per teachers, the physical engagement of children helped them to apply some memory "*techniques*" to improve their performance in the game. In that way, children managed to improve their memory performance by finding alternative ways to remember the visual objects and complete the game successfully.

The results from a Paired Sample T-Test showed a statistically significant difference (p_value <.001), from pre to post-testing, with large effect size (Cohen's d = 0,28). Also, analysis from automatic learning analytics (time-on-task, duration of playing the games) showed significant gains in children's academic performance in language and vocabulary acquisition. Specifically, there was a positive, strong correlation between scores on a vocabulary test and time-on-task in "Lexis" game, which was statistically significant (r = .675, n = 52, p <.001). Further, the quantitative data from learning analytics revealed progressive improvement of academic performance in language across time and increasing difficulty of the game. Students managed to progressively improve their language skills by acquiring new vocabulary and completing the “Lexis” game with success during the intervention period.

In addition, based on qualitative results, the teachers’ perceptions were entirely consistent with these academic learning gains. Teachers claimed that the EL with technology enabled the children to increase their academic skills in the language in the form of increased spelling skills, new vocabulary acquisition, and comprehension.

7.6 Summary

These promising insights of this study validate our previous finding and offer a deeper understanding of how we can engage the body in the learning environments making use of motion-based games. It is important to note that this investigation was conducted in real classroom settings, where children use to attend lessons every day. Results of this Phase C points out that this kind of EL activities can integrate effectively in the class-wide context with the use of technology offering meaningful, multi-modal and playful experiences to the children. As noted above, this was one example of EL activities using technology, and we chose to use a professional commercial suite of games which is totally linked with the variables of interest. The next phase -Phase D- makes use of other noncommercial technologies for the implementation of EL in the classroom.

8 Phase D: Developing and Implementing the PanBoy Intervention

Taking the empirical evidence from previous phases A, B and C into consideration, Phase D presents a classroom movement-based learning intervention called PanBoy, EL movement intervention developed for first and second graders in mainstream elementary schools. The study was conducted in authentic GE classrooms in order to re-examine whether EL would improve the academic and emotional performance of students in a class-wide context. This final cycle of investigation discusses the possibility of using an EL-based classroom intervention as a new teaching practice method in authentic language environments. Specifically, Phase D addresses the following research questions (see Figure 29).

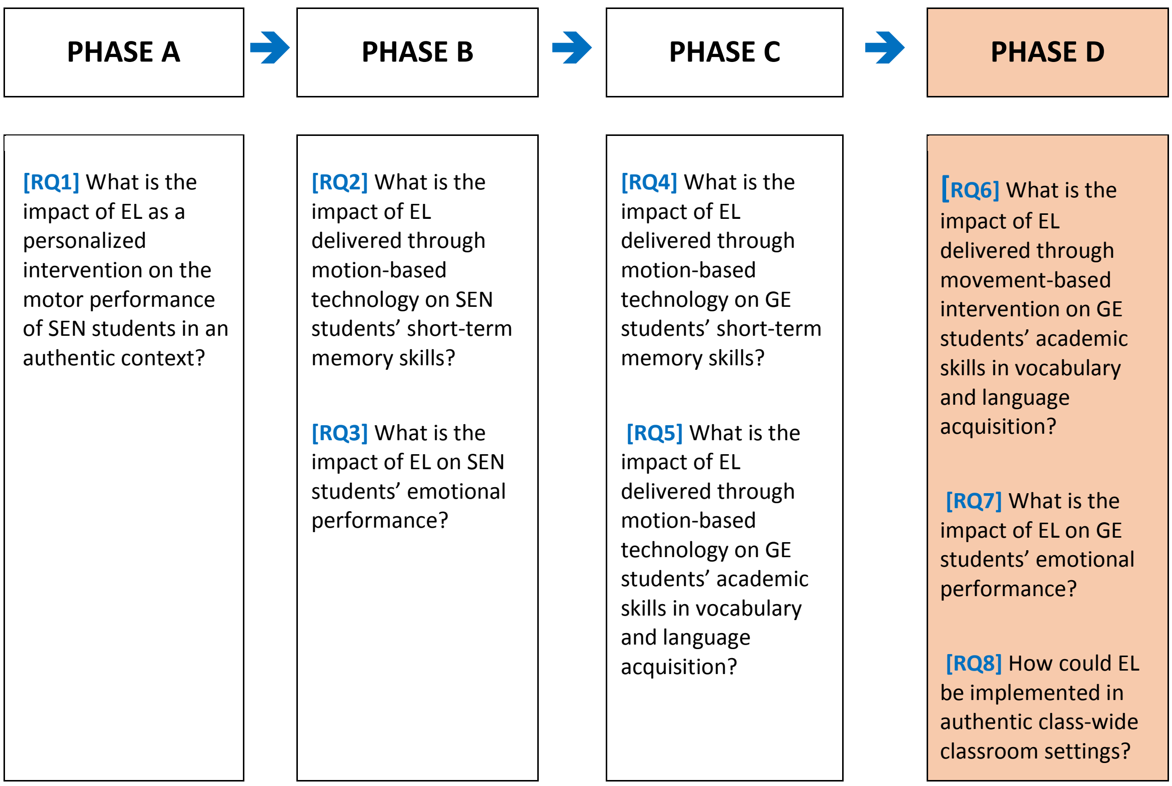


Figure 29: Research questions of Phase D

Findings revealed significant student gains in language acquisition and improvement in emotional engagement in the process.

8.1 Introduction

According to embodied theory, the body and brain work together in an inseparable linked 'brain-body' system (McClelland, Pitt, & Stein, 2015). Embodied theory can thus provide valuable insights into how we can design and prepare effective learning environments that adapt classroom lessons and content to blend physical activities with cognitive mechanisms. Considering that cognition is linked to sensorimotor experiences, combining bodily movement with physical interaction with the world can facilitate the development of new learning (Lindgren, 2014). Specifically, it is believed that physical movements enhance learners' memory by expanding working memory capacity in order to deal with complex learning tasks (Bokosmaty, Mavilidi, & Paas, 2017). For this reason, Glenberg (2010) claims that memory and perception are affected by bodily movement.

Over the last few decades, we have seen a growing body of research into the language's relationship with 'movement-learning.' Language learning scientists are now trying to integrate aspects of EC into their research in order to investigate how the human body is involved in learning experiences. Indeed, researchers in the field have already examined how movement improves learning outcomes and brain functioning (Pheloung, 2006; Blythe, 2000) and how movement can help the brain prepare for learning (Cheatum & Hammond, 2000). Evidence from embodied theory argues that gestures, bodily movements, and mind are deeply connected and capable of delivering learning, especially when the movement is aligned with what is being learned (Agostinho, Ginns, Tindall-Ford, Mavilidi, & Paas, 2016). In terms of literacy and language, this brain-body link derives from the evolution of language from gesture (Gentilucci & Corballis, 2006). In the context of language learning, Zwaan (2014) has discussed embeddedness and proposed five stages of language learning: demonstration, instruction, projection, displacement, and abstraction.

It is worth mentioning that many educators and school systems consider that learning only takes place when children are sitting. This is usually because they aren't familiar with the essential advantages of being actively engaged in learning (Hynes-Dusel, 2002). The fact is, movement and learning are not only complementary; when movement is not blended into classroom learning activities, children's learning suffers.

Given the limited empirical evidence linking movement and learning, this study investigates a new approach to classroom interventions from an EC perspective. Our EL intervention demonstrates empirically how using low-cost technologies, and a movement-based approach can improve language acquisition in classrooms (in this case First language - L1). Specifically, we show how EL can improve student learning outcomes and achievements in language and expressive vocabulary ability (Gc) according to the Cattell–Horn–Carroll Integrated Model of cognitive skills (Cattell, 1971), and how b) EL can improve student emotional outcomes and motivate students to engage in this type of learning approach.

8.2 Related Work

Because the relationship between movement and learning is so strong, educators/ learning scientists and researchers should take advantage of the opportunity to combine the two in the classroom. Some researchers and school systems have already realized the essential correlation between movement and learning and implemented interventions which give opportunities for physical activities and movement in the classroom. In fact, many of those who did report significant gains in their children's performance after physical activity in the classroom (McPhillips, Hepper, & Mulhern, 2000).

Indeed, in recent educational research, there is a growing focus on the effectiveness of physical activity interventions on academic performance. Zacharia, Loizou, and Papaevripidou (2012), for instance, have drawn attention to the importance of physicality, which they have shown to be a prerequisite for student comprehension. Their research, which tested embodied cognition and learning approaches on 80 five-year-old students, confirmed the significant impact of a dynamic interaction between the body and the physical world.

A number of education studies have found that physical engagement and interaction with learning material impact learners' academic, cognitive and motor performance (Kosmas, Ioannou, & Retalis, 2017; Kosmas, Ioannou, & Retalis, 2018; Kourakli et al., 2017; Donnelly & Lambourne, 2011; Gao et al., 2013). For example, in a recent study with 31 special education students, researchers found that physical engagement led to significant gains and improvements in students' short-memory skills (Kosmas, Ioannou,

& Retalis, 2018). In the same study, students also improved their emotional state during the intervention period.

Similarly, Tomporowski, Lambourne, and Okumura (2011) show that physical activity positively impacts children's academic achievements and cognitive abilities, as well as their language comprehension (Cassar & Jang, 2010). Moreover, Booth et al. (2014) working with 5000 students, have demonstrated that physical activity has a positive impact on student academic performance, while Chaddock-Heyman et al. (2014), who worked with elementary children, found that physical exercise improves neural connectivity within the brain. Similarly, Mavilidi, Okely, Chandler, Domazet, and Paas (2018) examined whether or not a 4-week movement program would improve numerical skills for 120 preschool children. They found that children in the physical activity group performed better than children in all other conditions. Furthermore, Donnelly and Lambourne (2011) looked at the effects of physical activities on academic performance in different subjects, including reading, spelling, language, math, etc. Their findings showed significant gains in academic scores, especially in math. Similarly, Mavilidi, Okely, Chandler, and Paas (2017) explored how whole-body movements impacted science skills in 90 preschool students. The results revealed, once again, that integrating physical activities into science lessons leads to significant increases in learning outcomes according to assessment results.

Several studies have shown how gestures and bodily movements benefit specific areas of language learning like phonological awareness and reading (Moritz et al., 2013). Findings from an empirical study where 52 elementary school students used motion-based games in class showed significant positive effects on language development and acquisition (Kosmas, Ioannou, & Zaphiris, 2018). Similarly, the findings of VanDam et al. (2012) have shown that using the embodied approach with university students improved overall language comprehension, confirming that word meaning is linked to sensorimotor experience. Additionally, a recent study with 111 preschool children that examined the learning gains of enacting words through whole-body movements in a foreign language vocabulary task found that children in the integrated physical exercise group achieved the highest learning outcomes (Mavilidi, Okely, Chandler, Cliff, & Paas, 2015). Furthermore, Trofatter, Kontra, Beilock, and Goldin-Meadow (2015), who argued that gestures and hand movements could affect thought by promoting the coordination of task-relevant hand movements with task-relevant speech, also found evidence in embodied theory for the argument that movement grounds thought in action through its representational properties. Finally, in a longitudinal study, Macedonia and Klimesch (2014) examined how gestures in the classroom impact students' ability to recall foreign language words, confirming that gestures do significantly enhance vocabulary learning in quantity and over time.

Tellier (2008) found that gesturing helped preschool children learn foreign vocabulary words and score better on recall tests, compared to other groups. The work of Rowe, Silverman, and Mullan (2013) also supports this finding, showing how gestures can help improve preschool students' long-term word recall of first and foreign languages. Along the same lines, Pesce, Crova, Cereatti, Casella, and Bellucci (2009) showed that physical activity boosts 11–12-year-old children's memorization of foreign language vocabulary words. From all of these studies, we can conclude that physical movements or gestures enhance children's abilities to learn and memorize new vocabulary in a first and foreign language.

Similarly, Kranowitz (2005) claims that engagement in physical activities enhances the visual coordination of learners. In particular, he argues that movement activities such as balancing, throwing bean bags or moving around can strengthen children's visual skills and spatial awareness (Kranowitz, 2005). The child's abilities to perform "coordinated movements require all the body parts to work together in an efficient, organized way" (Krog, 2015, p. 437). Likewise, Leppo et al. (2000) noted that children who can control and coordinate their bodily movements are better prepared to focus on specific learning goals.

Additionally, physical exercise, movements, and kinesthetically enhanced learning activities in the classroom are linked to positive emotions, especially for students in early childhood, as well as increased student motivation and engagement (Vallerand et al., 1992; Anastopoulou, Sharples, & Baber, 2011). Game-based learning is only one example of how we can combine learning with movement and enjoyment (Barab et al., 2005). For instance, Garris et al. (2002) argue that when learners are motivated and interested in learning a subject, the consistency and intensity of their work increases. The work of Stinson (1997), which examined how dance impacts student involvement, highlighted how important enjoyment is for learning and confirmed that physical exercise helps learners engage with their material. Results from an empirical study with 113 middle school students also revealed that whole-body interaction leads not only to significant learning gains in physics but also to higher levels of engagement and positive perceptions of science (Lindgren, Tscholl, Wang, & Johnson, 2016). Finally, Trost, Fees, and Dzewaltowski (2008) examined an intervention program in preschool education called 'move and learn,' demonstrating that in these kinds of interventions children are more physically active and showed more enthusiasm and responsiveness to learning tasks.

Despite the wealth of studies linking physical exercise to increased student performance, empirical evidence in this area of research is inconsistent and limited. Results from previous studies haven't yet offered a scientific explanation for the relationship between physical movement and academic improvement (Tomporowski et al., 2008). Furthermore, the existing literature has reported no causality between physical activity and academic achievement (Lindner, 2002). To sum up, the link between EL and movement in education is still an emerging and largely unexplored area of investigation (Kosmas & Zaphiris, 2018). The present study aims to provide a new teaching paradigm for teachers and researchers to use in their exploration of EL-driven technology as a learning tool.

8.3 Method

In Phase D, we used a mixed methods approach, combining quantitative and qualitative methods (Punch & Oancea, 2014).

8.3.1 Participants

A total of 118 typically developing students (M = 6.92 years; SD = 0.66; 80 girls) from six mainstream school classrooms participated in a three-month movement-based intervention. 62 students (52.5%) were first graders, while 56 students (47.5%) were second graders. Most students were Cypriot (83%)—mother language Greek—and all attended mainstream public classrooms in Cyprus. Table 16 summarizes all the descriptive statistics of the 118 participating students (i.e., age, grade, gender, nationality, L1 and other languages).

Six teachers were involved in the intervention. The teachers were responsible for delivering the movement-based language (L1) activity sessions. The schools were randomly selected from a list of all the public schools in Limassol. The study was approved by the Centre of Educational Research and Evaluation (CERE) and all the release forms from the Cyprus Ministry of Education were obtained. Consent to participate was granted by teachers, who were in charge of distributing and collecting parental permission forms. All parents completed a written consent form allowing their children to participate in the research.

Table 16: Descriptive statistics of participating students (N=118)

	Age	**Grade**	**Gender**	**Nationality**	**Language (L1)**
Students	M: 6.92 S.D: 0.66	Grade 1 52,5% N=62 Grade 2 47,5 % N=56	Male 32% N=38 Girls 68 % N=80	Cypriot 83% Turkish 9% Russian 7% Romanian 1%	Greek 88% Turkish 5% Russian 7%

8.3.2 PanBoy: Designing the movement-based intervention

The movement-based activities were based on the idea of EL and movement-based learning, taking into consideration the current scientific evidence on what prevents effective learning. Our aim in designing the intervention was to enhance the vocabulary and language acquisition of first and second graders using the strengths of their bodily movements. We wanted to create a simple and easily implemented intervention that could be used in classrooms by teachers without expensive technological equipment and we wanted teachers to be able to integrate PanBoy into the curricula of their classes.

The intervention combined bodily movements with specific words from the vocabulary acquisition curriculum for first and second graders.

Unity® software was used to develop and record character movements. A student volunteered to help us with this, performing the movements. A Kinect 2.0 motion-sensing input device was used to track the students' movements, and then a humanoid 3D character was downloaded from mixamo.com. Using Kinect's skeleton-tracking feature, we were able to map the movements of the person visualizing the words with body and hand movements. Initially, 100 movement-words were recorded, from which the 80 most accurate were selected (see the 80 target words tested during the intervention in Table 17).

Table 17: The PanBoy's Vocabulary tested in Phase D

PanBoy Vocabulary
Leg Hand Helicopter Bus Submarine Kayak Flag
Rocket Kangaroo Power Bicycle High Sleeve Happiness
Sadness Cycle Bridge Violin Surprise Window Racket
Motorcycle Elbow Get up Sit Dance Hear Welcome
Say goodbye Cry Jump Gym Cook Eat Run Fly
Show Open Close Wake up Sleep Swing Go up Go
down Enter Exit Hug Twist Hit Walk Hide
Swim Search Turn Act Arrive Ask Build Climb
Come Drink Fall Grab Hop Kick Lift Push
Shout Courage Curiosity Joy Intelligence Love Dreams
Failure Faith Freedom Imagination Fear Goal

This was because Kinect is limited in its ability to track the skeleton accurately and correctly if users are moving too quickly or moving beyond its range of vision. While the student was performing the movements, the computer screen was recording them using FRAPS screen capture and screen recording software. The exported videos were then embedded into the presentations (see Figure 30).

Finally, we created ten PowerPoint presentations for the intervention in the classroom. Each presentation included ten movement-words with colorful pictures, music, and animations accompanied by very clear and easy steps to be followed by students. Each session/intervention was designed to be implemented in a playful, collaborative way with increased difficulty across the sessions. Before the implementation in the classroom, the PanBoy movement-based intervention was tested with a small group of elementary children at the Cyprus Interaction Lab (see Figure 30) in order to identify any obstacles, challenges or limitations.

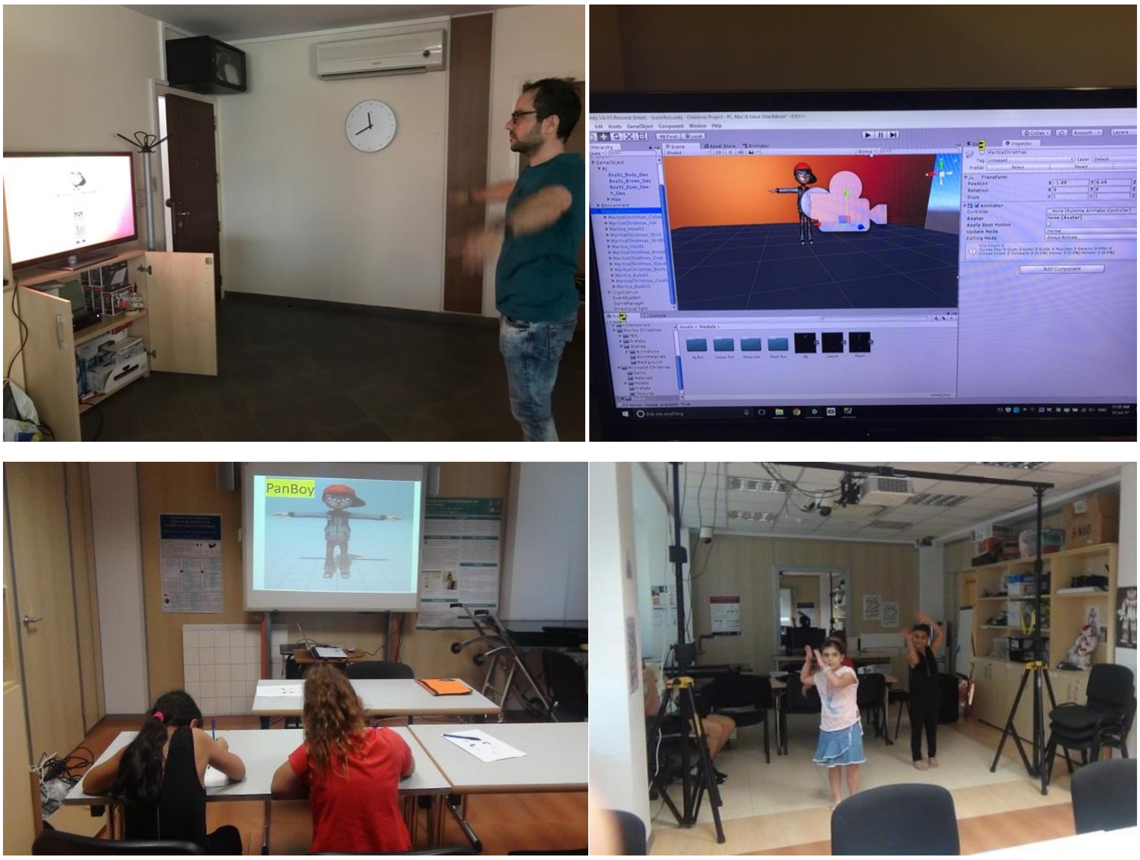


Figure 30: Preparing the PanBoy embodied learning intervention

8.3.3 Procedures

The intervention period in the six classrooms lasted for three months. Each session of 30-minute video-based activities was delivered to the whole class once a week by trained teachers with the help of the researchers (see Figure 31).

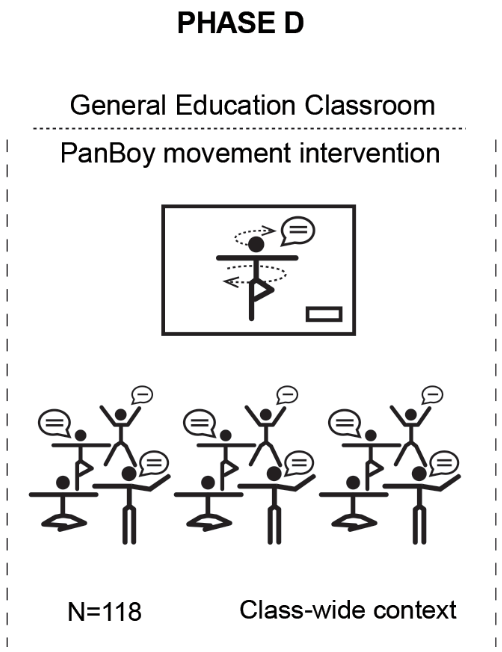


Figure 31: Intervention in the classroom – Phase D

Classroom activities started out simple at the beginning of the intervention period and built in complexity each week. The presentation/sessions were very prescriptive, using a step-by-step format, and all teachers participated in a six-hour workshop before the actual implementation of the interventions. In the workshop, the teachers had the opportunity to pilot PanBoy sessions and prepare for the intervention in their classrooms. It is important to note that teachers were very much involved during the planning and implementation of the intervention sessions.

All participating students received 12 sessions of PanBoy movement-based learning in which they engaged in a playful lesson environment using their bodies to learn and acquire new vocabulary. The average number of students in each class was 18. During each session students saw a short video segment with movements, words, and pictures that gave them explicit visual instruction as to how to perform each movement. This allowed them to essentially teach themselves the necessary skills to complete the activities successfully. Each session included ten new words based on the class curriculum. The topics covered during the three-month period were 'the human body', 'nutrition', 'my daily routine,' 'traveling' and 'feelings/emotions.'

The children had to follow the instructions displayed on the interactive board and imitate PanBoy's movements. There were ten different movements; each movement corresponded to one new word (action or abstract verb/noun). The children performed the movement saying the appropriate word aloud. When they were done, the children repeated the activity again. Then they watched only the movement and had to recall the corresponding word (see Figure 32).

Each week the children followed the same procedure. Once 80 movement-words had been completed, two review sessions were carried out that covered all the vocabulary the children had learned. The equipment needed for the intervention was a computer, music speakers, and an interactive whiteboard/projector.

Figure 32: Acquiring new vocabulary with PanBoy in classroom

8.3.4 Data Collection in Phase D

Instrumentation of students' pre-post language and vocabulary tests was based on the standardized Greek version of the Word Finding Vocabulary Test (Renfrew, 1997), normed on Greek preschool and school-aged children (Kambanaros, Michaelides, & Grohmann, 2015; Vogindroukas, Protopapas, & Sideridis, 2009). The test includes 50 line-drawn pictures and measures the Gc-crystallized Knowledge of children, according to Cattell's (1971) empirically supported classification of skills. The language pre-test was conducted by the teachers the week before the interventions began; the post-test was administered by the teachers the week after the interventions.

In order to see how many new words the children actually learned from the PanBoy intervention, we gave children a test based on PanBoy vocabulary in which each child had to write the word that corresponded to each movement. The test was personalized and included 50 randomly selected words from the PanBoy vocabulary. The students watched the PanBoy movements individually and then wrote down the word that corresponded to each movement. The test was administered to all children (N=118) during the last session and was the final task of the intervention period.

At the end of the intervention period, all teachers participated in a personal semi-structured interview session to discuss their overall experience and perceptions of the class-wide intervention. The teachers' interviews focused on the children's performance in relation to the specific goals we set and on their overall enjoyment of the intervention.

All classroom sessions using PanBoy intervention were video recorded. The video data was used to yield more information about the physical engagement and interaction of the students and to triangulate our findings in order to understand how EL worked in the classroom.

Finally, a short attitudinal Likert scale was administered to the students to assess their overall experience and perceptions of the intervention. The questionnaire focused on children's emotions and feelings during the intervention period. The flowchart of the data collection process appears in Figure 33.

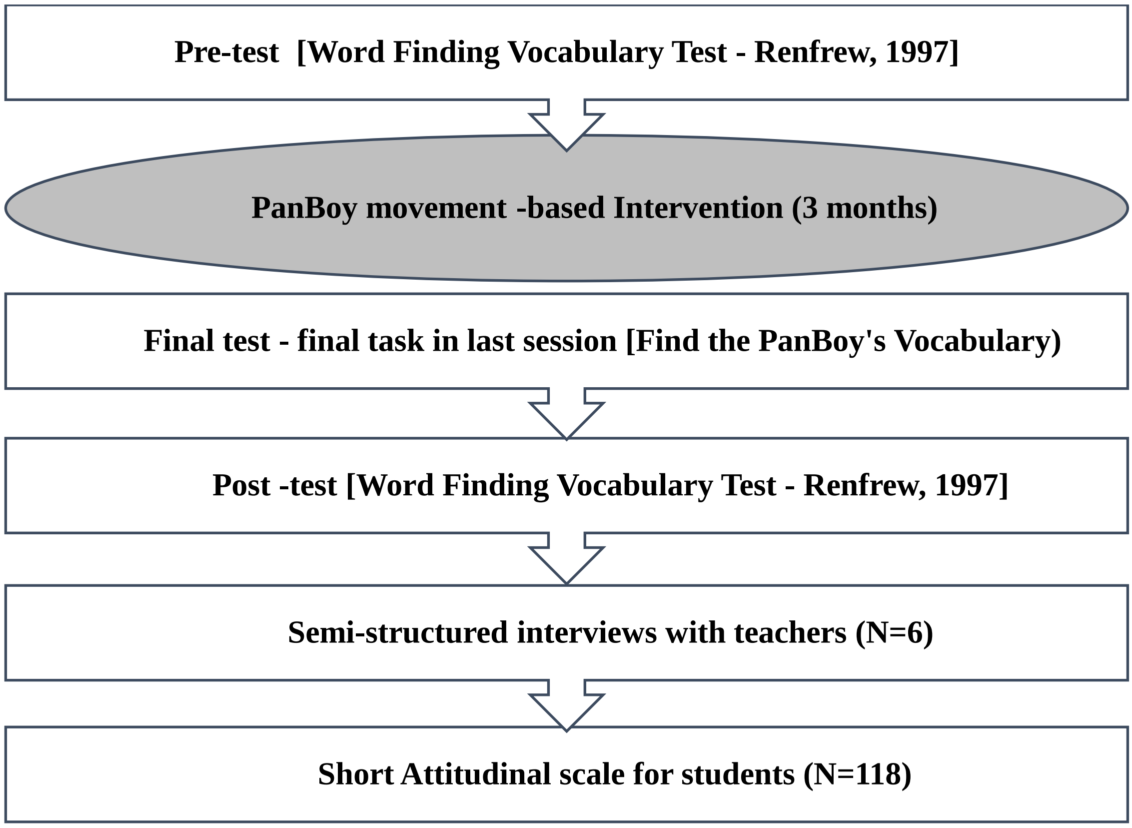


Figure 33: Data collection procedure of Phase D

8.4 Findings of Phase D

This section presents findings on children's overall experience with movement-based learning according to the feedback we received from teacher interviews. It also presents results from student assessment tests, which measured academic achievement in vocabulary acquisition and student emotional engagement with the EL process. Specifically, the quantitative analysis was based on the pre-post Word Finding Test and the final PanBoy test in conjunction with the qualitative data collected from teacher interviews.

8.4.1 Students' learning outcomes on language and vocabulary

In order to discover if there was any improvement in children's expressive vocabulary, we examined the data from pre and post-testing. First, we reported the results from a Paired Sample T-Test (see Table 18) in which there was a statistically significant difference (p_value <.001) from pre-to post-testing with a large effect size (Cohen's d = 0,65).

Table 18: Effects on expressive vocabulary from pre to post-testing (N=118)

	Pre-test (mean)	Post-test (mean)	P value	Cohen d
Expressive Vocabulary	22.57	28.64	.000**	0.65

**p<.01 = Indicates significance

Then, in order to see how many new words the children learned, a final personalized PanBoy test was administered to all participating students during the final intervention session. This final test (as a final task) measured how many new words students acquired based on PanBoy vocabulary. The results of the final test showed that the majority of children (72%) managed to memorize most new words by combining each word with its corresponding movement. The average score of all students on the final test was 44.7 (out of a maximum score of 50).

To confirm these positive results from the final task, a Pearson product-moment correlation was run to determine the relationship between post-testing scores in expressive vocabulary (Word Finding Test) and the final PanBoy task/test scores at the end of the intervention. There was a positive correlation between post-test and final task/test, which was statistically significant (r = .403, n = 118, p = .000). This correlation supports our assumption that our intervention did indeed help children enrich their vocabulary and learn new words they didn't know before.

Given the statistically significant differences in student academic performance, teachers' perceptions were further considered to understand better what this improvement meant. To this end, the qualitative data from teacher interviews were transcribed and coded by two researchers and then organized into thematic units, as set out by Saldaña (2009). The analysis of this data set focused on the two larger themes that were connected to our variable of interest: improvement in student language skills and emotional outcomes.

For academic performance in language and vocabulary acquisition, teachers (n=6) reported that our movement-based learning intervention helped students perform better in language learning, facilitating the acquiring of new vocabulary, even ‘difficult’ abstract vocabulary. Specifically, interview coding revealed that the movements themselves enhanced language acquisition and understanding of abstract words. As shown in Figure 34, teachers explained that this teaching approach, based on movement and embodied learning, improved student learning outcomes in areas of language acquisition that focused on themes like *bodily engagement* and *task integration*, *visual input/stimuli, concentration, visual-motor coordination, experiential lesson*, ‘*feeling’ the words*, and other areas like *creativity, linking movement and thinking*, and *combining cognitive functions*.

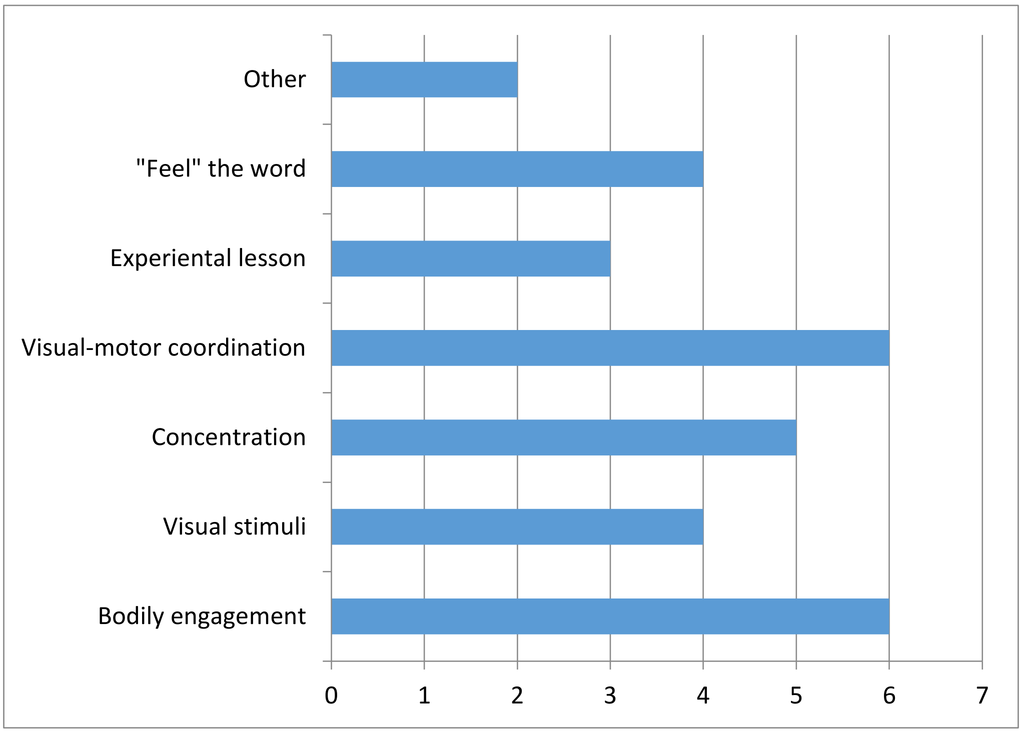


Figure 34: Teachers explain how the movement facilitated the language acquisition

Regarding the specific learning outcome based on the class curriculum (e.g., acquisition of new vocabulary), teachers claimed that students were very concentrated on the sessions, as they wanted to perform all the movements well and remember the new words.

As one participant/teacher (t5) explained:

"*It's so creative and fun for the children to use their bodily movements during the language lesson, and that was the key element of this approach. Attracting children's attention to the learning material helped children reach their learning goals*".

In another teacher's words (t2):

"*Representing words through the movements was very helpful for children. It helped them learn new difficult and abstract words. The movement was connected with the word, and indeed I saw that whenever they had to remember a word, they first performed the movement, and then the appropriate word came to mind*".

Some even more encouraging feedback from teachers shows just how powerfully physical engagement improves experiential language lessons in the classroom. One teacher (t6) said:

"*I believe that children at this age can learn and gain better academic outcomes more effectively through an experiential lesson. This approach with PanBoy is an easy solution because we use many brain functions at the same time, so learning comes effortlessly, and I think the material remains in children's minds for a long time".*

Along the same lines, another teacher (t1) explained:

"*Students need visual stimuli to understand an abstract concept or object. When they can engage their bodies in the learning process together with visual stimuli, even just their hands, then they thoroughly reinforce their performance. With the PanBoy intervention, I saw that the children acquired many new words, and not in isolation, but as words with specific meanings*".

Summing up, teacher perceptions, experiences, and reflections reinforce our claim that EL-driven technology improves student academic performance and provide useful feedback for how a movement-based approach can further enhance student language learning outcomes.

8.4.2 Students' emotional engagement and motivation

The data derived from student responses to the questionnaire showed that this learning approach made a difference for the children who participated. As illustrated in Figure

35, most students believe that the lesson with PanBoy was funny (82%) and that they learned new words using their bodies (74%). The children's responses to the questionnaire revealed that children not only benefitted from the intervention, but that they enjoyed this approach to language learning a lot as they found new ways to acquire new vocabulary in a playful environment.

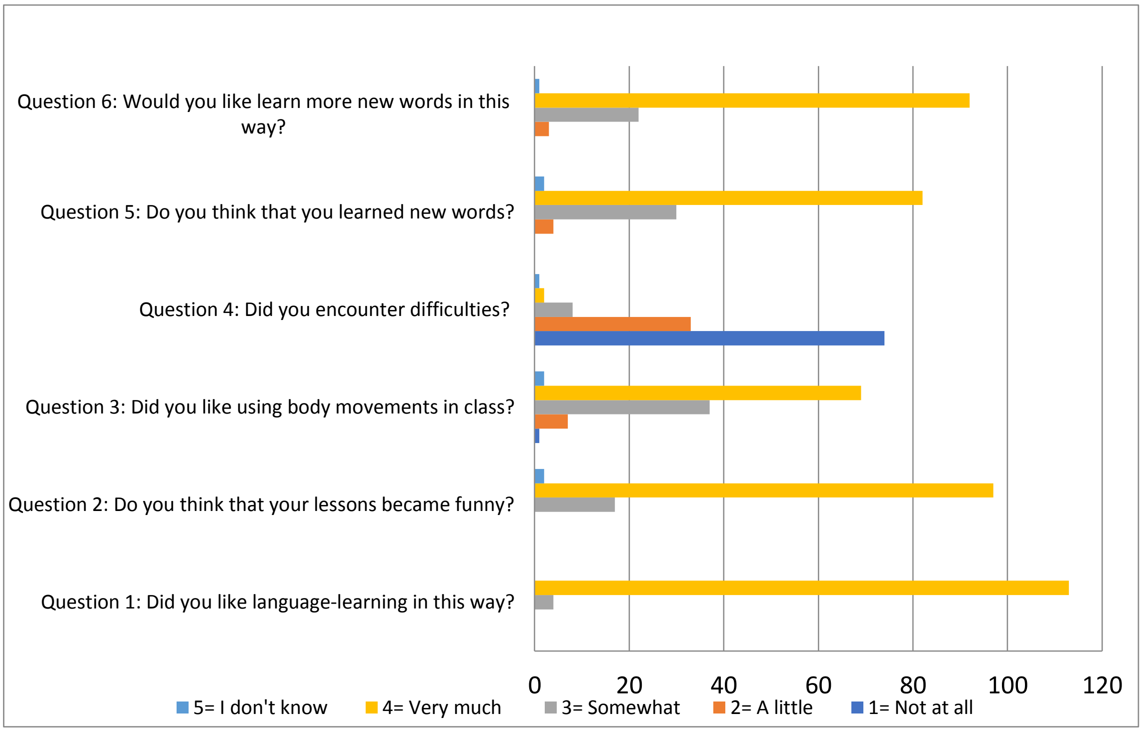


Figure 35: Children's perceptions of the intervention

After we coded and analyzed the teacher interviews, we were able to report on the second larger theme of student emotional engagement with the learning process. Generally, according to teachers, movement-based learning delivered via PanBoy improved children's emotional state and motivated them to participate and engage more in the learning process. Teachers revealed that students were physically and emotionally involved in the process and expressed their feelings on how their emotional outcomes improved during the intervention period. Regarding the overall emotional state of the students, teachers discussed variables such as motivation to participate, self-confidence, enthusiasm, happiness, curiosity, collaboration, etc. Table 19 summarises some of the most indicative quotes from the semi-structured interviews with teachers.

Table 19: Teachers discuss the emotional outcomes of children during the sessions

	Teachers' comments
p1	"They were happy; they didn't bother the others and were very concentrated. Even those who were sad about something else were motivated to participate. It was one way to forget their concerns".
p2	"They were excited during the lesson. They liked it a lot because every session combines movement with music. It was like a dance".
p3	"The children enjoyed the sessions. It was really an incentive for children to engage actively in language learning".
p3	"The children absolutely loved it. They think it's a really good way to learn new vocabulary."
p4	"All the children were excited, cheerful, and willing to participate in all the activities. As they participated in the intervention, they expressed their positive feelings and their joy. It was like a pleasant break from their other conventional lessons. I think that this approach helped children become more self-confident".
p5	"Children are more alert and engaged with language learning after the intervention with PanBoy".
p6	"During the intervention period, students were more creative, learned to work on their own, and most importantly, they were excited to do these activities. They also managed to increase their self-confidence because the activities were like a game. "

Overall, quantitative data from student questionnaires and qualitative data from teacher interviews and video recording confirmed that the intervention in classrooms was fully endorsed by the participants. This learning approach/method encouraged students to engage emotionally in the learning process while expressing positive feelings. According to the teachers, the intervention was also very easy to implement because the children simply followed the instructions on the screen, which means it can be implemented in classrooms with very little training.

8.4.3 EL in an authentic class-wide setting – Video analysis

These positive results corroborate the positive results from the previous phases of the study (Kosmas, Ioannou, & Retalis, 2017; Kosmas. Ioannou, & Retalis, 2018) and provide more evidence of how the body can be used in educational interventions, taking into consideration the video recording data. This type of practice in teaching, known as EL, encourages students to engage in learning activities both physically and emotionally, while this specific experiment offers a paradigm for movement-based language lessons, especially for first and second graders.

All the intervention sessions in Phase D were video recorded in order to examine the implementation of EL in the classroom further. The video recording process used in this cycle of investigation to enrich our existing collected data (especially the data derived from interviews and assessment tests) and also to triangulate our findings across sources of evidence. As Garcez, Duarte, and Eisenberg (2011) stated, the video recording as a data collection strategy is a rich source of information, especially in research with children. Indeed, video data gave us opportunities to capture aspects that may go unnoticed during the intervention session. Many episodes in video data gave us a whole picture of students' performance and engagement in the classroom.

Analysis of the video data was employed according to the procedure described in Barron and Engle (2007), as follows: 1) Guiding questions and indexing (field notes), 2) macro level coding, 3) narrative summaries, 4) categorization of the themes, 5) final coding and 6) discussion of emerged topics/ categories.

Video analysis revealed many important insights into how EL can be implemented in authentic classroom environments. As derived from video data, the essential point is that this movement-based intervention enabled all students to participate actively in learning and to improve their performance. Data from video recording revealed that the effective implementation of EL in the classroom is based on five factors: a) the teacher's role, b) the technology, c) the collaboration between students, d) the classroom design/ setting, and e) the organization of in-class activities.

First important factor in implementing successful EL interventions in class-wide settings is the teacher, whose participation is critical at the beginning. The teacher must provide clear guidelines for children to become autonomous. These guidelines should be restated if necessary. Encouraging children to continue is also very important, especially during the first interventions. In subsequent sessions, the role of the teacher is more instructive. The teacher should help children where needed and intervene only when children find it difficult to progress. For instance, observing an episode in the classroom, the teacher encouraged students to continue the activities giving them some guidelines, as showcased in the following information flow example.

> Teacher*: Come on guys; follow the instructions of Panboy [Points to a particular area on the screen that encloses the instructions.]*
>
> Student 1*: And now? What will I do now?*
>
> Teacher*: Look at the screen [points to the specific area on the screen]. PanBoy says that you should raise your left hand.*
>
> Student 1*: [Follows the instructions]*
>
> Teacher*: Good job! Great!*
>
> Student 1*: And now?*
>
> Teacher*: Continue…. [Points again on screen]. Be careful of what Panboy says.*
>
> Student 1*: Ah ok…*

The classroom setting is also significant for the development of the intervention. Children need to have the space to move into the classroom without any obstacles. They need to feel comfortable and familiar with the space so they can participate actively throughout the process. Students must have easy access to the screen, so they do not lose the instructions. For example, observing some children during the session, we realized that the children in the back rows of the classroom and they have no direct access to the screen, could not follow the instructions, as shown in the example below.

Student 2*: What should we do now? I don't know!*

Student 3*: Look at the screen!*

Student 2*: [student tries to read the instructions]*

Teacher*: Come on! Do you see what PanBoy is doing?*

Student 2*: No, the screen is far away from me! I can't see!*

Student 4*: And now? I don't see very well the PanBoy's movements!*

Technology also plays an essential role in a successful intervention. Everything should be ready and organized in advance so as not to waste time or create confusion when the intervention starts. The more playful the activities, the more kids like them. Technology encourages children to participate in the learning process, but when the technology doesn't work, it makes the situation difficult and the classroom experience more chaotic. Due to the physicality of EL learning activities, the technological tools that teachers use should make the classroom physical and flexible.

Finally, activities need to change from session to session because children get bored easily. Each new activity must build on the last so that children are motivated to continue, as in the example below.

Student 5*: Oh! This is a new movement!*

Student 6*: Yep…. It's difficult! I am not sure if I will manage it!*

Student 5*: [Tries to do the movement showing the way to his classmate]*

Student 7*: I did it! Great!*

Student 5*: I did it too! Cool!*

Student 6*: Look at this [shows the PanBoy's movement and laughs].*

Student 5*: Let's try then!*

It is also important to cultivate an atmosphere of cooperation in the classroom because interventions often require teamwork. It was often observed during the intervention that some children were encouraged to continue by their classmates. At other times, when students didn't understand instructions, they followed their classmates in order to advance to the next step, as in the example below.

Student 8*: What is this?*

Student 9*: What? It's easy! [Tries to perform the movement]*

Student 8*: [Observe what his classmate is doing]*

Student 9*: You see? I did it! Do you see? [Perform the movement again]. Did you understand?*

Student 8*: [tries one more time to perform the movement]*

Student 9*: Bravo! That's it!*

Given the positive and significant results from our investigation, we can argue categorically that EL-driven technologies should be incorporated into language learning curricula. The following Figure 36 visualizes the pattern of the implementation of EL in class-wide classroom context highlighting the five factors of such implementation.

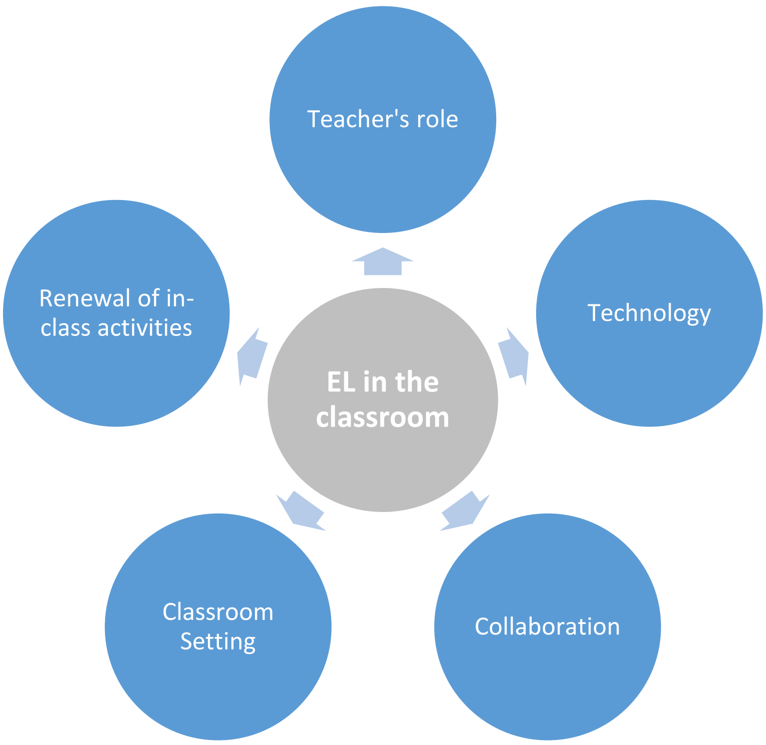


Figure 36: Essential factors for the implementation of EL in the classroom

8.5 Discussion - Addressing RQ6, RQ7, and RQ8

Previous research on physical engagement and movement in the classroom demonstrated that the body is a valuable tool for improving cognitive functioning, which in turn helps students achieve better learning outcomes. Phase D presents original research based on this idea, implementing a movement-based intervention in the classroom.

Findings from this study demonstrate that students who were involved in the intervention significantly improved their academic gains—particularly in expressive vocabulary—when scores from pre-post testing and scores from the final language test were compared. These results demonstrate that movement/physical engagement in the classroom was linked to learning outcomes among first and second graders. Indeed, the statistical analysis appears to have revealed a significant difference and high impact/effect on academic performance in children's language and vocabulary acquisition. This positive impact corroborates results from the previous phases (Kosmas et al., 2017; Kosmas at al., 2018) of the research and provides evidence of how the body can be used in educational interventions.

Nowadays, many educators consider learning only to take place when children are sitting still (Hynes-Dusel, 2002), ignoring the positive effects of movement on children's learning outcomes. The results of Phase D suggest that movement, and generally the body, can be used as a tool to enhance learning experiences for children. Specifically, in a language learning context, EL helps students acquire new vocabulary and boost vocabulary comprehension. It does this by linking words with movements so that, as the teachers said, students 'feel' the meaning of words with their bodies.

Additionally, EL encourages students to engage in learning activities both physically and emotionally. Our qualitative data indicates that movement-based learning with PanBoy helped students express their emotions (e.g., joy, enthusiasm, motivation, etc.) during the lesson, improving their self-confidence. This emotional improvement was also observed by other researchers (Kosmas et al., 2018).

This cycle of investigation offers a paradigm for movement-based interventions that can be used to make classroom language learning more meaningful and enjoyable, especially for first and second graders. Our intervention, based on EL principles, enriches the delivery of language lessons by integrating the benefits of physical engagement into the learning process, something most classroom curricula has not attempted so far, despite the fact that there is ample. The current class curriculum does not include movement activities which can facilitate the students' physical interaction with the learning content. Previous research is suggesting that movement improves language readiness (Krog & Krüger, 2011). The reasons for this apathy are varied, but often teachers are simply not interested in creating structured movement lessons (McClelland, Pitt, & Stein, 2015). Additionally, training for teachers is often absent. Awareness and training, therefore, would go a long way to improving the situation, giving teachers the tools they need to implement movement activities in their daily teaching practice (Robinson et al., 2012).

Phase D provides a teaching paradigm based on the link between movement and learning, offering possibilities for further use and research in educational settings with very simple implementation and little adaptation on the teachers' part. The fact that the intervention was designed for use in a class-wide setting allows all students to participate together in the learning process, supporting Hill's (2010) belief that "classroom interventions that do not single out specific children and appear to benefit all children will be crucial in improving outcome for all" (p. 888). Moreover, the study shows that EL practices offer an exciting opportunity for students to use both their bodies and brains to solve problems interactively and boost their academic performance.

8.6 Summary

In closing, given the positive and significant results from our investigation, we can argue that EL technologies can and should be integrated into classroom language learning curricula. By doing so, teachers will have the opportunity to boost children's cognitive abilities in an enriched sensorimotor environment, which can positively impact not only their academic performance but also their emotional state.

9 DISCUSSION

This chapter discusses the findings of this research, providing significant insights into the use of EL in different authentic classroom environments. Specifically, in this chapter, I combine the results of the four individual phases conducted in the classrooms and provide an overview of the outcomes of this dissertation. At the end of the chapter is a summary of the contribution this research makes to the field and some directions for future research.

9.1 Introduction

For this dissertation, I conducted four phases of research in order to determine how EL-driven technology would impact overall student performance in the classroom (i.e., how it would affect cognitive, academic, motor, and emotional skills). I also addressed some important factors and useful guidelines for implementing EL in real learning contexts.

Phase A (Chapter 5) described the experiences of SEN students and teachers with EL through motion-based educational games. The findings of this first exploratory phase indicated that students and teachers thought EL lessons were engaging and an incentive to learn. Specifically, the results of Phase A revealed that learning with EL games improved SEN student motor performance. This phase was crucial for the progress of this dissertation. As Schuck, Aubusson, Kearney, and Burden (2013) point out, the evaluation and critique of a new technological setting within a learning environment is essential because it allows the researcher to understand the perspectives of students and teachers better.

Phase B (Chapter 6) sought to examine whether EL could improve student cognitive abilities and emotional performance. This phase deepened our understanding of how EL delivered via motion-based technology impacts teaching and learning with SEN children. The results of this phase showed that motion-based EL games improved the short-term memory ability of SEN children significantly. These findings agree with the results of previous studies on the value of using motion-based games in learning for children with multiple learning difficulties (Altanis et al., 2014; Bartoli et al., 2013, 2014; Retalis et al., 2014; Kourakli et al., 2017; Kosmas et al., 2017). Furthermore, the findings of Phase B support the idea that EL activities can help SEN children engage in learning tasks, motivating them, making them enthusiastic and happy, and improving their overall emotional state.

Phase C (Chapter 7) focused on implementing motion-based EL technology in a GE classroom. Our results showed that the EL approach, as a learning method in a real classroom environment supported and mediated by motion-based games (in this case Kinect-based educational games), positively impacts children’s cognitive skills (i.e., short-term memory ability-Gsm) and academic performance (i.e., linguistic development and vocabulary acquisition). Results from this third cycle of investigation revealed that EL could be implemented in the real classroom context as part of the curriculum, specifically in terms of new vocabulary acquisition.

Phase D (Chapter 8) examined the use of EL activities via a movement-based intervention (PanBoy) developed especially for first and second graders. The findings from this study demonstrated that students who were involved in the intervention improved their academic gains significantly, particularly in expressive vocabulary. Moreover, this experience enabled students to engage in learning activities both physically and emotionally while expressing their emotions (e.g., joy, enthusiasm, motivation, etc.) and improving their self-confidence. Qualitative data derived from interviews and video recording provided a coherent picture of how EL implemented in the classroom, bringing to the light essential factors for an effective EL implementation. Figure 37 illustrates the educational interventions in the classroom over a three-year period and points out the general findings of each consecutive study.

The following sections of this chapter provide a comprehensive answer to each research question and offer a set of implications and useful insights that can help researchers and practitioners implement EL-driven technology in real classrooms.

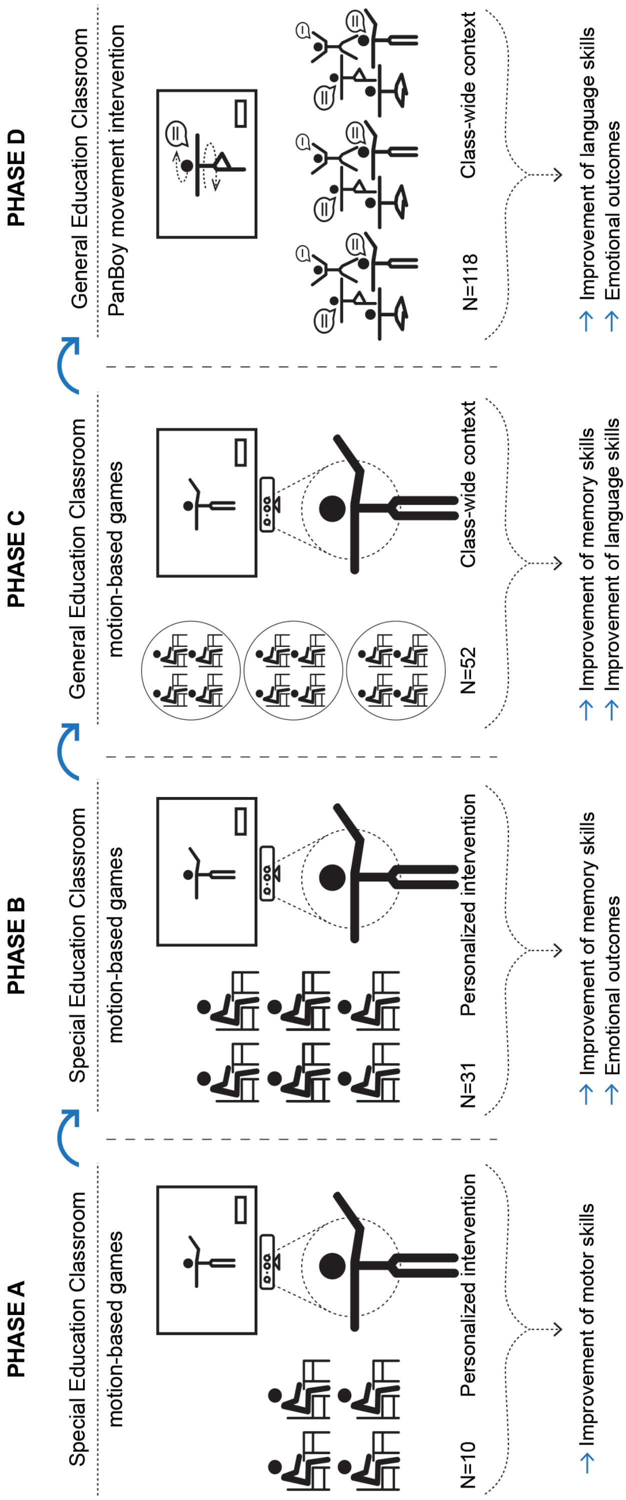


Figure 37: Investigation of Embodied Learning in the classroom across four phases

9.2 Addressing the Research Questions of this Work

In the previous sections of this dissertation, I have already addressed the research questions introduced in Chapter 1. This section reflects on the eight different research questions we attempted to answer in four phases (see Figure 38).

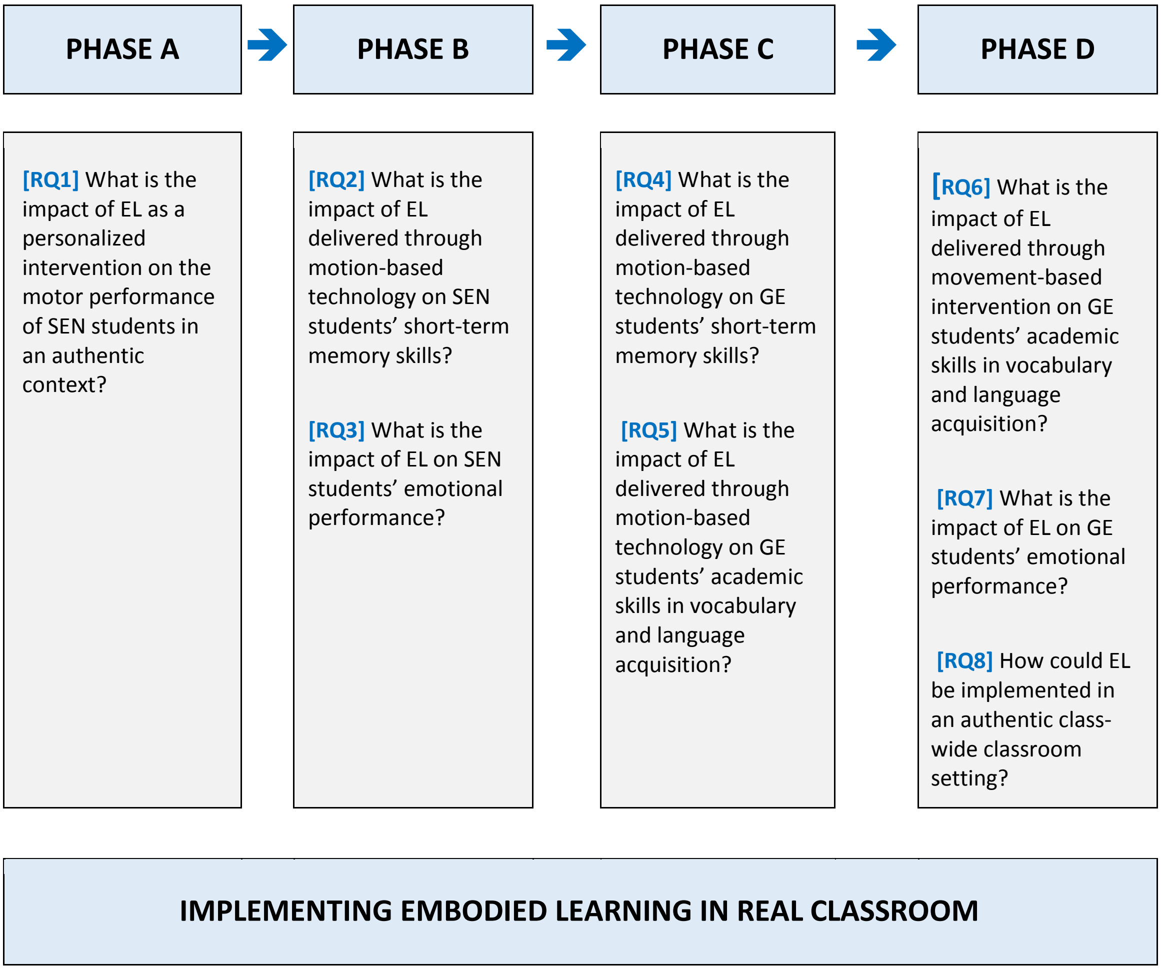


Figure 38: The research questions of four phases

9.2.1 [RQ1] What is the impact of EL as a personalized intervention on the motor performance of SEN students in an authentic context?

The analysis of quantitative and qualitative data revealed that children experienced significant gains in (i) psychomotor abilities (Gp) (operationalized as stable hand movement) and (ii) psychomotor speed (Gps) (operationalized as the time needed to complete the task successfully). Results showed that motion-based EL games using Kinect helped children engage in physical activity and improved their motor abilities, especially body and hand movement.

Participating teachers also confirmed the gains and discussed progress in vision-motor coordination, hand stability, and speed improvement. They claimed that the embodied interaction with the motion-based games improved SEN children's gross motor and fine motor skills, spatial body position, and their ability to coordinate thought and movement. It is important to note that the teachers' perceptions were entirely consistent with the findings from the Kinetic platform analytics. All the teachers mentioned that motion-based EL games helped SEN children with motor impairments and learning difficulties. Specifically, the results of Phase A demonstrated the enormous potential of using touchless, multimodal EL games to improve SEN student motor performance in an authentic SE classroom.

9.2.2 [RQ2] What is the impact of EL delivered through motion-based technology on SEN students' short-term memory skills?

Observing EL at work in an SE classroom, I found that it impacted children's short-memory skills (Gsm) significantly. Based on data from assessment tests on memory ability, there was a statistically significant increase (p value $< .05$) from pre (mean performance score = 18.90 out of 31) to post-testing (mean performance score = 20.84 out of 31), with a medium effect size (Cohen's $d = 0.60$). The findings from Phase B, therefore, showed that EL delivered by motion-based educational games does improve children's short-term memory (measured, in this case, by a word recall test). I found medium effect sizes, indicating the difference is meaningful and may have practical importance for education (Lecroy & Krysik, 2007).

Our qualitative dataset indicates that teacher feedback was fully consistent with their children's cognitive gains. The teachers argued that the experience improved the memory skills of the participants, particularly their ability to execute a series of tasks and their ability to make choices in problem-solving tasks. Additionally, the teachers argued that the experience could be beneficial not only for SE students but also for GE first and second graders in mainstream schools.

9.2.3 [RQ3] What is the impact of EL on SEN students' emotional performance?

Quantitative data derived from children's responses to the attitudinal scale demonstrated that the experience was fully endorsed by the participants/students. The majority of students (79%) reported that the lesson with motion-based games was more enjoyable than traditional lessons and that they would like to use this method in more classes. These statistics suggest that the EL learning experience deepened their engagement with the material and motivation to learn.

The teachers' perspective was fully consistent with these outcomes. As teachers explained, motion-based interaction improved the emotional state of the participants, resulting in increased self-confidence, joy, enthusiasm, calmness, and motivation to participate in the learning process. All the teachers confirmed that all the students were happy during the intervention period.

Finally, based on the findings of Phase B, EL activities were shown to help SEN children engage with the learning tasks, making them more motivated, enthusiastic and happy, and improving their overall emotional state.

9.2.4 [RQ4] What is the impact of EL delivered through motion-based technology on GE students' short-term memory skills?

Outside of an SE context, I examined how EL could be integrated into a GE classroom. Looking at the impact of EL-driven motion-based technology on short-term memory skills (Gsm), there was a statistically significant difference (p_value = <.001) from pre-to-post testing with a strong effect size (Cohen's d = 1,01). Besides the statistically significant differences in pre-post testing for memory skills, the general learning analytics showed that children's memory performance also improved during the educational intervention. Additionally, over the course of the sessions, children's memory performance progressively enhanced in terms of task completion time and wrong answers/trials.

Teachers' perceptions were fully consistent with these significant gains in memory skills. Results from teacher interviews and observations show that they felt children's memory skills had progressively improved after the first two sessions. Teachers also claimed that EL activities reinforced children's memory skills, talking about *absolute concentration, focus on the game, structure,* and *organization of objects, think aloud* and *use of body* and especially of *hands*.

Overall, based on quantitative and qualitative data, children managed to improve their memory performance during the intervention session by finding alternative ways to remember the visual objects and complete the game. These results agree with and confirm the findings from previous phases conducted in an SE context.

9.2.5 [RQ5] What is the impact of EL delivered through motion-based technology on GE students' academic skills in vocabulary and language acquisition?

Students that used EL-driven motion-based games in an authentic GE classroom demonstrated a statistically significant difference (p_value <.001) from pre-to-post testing on vocabulary and language assessment tests with a large effect size (Cohen's d = 0,28). The analysis from automatic learning analytics confirmed these results. Specifically, there was a strong positive correlation between scores on vocabulary tests and time-on-tasks in the 'Lexis' game, which was statistically significant ($r = .675$, $n = 52$, $p < .001$). Learning analytics from the motion-based language game likewise revealed progressive improvement in language across time and with increased task difficulty, reconfirming that students improved their language skills and acquired new vocabulary progressively.

The meaningful differences and significant effect sizes in measurements of language skills agree with the teachers' perceptions, notes, and reflections regarding children's overall experience, as the teachers' perspective was fully consistent with these learning gains. The teachers argued that children's motion-based interaction with the technology facilitated their academic achievements in language and vocabulary acquisition. Indeed, they stated that the engagement in these EL sessions increased their academic performance in language, resulting in better spelling skills and new vocabulary acquisition and comprehension. The teachers claimed that the students benefited from this experience because they had the opportunity not only to practice their existing language knowledge but also to enrich their vocabulary. Furthermore, according to the teachers, the classroom EL activities delivered via the motion-based games allowed students to experience lessons in a more enjoyable and meaningful way.

9.2.6 [RQ6] What is the impact of EL delivered through movement-based intervention on GE students' academic skills in vocabulary and language acquisition?

According to the results from the movement-based intervention, PanBoy, there was a statistically significant improvement in academic language gains (p_value <.001) from pre-to post-testing in vocabulary with a large effect size (Cohen's d = 0,65). There was also a positive correlation between post-test vocabulary assessment and final task/test assessment that was statistically significant (r = .403, n = 118, p = .000). This significant correlation shows that PanBoy helped children enrich their expressive vocabulary and also better understand the meanings of new words.

Given the statistically significant differences in students' academic performance, the teachers' perceptions were further considered to evaluate the language improvement of students. According to teachers, movement-based learning did help students improve language skills, especially their ability to learn new vocabulary and even 'difficult' abstract vocabulary. In addition, teachers explained that this teaching approach improved student language acquisition learning outcomes in areas like bodily engagement and task integration, visual input/stimuli, concentration, visual-motor coordination, experiential lesson, 'feeling' the word, and creativity. Teachers also reported that EL was successful in linking movement and thinking and combining cognitive functions.

9.2.7 [RQ7] What is the impact of EL on GE students' emotional performance?

The data derived from student responses to the questionnaire showed that an EL learning approach was beneficial for the children who participated. It seems that children also enjoyed learning a language this way as they found new ways to acquire new vocabulary in a playful environment.

According to teachers, movement-based learning improved children's emotional states and motivated them to participate and engage in the learning process. They reported that the children were physically and emotionally involved in the process and expressed positive feelings that improved their emotional outcomes. Regarding the overall emotional state of the students, teachers discussed variables such as motivation to participate, self-confidence, enthusiasm, happiness, curiosity, and collaboration.

9.2.8 [RQ8] How could EL be implemented in an authentic class-wide classroom setting?

Results from teachers' observations and video recordings of the classroom provide evidence of how bodily experiences and movement can be successfully integrated into educational environments. EL helped students engage in learning activities both physically and emotionally. Our experiment can also provide a paradigm for movement-based language learning interventions in the future, especially those designed for first and second graders. Given the positive and significant results from this investigation, I can argue that EL can be easily integrated into existing language learning curricula.

The analysis of qualitative data from video recordings and observations has yielded significant insight into how EL can be implemented in an authentic classroom environment, but mainly it has shown that our movement-based intervention improved students' participation and test performance.

The essential factors for implementing EL in the classroom are:

a. *The role of the teacher*. Teachers must be supportive. The teacher must provide clear guidelines for children if they are to become autonomous and continue on their own, especially during the first interventions.

Teachers should also be on hand to help children when they need it, but should only intervene when children find it difficult to progress.

b. *The classroom setting*. Comfortable classrooms and enough space to move about in the classroom without any obstacles are essential. Children need to feel comfortable and familiar with space so that they can participate actively in the process.
c. *The technology*. Everything should be ready and organized in advance so as not to create confusion among students.
d. *Classroom activities – Learning material*. The more playful the activities, the more kids like them. Activities also need to change from session to session because children are easily bored. Every new activity must build on the last so that children are constantly motivated to continue.
e. *Collaboration between students*. Such interventions require collaboration between children. Teachers must create appropriate the right atmosphere and the right type of activities to foster this collaboration.

9.3 Contributions

The intent of this dissertation was to provide new knowledge and a better understanding of how EL-driven technology can be implemented in an authentic classroom environment. Even though the analysis, descriptions, and presentation of the findings are significant, drawing attention to the implications of this research for researchers and practitioners is equally important. The dissertation provides three main contributions. First, it shows how EL can be integrated into authentic classrooms in special and general contexts and for specific learning purposes. Second, it provides essential considerations and theoretical guidelines for researchers and practitioners. Third, and most important, it moves the discussion about the use of EL further in the direction of EdTech. In the following section, we reflect on the important contributions and implications of this study on research and practice.

9.3.1 Making Embodied Learning part of the curriculum

Nowadays, the way in which we educate children is changing radically. As a result, school systems need to improve not only teaching methods but, above all, their theoretical vision about how learning works (Paloma, 2017). Educators and learning scientists must, therefore, consider new approaches to teaching practices like EC and EL. This research clearly demonstrated that the integration of movement into learning could significantly affect students' cognitive, academic and emotional performance. As Margiotta (2017) writes, "the most commonly accepted and widely adopted approach is the one which emphasizes the transmission of knowledge and the teaching of basic school/academic skills".

Students in the first stages of school need to be in movement in order to learn and focus their attention (Paloma, 2017). This is because children learn through their bodies and senses. Or, as Uwe Pushe puts it, "The body is more than just a support for the head, and at school we do not only deal with the head but a with a human being as a whole" (in Paloma, 2017 p. 100). Some educational systems have already adopted this theoretical approach and implemented EL in their teaching practices. One such example is the School in Movement in Switzerland. The School of Movement, whose fundamental tenet is that movement is essential for learning and memorizing (Paloma, 2017), promotes movement in schools and in educational activity. Likewise, the program "Learning in Movement" encourages children to perform tasks like calculating and conjugating verbs while in motion (Buser, 2005).

Despite these limited examples, there is no universally adopted program to provide specific explanations of guidelines for how we can integrate EL and movement into the classroom. Indeed, the revolutionary scope of this approach is still underestimated in daily teaching practice. Though previous research has found that movement can help prepare students to learn (Krog & Krüger, 2011), unfortunately, movement is still excluded from today's classrooms for a number of reasons. These reasons include a lack of adequate equipment, a lack of knowledge about the benefits of movement for learning, and teacher apathy (McClelland, Pitt, & Stein, 2015).

This dissertation offers a more profound and empirically supported understanding of what EL is and how we can implement it in the real classroom. Where our research stands apart is that, unlike most laboratory-tested studies, it actually introduced EL-driven technology into a real classroom setting with children and teachers, thus confronting and addressing the practical challenges of EL interventions, while gathering real-life data that supports its effectiveness. The data we collected and the results we have drawn from it are expected to give instructors, researchers, and practitioners a better understanding of the features of EL-driven technology and the means to implement them successfully in a classroom.

9.3.2 Embodied Learning in language learning context

There is a large and diverse body of literature on the significance of EC theory to language learning and teaching. Previous research unanimously points out the need to move from abstract teaching and learning to active teaching and learning, using learners' bodies as learning devices. While studies in the past have recognized that the body can be used as a valuable tool for improving cognitive functioning and helping students achieve better learning outcomes, few educational interventions based on EC and EL that combine this embodied view of language learning with technology in real contexts have been carried out.

The significant academic gains in language learning (see Phase C and D of this study) demonstrate that movement/physical engagement in the classroom was linked with improved learning outcomes for first and second graders. Moreover, EL helped students engage in learning activities both physically and emotionally, showing that movement, and the body in general, can be used as a tool to enhance learning and improve emotional states.

Specifically, in a language learning context, it is very important for students to understand the meanings of new words they acquire. As the results of Phase D confirm, when movement is linked to specific words, students learn new abstract words better. They 'felt' the words' meanings using their bodies. Our findings are in line with previous studies, which have also found that physical activity and movement not only positively impact children's academic achievement and cognitive abilities (Tomporowski, Lambourne, & Okumura, 2011), but also their language comprehension (Cassar & Jang, 2010) in phonological awareness and reading (Moritz et al., 2013).

Word meaning has been linked to sensorimotor experience (VanDam et al., 2012). Considering that motor abilities contribute to the development of language, the EL paradigm provides essential insights into how sensorimotor capabilities aid language acquisition (Iverson, 2010). One example of combining both sensorimotor and linguistic experiences is “Words as Social Tools”. According to this approach, words are tools that allow us to interact with our physical and social environments (Borghi et al., 2013).

Along the same lines, this dissertation offers a paradigm for movement-based EL language learning interventions, especially those designed for first and second graders. The significant academic gains our study has yielded confirm the fact that EL can enrich the delivery of language lessons by incorporating the benefits of physical engagement into learning. While this approach is a rarity in classrooms these days, it is a trend that should be corrected, in so far as the results of this study clearly reveal that implementing EL through motion-based technology (Phase C) or other easily implemented technologies (Phase D) can indeed boost language learning and vocabulary acquisition. Thus, language learning curriculum should offer new didactic paths for students, taking into consideration the benefits of physical movement and engagement in learning practices. I believe that this dissertation offers some fundamental insights into how we can implement EL for specific learning goals in language and vocabulary acquisition.

9.3.3 Applying EL in the classroom: Considerations for researchers

The core concepts and ideas of EC and EL can also serve to guide research practice in the direction of educational technology. In this study, EL research was carried out in authentic classroom environments. Research in a real classroom has many practical difficulties, but it offers the possibility of examining the phenomenon in real time and in a real environment, taking into account all the complexities and obstacles that arise.

In this dissertation, EL was implemented via motion-based technology (e.g., Kinect-based games) in the first three phases and via animations in a movement-based intervention (developed through Kinect technology) in the last phase. On the one hand, designers and HCI scientists can learn more about technologies for implementing EL in the classroom from this dissertation, not only as a personalized intervention but in a class-wide setting. However, our study doesn’t deal with every aspect of implementing EL in the classroom. Even so, researchers in the fields of EdTech and TEL can use the results of this research as a basis for exploring different approaches to implementing EL-driven technology in authentic classrooms.

On the other hand, the findings of this research suggest several new directions for the field to move in. One path involves tracking the ways EL-driven technology can be used in classrooms. Personalized interventions for children with learning difficulties or disabilities within the SE context, for example, can help them learn and motivate them to participate in the process (see Phase A and B). Another way is to include EL in classroom curriculum to enhance specific learning goals and to motivate all the children to participate in the learning process (see Phase C and D).

To that end, researchers could also focus on examining how EL-driven technology could be used in different contexts and circumstances, i.e., in SE classrooms with SEN students and in GE classrooms. In both cases, researchers must take into account the following factors:

- *The age and number of children in the classroom*. This will help researchers organize the educational intervention in such a way that all children can benefit. EL has been shown to work not only in SE but also in GE elementary school classrooms. The mean number of children in the classroom was 16 children, which is a good number for an effective EL intervention. While we have focused only on elementary school children, there is also evidence from other studies that EL is also effective for high school and university students (Lee et al., 2012; Van Dam et al., 2012; Chang et al., 2013; Chao et al., 2013; Enyedy et al., 2012).
- *The viability of the technology*. The researcher should be sure that the technology fits the study and that it serves the research objectives. Because computers and technology by themselves cannot improve children's abilities to learn (Paloma, 2017), researchers must organize the learning activities based on the kinds of technology they use in the classroom. The researcher should also be familiar with the technology in order to troubleshoot any problems that may arise in the course of the research.

- *Student assessments.* The assessments should be viewed only as an indication of student achievements before, during and after the intervention. Tests can just ‘measure’ and show a trend of the intervention’s success or failure. Therefore, researchers should always use data from other methods, quantitative or qualitative, to back up their findings.
- *Mixed methods of data collection.* With a mixed methods approach, the researcher can look at multiple aspects of the research in real learning environments, collecting and analyzing both quantitative and qualitative data. Researchers can also evaluate and interpret student interactions and gains holistically. For example, since teachers have a clear picture of their students’ abilities, their input can explain how students perceived the experiences in the classroom.
- *The classroom setting.* The researcher should address all practical issues related to the classroom setting (class size, desk arrangement, technologies, etc.) before the intervention begins.

In conclusion, if researchers are aware of and follow all the research recommendations mentioned above, their EC and EL research will produce more useful results. The research recommendations presented above may help future researchers to enact research in the direction of EC and EL (see Figure 39).

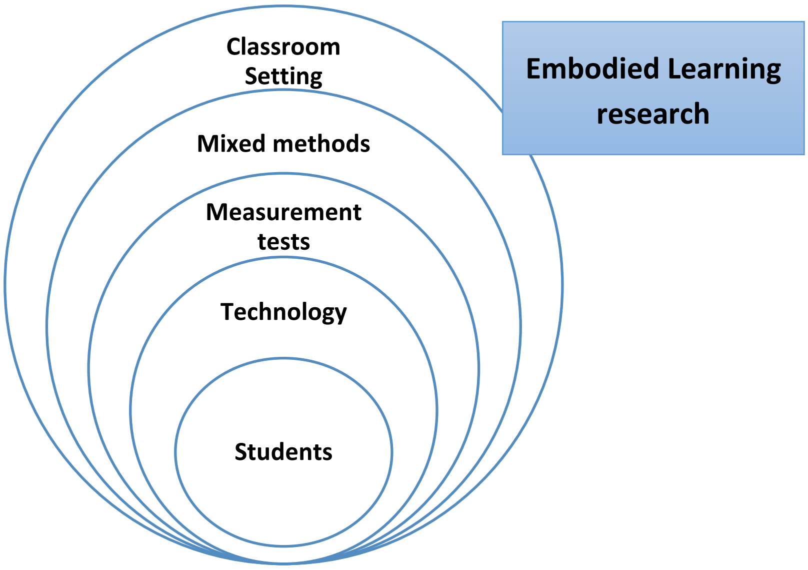


Figure 39: Implementation of EL and considerations for researchers

9.3.4 Implications/ Guidelines for practitioners

This dissertation also provides an in-depth and holistic understanding of how EL technology can help teachers enrich their existing learning environments. Specifically, the results from this study show how EL-driven technology can be used in real classrooms for specific learning purposes (i.e., development of motor skills, memory skills, and academic language skills). Additionally, our effective implementations of EL approaches indicate key elements for designing future curriculum, technological tools, and classroom practices, and nurturing new cultures of learning and theoretically and pedagogically aligned task-design.

As we have shown, there are many advantages to be gained from implementing EL in classrooms. Practitioners (in this case teachers) benefit from implementing EL in their classrooms, enriching the learning experiences of their students and motivating them to engage in the learning process. That said, teachers who are interested in integrating EL-driven technology into their classrooms must be aware of some important issues.

First, classroom orchestration is essential for implementing EL. The classroom must be designed in such a way that children have space to move comfortably in because a disorganized and uncomfortable class can lead to many problems. The orchestration of classroom activities also encompasses the spatial relationship of tables, chairs and tools, and student dynamics. Teachers must also take into account the viability of the technology they use and make decisions about how they combine technology with learning activities. Due to the physicality of EL learning activities, the technological tools that teachers use should make the classroom physical and flexible. Teachers should also be able to use the technologies in the intervention so they can manage them effectively.

Second, the role of the teacher in EL classroom is critical. Teachers, as leaders of the class and mentors, have the responsibility of deciding what directions the activities take. That is, the teacher should encourage students to strive to be the best they can and enjoy the learning experience. Moreover, teachers must be prepared to lead the implementation and to create a positive, playful environment where students are motivated and eager to learn.

Third, EL implementations like motion-based games are only one part of the whole learning process and should be based on the class curriculum. In this spirit, the adjustment or adaptation of EL should be found on the dynamic of the classroom, on students' personal, social and learning tastes, and their skill levels. To be able to engage all the students in the learning process, activities must include individual activities, class-wide activities, and group activities. Teachers must also find a way to motivate students in learning over time. For this reason, activities need to change from session to session and get more difficult and complex as the sessions progress.

Summing up, creating or designing an EL environment that uses technology requires that we take into account the classroom setting, the viability of the technology, the role of the teacher, the curriculum and learning goals, student dynamics and classroom orchestration. Figure 40 visualizes the four key aspects and factors for EL implementation in the classroom settings.

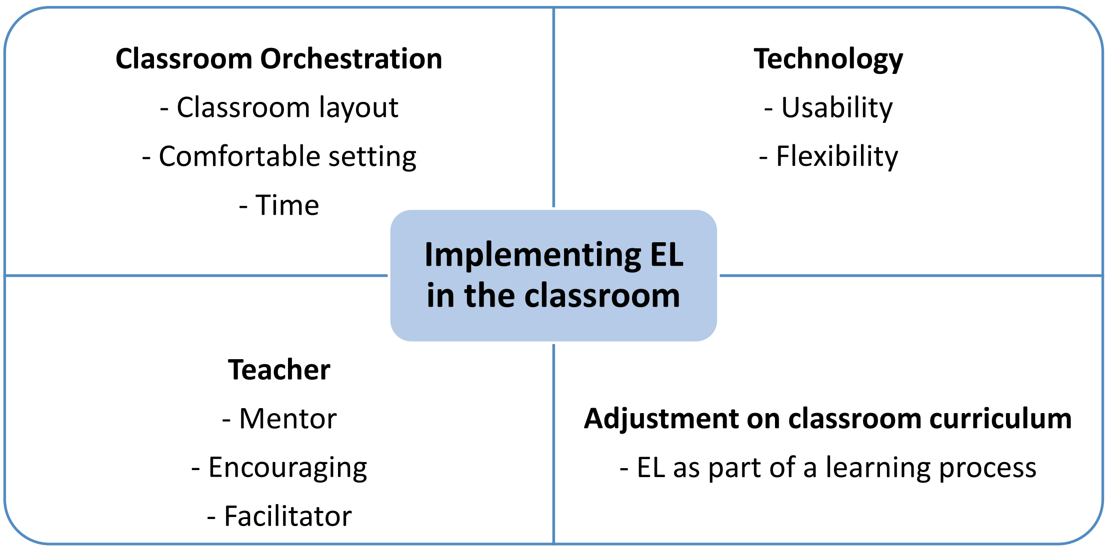


Figure 40: The four key aspects of EL implementation in the classroom

9.4 Limitations

Although the research has reached its aims, some limitations and concerns arose. Our first concern has to do with the generalizability of this research and the applicability of its findings to other areas of education. EL implementations (all the phases in this study) were conducted in primary mainstream classrooms with elementary students for a period of four months maximum. The intervention period was not enough for the researchers to observe all of the students' cognitive, academic, and emotional performance in the classrooms. Thus, in order to determine the longitudinal effects on children, the study should have involved more participants at different educational levels and for more extended periods. However, the dissertation intends only to offer a paradigm for how we can implement EL in elementary schools via specific technologies. There are other ways to achieve EL using different technologies and different methodologies.

Another limitation of this dissertation is that I have only analyzed data from experimental groups and I have no data to report regarding the possible effects on children in conventional classrooms (as control groups). The primary purpose of this research was to suggest some useful advice on the implementation of ways EL could be implemented successfully in a classroom, rather than compare the performance of children in two different groups. The value of EC and EL was taken for granted in this study based on compelling evidence from the recent literature. My aim was to examine how such a practice could become a reality in an authentic classroom environment with documented gains for students. Specifically, I intended to provide evidence on how students can learn and achieve cognitive, academic and emotional benefits using EL.

Furthermore, another limitation of this research was the complexity and messiness of the learning environment. As the research was conducted in real-world classrooms where teaching and learning take place, many variables could not be controlled (Collins, Joseph & Bielaczyc, 2004, p. 19). For this reason, for the scope of this dissertation, I focused only on the variables I was interested in (i.e., cognitive, academic, and emotional outcomes) and addressed specific research questions across the four phases.

Additionally, this study used a commercial suite of learning games. Since the suite was commercial, it might be difficult for other teachers /researchers to purchase the software. However, this was the only commercial motion-based technology used in this study. In an effort to explore alternative, non-commercial technologies for implementing EL, a movement-based intervention was developed in the last phase of the study (see Phase D). This could also be an option for practitioners who want to implement EL in their classrooms but don't have the budgets to purchase expensive technology.

In conclusion, none of these limitations impacted my research significantly. The evidence for a successful and effective EL implementation still holds, whilst these limitations provide scope for the further research suggested in the following section.

9.5 Future Work

Further EL implementations could use the ideas of this dissertation for in-class and out-of-class activities so that learners could explore the benefits of movement-based EC and EL. Future researchers in the area of educational technology and TEL are particularly encouraged to apply an EL approach to authentic learning environments and ecosystems to explore whether movement and EL principles can help meet specific learning goals outside language learning. Future studies based on this research could also investigate the impact of EL activities on different subjects/topics in the curriculum. Researchers should do more experiments to find the effects of EL on higher-order thinking skills

Further research is needed to reach the limitations of the relationship between the body and more abstract representations. More theoretical approaches also need to explain clearly the idea that the body can influence cognition and thus body is necessary for cognitive work. This area needs theory and substantial empirical support of what human bodies are capable of doing for cognitive purposes.

More research is also needed for developing and designing technologies for implementing EL in different educational settings and contexts. Future researchers could examine how digital technologies enable embodied experiences and investigate their role in learning settings (Farr et al., 2012). In this study, the use of motion-based technology was personalized. Children played the game one by one. In the future, it would be useful to design motion-based technologies for engaging the body in classrooms in collaborative ways and for a wider range of participants/students. To this end, the future design should find ways for students to more deeply engage in technology-based EL activities, taking into consideration children's unexpected gestures and postures, their ages and the possibilities for more collaboration. Future research should explore the value added of EL in game-based environments. Some directions are the exploration of how embodied devices can support learning, and how the embodied learning apps can influence the relationship between learner characteristics and game features.

We also need more extensive research to confirm whether the positive impact confirmed by this study will have a long-lasting impact on children's cognitive functioning and, thus if this type of intervention is indeed a new model for teaching. That said, larger-scale studies are still needed to confirm whether or not EL has a long-term positive impact on children's cognitive abilities and academic achievements so as to make it a new model for language learning environments.

Given the initial teacher-reported evidence of skills transfer, future studies would do well to investigate whether any competence developed during the intervention might transfer to other domains. In other words, it is essential to learn if significant gains in the classroom via EL are linked to better skills in real life. Further studies are also necessary to validate the proposed guidelines and implications of EL in other learning contexts, formal and informal.

Furthermore, future research should demonstrate more explicit connections between bodily activity and cognition, providing a better understanding of the value of EL approaches to the educational field. Additional use of technologies, such as biosignal sensors, wearable body sensing equipment, and EEG (to measure brain waves), will also shed more light on the inseparable link between body and brain, and, therefore, inform a richer practical framework for embodied learning.

Finally, researchers and practitioners need to do more research on establishing a comprehensive pedagogical framework based on EC and EL that would revitalize teaching methods and make knowledge more accessible by incorporating sensorimotor abilities into learning curriculum.

9.6 Concluding Remarks

The value of EC for learning is given and proven. Previous bibliographic and empirical research in the area has demonstrated the positive impact of this EL practice on the development of the cognitive and academic performance of children. They have even revealed the impact of this framework on improving the emotional state of children by enhancing their involvement in the learning process and by encouraging their motivation for learning.

This dissertation provided a comprehensive understanding of how EL approaches based on the theoretical framework of EC could be implemented in real learning contexts. The general idea, according to the findings of this study, is that children are embodied learners and that bodily movements help improving students' motor, cognitive and academic performance. Our results offer significant insights for researchers and practitioners eager to explore the possibilities of embodied learning in the classroom. We have clearly demonstrated how an EC framework can be used in as an education tool in an authentic classroom environment and we have provided a set of guidelines and implications for its implementation.

The results of this dissertation come to reinforce the embodied view of learning through empirical data in authentic learning environments. Specifically, the research, through a series of empirical studies in different learning environments, offers a set of guidelines for the implementation of EL in the classroom via technology in order to develop specific cognitive and academic skills, as well as to improve the emotional performance of the students. The research also provides examples of how EL can be implemented in special and general classroom environments, as a personalized intervention as well as class-wide intervention. The fact that the implementation of the research took place in real learning contexts reinforces the significant findings of the study and demonstrates that this theory can be successfully integrated into the classroom offering children opportunities for learning, experimentation, active engagement and enjoyment during the learning process.

Finally, the results of the research can move the discussion in the direction of EdTech and can be the starting point for creating a completed theoretical and methodological model for the implementation of such practices in the school environment as part of the curriculum.

Given the significant results from this almost four-year study, I argue that our technology-based EL paradigm can and should be used in classrooms and that it will improve the student learning experience. At this point, it is crucial for teachers to be aware that they have the opportunity to use movement to help early learners learn, both cognitively and emotionally. We hope this study gives them the incentive they need to take advantage of that opportunity.

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APPENDIX I – List of Relevant Publications

Kosmas, P., Ioannou A., & Retalis, S. (2017). Using embodied learning technology to advance motor performance of children with special educational needs and motor impairments. In É. Lavoué, H. Drachsler, K. Verbert, J. Broisin, M. Pérez-Sanagustín (Eds.), *Data-driven approaches in digital education*. EC-TEL 2017. Lecture Notes in Computer Science, vol 10474. Springer, Cham.

Kosmas, P., Ioannou, A., & Retalis, S. (2018). Moving Bodies to Moving Minds: A Study of the Use of Motion-Based Games in Special Education. *TechTrends*, 1-8.

Kosmas, P., & Zaphiris, P. (2018). Embodied Cognition and Its Implications in Education: An Overview of Recent Literature. World Academy of Science, Engineering and Technology, International Science Index 139, *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, *12* (7), 946 - 952.

Kosmas, P., Ioannou, A., & Zaphiris, P. (2018). Implementing embodied learning in the classroom: Effects on children's memory and language skills. In Valjataga T. & Laanpere M. (eds), *Digital turn in schools: Research, Policy, Practice*. ICEM 2018. Lecture Notes in Computer Science, Springer.

Kosmas, P., & Zaphiris, P. (2019). Moving the Vocabulary: Exploring elementary students' language acquisition through embodied learning in real classrooms. *Innovation in Language Learning and Teaching.* (Under review)

APPENDIX II - Approvals by the Centre of Educational Research and Evaluation

ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΠΟΛΙΤΙΣΜΟΥ

ΔΙΕΥΘΥΝΣΗ ΔΗΜΟΤΙΚΗΣ ΕΚΠΑΙΔΕΥΣΗΣ

Αρ. Φακ.: 7.4.01.3/14
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21 Αυγούστου, 2017

Κύριο Παναγιώτη Κοσμά
Ανεξαρτησίας 94
Κτήριο Ιακωβίδη, 1ος όροφος
3040 Λεμεσός

Θέμα: Άδεια για διεξαγωγή έρευνας με μαθητές και εκπαιδευτικούς δημοτικών σχολείων

Αγαπητέ κύριε Κοσμά,

Έχω οδηγίες να αναφερθώ στη σχετική με το πιο πάνω θέμα αίτησή σας προς το Κέντρο Εκπαιδευτικής Έρευνας και Αξιολόγησης, που υποβλήθηκε στις 11 Ιουλίου 2017, και να σας πληροφορήσω ότι εγκρίνεται το αίτημά σας για διεξαγωγή έρευνας με μαθητές και εκπαιδευτικούς δημοτικών σχολείων που εσείς θα επιλέξετε, με θέμα *«Η εφαρμογή της "Ενσώματης μάθησης" μέσω διάφορων τεχνολογιών που προϋποθέτουν την εμπλοκή του σώματος ή των αισθήσεων στη διαδικασία της μάθησης και συγκεκριμένα στην κατάκτηση της γλώσσας και του εκφραστικού λεξιλογίου»*, την ερχόμενη σχολική χρονιά 2017-2018. Η απάντηση του Κέντρου Εκπαιδευτικής Έρευνας και Αξιολόγησης σας αποστέλλεται συνημμένα, για δική σας ενημέρωση. Θα πρέπει, επίσης, να παρουσιάζετε το Αναλυτικό Σχέδιο Έρευνας, σε περίπτωση που αυτό σας ζητηθεί.

2. Νοείται, βέβαια, ότι πρέπει να εξασφαλιστεί η άδεια των διευθυντών/ διευθυντριών των σχολείων, εκ των προτέρων, ώστε να ληφθούν όλα τα απαραίτητα μέτρα για να μην επηρεαστεί η ομαλή λειτουργία τους. Η έρευνα θα πρέπει να διεξαχθεί με ιδιαίτερα προσεγμένο τρόπο, ώστε να μη θίγεται το έργο των εκπαιδευτικών, το σχολικό περιβάλλον ή οι οικογένειες των μαθητών και όλες οι δραστηριότητες που θα αναπτυχθούν πρέπει να εμπίπτουν μέσα στο πλαίσιο που καθορίζεται από το Αναλυτικό Πρόγραμμα. Οι εκπαιδευτικοί πρέπει να λάβουν μέρος στην έρευνα στον μη διδακτικό τους χρόνο. Η έρευνα θα διεξαχθεί νοουμένου ότι η απώλεια του διδακτικού χρόνου των μαθητών θα περιοριστεί στον ελάχιστο δυνατό βαθμό, ενώ για τη συμμετοχή τους χρειάζεται η **γραπτή** συγκατάθεση των γονιών τους. Οι γονείς πρέπει να γνωρίζουν όλες τις σχετικές λεπτομέρειες για τη διεξαγωγή της έρευνας, καθώς και τα στάδια μέσα από τα οποία θα εξελιχθεί. Σημειώνεται, επίσης, ότι τα πορίσματά σας κρίνεται απαραίτητο να είναι ανώνυμα και οι πληροφορίες που θα συλλέξετε να τηρηθούν απόλυτα εμπιστευτικές και αποκλειστικά και μόνο για τον σκοπό της έρευνας.

3. Η παρούσα έγκριση παραχωρείται με την προϋπόθεση ότι τα πορίσματα της εργασίας, θα κοινοποιηθούν μόλις αυτή ολοκληρωθεί, στη Διεύθυνση Δημοτικής Εκπαίδευσης για σχετική μελέτη και κατάλληλη αξιοποίηση.

Με εκτίμηση,

(Χρίστος Χατζηαθανασίου)
για Γενική Διευθύντρια

Κοιν.: Π.Λ.Ε.
Επαρχιακά Γραφεία Παιδείας

AT/AT EREVNES

Σχόλια για ερευνητικές προτάσεις

Θέμα έρευνας:	Η εφαρμογή της "Ενσώματης μάθησης" μέσω διαφόρων τεχνολογιών που προϋποθέτουν την εμπλοκή του σώματος ή των αισθήσεων στη διαδικασία της μάθησης και συγκεκριμένα στην κατάκτηση της γλώσσας και του εκφραστικού λεξιλογίου.
Κωδικός έρευνας:	133563
Ονοματεπώνυμο Ερευνητή:	Κοσμάς Παναγιώτης
Διεύθυνση στην οποία υποβλήθηκε:	Διεύθυνση Δημοτικής Εκπαίδευσης Διεύθυνση Μέσης Εκπαίδευσης
Ημερομηνία υποβολής στο ΚΕΕΑ:	27/07/2017

1. **Σκοπός -ερευνητικά ερωτήματα/υποθέσεις**

   Δεν υπάρχουν παρατηρήσεις.

2. **Χρησιμότητα-αναγκαιότητα της έρευνας**

   Δεν υπάρχουν παρατηρήσεις.

3. **Διαδικασία συλλογής δεδομένων**

   Δεν υπάρχουν παρατηρήσεις.

4. **Δειγματοληψία**

   Δεν υπάρχουν παρατηρήσεις.

5. **Ερευνητικά εργαλεία**

   Δεν υπάρχουν παρατηρήσεις.

6. **Χρόνος απασχόλησης**

   Δεν υπάρχουν παρατηρήσεις.

7. **Χρονική περίοδος έρευνας και αναμενόμενος χρόνος αποτελεσμάτων**

Δεν υπάρχουν παρατηρήσεις.

8. **Θέματα ηθικής και ερευνητικής δεοντολογίας**

Δεν υπάρχουν παρατηρήσεις.

9. **Εισήγηση ΚΕΕΑ**

Η έρευνα να προχωρήσει ως έχει για υλοποίηση	√
Η έρευνα να προχωρήσει για υλοποίηση, νοουμένου ότι θα γίνουν οι αλλαγές/τροποποιήσεις/εισηγήσεις που επισημαίνονται πιο πάνω	
Η αίτηση για έρευνα να υποβληθεί ξανά αφού ληφθούν υπόψη τα πιο πάνω	

APPENDIX III - Informed Consent Forms

ΈΝΤΥΠΟ ΣΥΓΚΑΤΑΘΕΣΗΣ ΕΚΠΑΙΔΕΥΤΙΚΩΝ

Τίτλος έρευνας: «Η εφαρμογή της Ενσώματης μάθησης μέσω διαφόρων τεχνολογιών που προϋποθέτουν την εμπλοκή του σώματος ή των αισθήσεων στη διαδικασία της μάθησης και συγκεκριμένα στην κατάκτηση της γλώσσας και του εκφραστικού λεξιλογίου». Η συγκεκριμένη έρευνα είναι εγκεκριμένη από το Κέντρο Εκπαιδευτικής Έρευνας και Αξιολόγησης (ΚΕΕΑ) του ΥΠΠ.

Επιστημονικός φορέας: Τεχνολογικό Πανεπιστήμιο Κύπρου

Ερευνητικός υπεύθυνος: Παναγιώτης Κοσμάς

Μέλη ερευνητικής ομάδας: Καθηγητής Παναγιώτης Ζαφείρης (ΤΕΠΑΚ)

Θέματα ηθικής και ερευνητικής δεοντολογίας:
α) Η συμμετοχή στην έρευνα είναι εθελοντική και οι εκπαιδευτικοί μπορούν να αποχωρήσουν οποιαδήποτε στιγμή χωρίς συνέπειες.
β) Τα δεδομένα που θα συλλεγούν θα χρησιμοποιηθούν μόνο για σκοπούς της συγκεκριμένης έρευνας και θα ληφθούν όλα τα απαραίτητα μέτρα για την ασφαλή φύλαξη των δεδομένων της έρευνας.
γ) Θα διασφαλιστεί η ανωνυμία των συμμετεχόντων/ουσών εκπαιδευτικών.
δ) Οι συνεντεύξεις με τους εκπαιδευτικούς θα μαγνητοσκοπηθούν και τα δεδομένα θα χρησιμοποιηθούν μόνο για τους σκοπούς της συγκεκριμένης έρευνας.
ε) Σε περίπτωση δημοσιοποίησης των αποτελεσμάτων της έρευνας δεν θα γίνει αναφορά στα ονόματα των σχολείων και των εκπαιδευτικών που συμμετείχαν.

Υπογράφοντας το παρόν έγγραφο δηλώνετε τη συναίνεσή σας για συμμετοχή στην επιστημονική έρευνα, και αναγνωρίζετε ότι όλες οι πιο πάνω πληροφορίες σας γνωστοποιήθηκαν προφορικώς και ότι συμφωνείτε εθελοντικά να συμμετάσχετε σε αυτήν.

<u>ΔΗΛΩΣΗ ΣΥΜΜΕΤΟΧΗΣ</u>

Ονοματεπώνυμο:………………………………………………………………………

Υπογραφή: ……………………………………

Ημερομηνία: ………………………………….

ΈΝΤΥΠΟ ΣΥΓΚΑΤΑΘΕΣΗΣ ΓΟΝΕΩΝ/ΚΗΔΕΜΟΝΩΝ

Τίτλος έρευνας: «Η εφαρμογή της Ενσώματης μάθησης μέσω διαφόρων τεχνολογιών που προϋποθέτουν την εμπλοκή του σώματος ή των αισθήσεων στη διαδικασία της μάθησης και συγκεκριμένα στην κατάκτηση της γλώσσας και του εκφραστικού λεξιλογίου». Η συγκεκριμένη έρευνα είναι εγκεκριμένη από το Κέντρο Εκπαιδευτικής Έρευνας και Αξιολόγησης (ΚΕΕΑ) του ΥΠΠ.

Επιστημονικός φορέας: Τεχνολογικό Πανεπιστήμιο Κύπρου

Για τη συγκεκριμένη ερευνητική δράση λαμβάνονται όλα τα σχετικά μέτρα που αφορούν την ορθή λειτουργία του σχολείου και της τάξης καθώς και τα αντίστοιχα μέτρα για τη διαφύλαξη των προσωπικών δεδομένων των συμμετεχόντων μαθητών.

Θέματα ηθικής και ερευνητικής δεοντολογίας:

α) Η συμμετοχή στην έρευνα είναι εθελοντική και τα παιδιά μπορούν να αποχωρήσουν οποιαδήποτε στιγμή χωρίς συνέπειες.

β) Η έρευνα προϋποθέτει τη σύμφωνη γνώμη του παιδιού ανεξάρτητα από το αν ο/η γονέας/κηδεμόνας έχει δώσει τη συγκατάθεσή του/της για τη συμμετοχή του παιδιού.

γ) Τα δεδομένα που θα συλλεγούν θα χρησιμοποιηθούν μόνο για σκοπούς της συγκεκριμένης έρευνας και θα ληφθούν όλα τα απαραίτητα μέτρα για την ασφαλή φύλαξη των δεδομένων της έρευνας.

δ) Θα διασφαλιστεί η ανωνυμία των συμμετεχόντων/ουσών (τα ερωτηματολόγια θα είναι ανώνυμα).

ε) Το όνομα του παιδιού και η ηλικία του θα συμπληρωθεί σε κάποια έντυπα αλλά δεν θα χρησιμοποιηθούν πουθενά παρά μόνο για ερευνητικούς σκοπούς.

στ) Κατά τη διάρκεια της έρευνας θα γίνει μαγνητοφώνηση/βιντεοσκόπηση και η χρήση των δεδομένων θα γίνει μόνο για τους σκοπούς της συγκεκριμένης έρευνας.

ΔΗΛΩΣΗ ΣΥΜΜΕΤΟΧΗΣ

Συναινώ στη συμμετοχή του/της μαθητή/μαθήτριας ………………………………… της τάξης ……………………….. στην πιο πάνω ερευνητική δραστηριότητα που πρόκειται να πραγματοποιηθεί στο σχολείο.

Ονοματεπώνυμο γονέα/κηδεμόνα: ……………………………………………………

Υπογραφή γονέα/κηδεμόνα: …………………………………………….

Ημερομηνία: ………………………

APPENDIX IV – Psychometric and Assessment Tests

ΚΡΙΤΗΡΙΟ ΓΝΩΣΤΙΚΗΣ ΕΠΑΡΚΕΙΑΣ

ΓΙΑ ΠΑΙΔΙΑ ΚΑΙ ΕΦΗΒΟΥΣ

Ατομικό Φυλλάδιο Εξέτασης

Όνομα:		Αγόρι □	Κορίτσι □
User ID:	Έτος	Μήνας	Ημέρα
Σχολείο		Τάξη	

ΑΝΑΚΛΗΣΗ ΛΕΞΕΩΝ

Ερώτημα	Βαθμός	Απάντηση
1	2	Προσπάθεια 1 Πιρούνι δ
	0 1	Προσπάθεια 2
2	2	Προσπάθεια 1 Ήλιος δ
	0 1	Προσπάθεια 2
3	0 1	Μπουκάλι
Παράδειγμα Α		Ομπρέλα – Πιρούνι δ
4	2	Προσπάθεια 1 Γάτα – Μπουκάλι δ
	0 1	Προσπάθεια 2
5	2	Προσπάθεια 1 Ήλιος – Πιρούνι δ
	0 1	Προσπάθεια 2
6	0 1	Μπουκάλι – Ομπρέλα
7	0 1	Ήλιος – Πιρούνι - Ομπρέλα
8	0 1	Ομπρέλα – Γάτα – Ήλιος
9	0 1	Πιρούνι – Μπουκάλι – Γάτα
10	0 1	Μπουκάλι – Γάτα – Ήλιος – Ομπρέλα
11	0 1	Ομπρέλα – Ήλιος – Μπουκάλι – Πιρούνι
12	0 1	Αστέρι – Λουλούδι – Ψάρι – Μάτι

13	0	1	Ψάρι – Πόδι – Καπέλο – Βιβλίο
14	0	1	Ψάρι – Βιβλίο – Καπέλο – Αστέρι – Πόδι
15	0	1	Καπέλο – Λουλούδι – Βιβλίο – Μάτι – Αστέρι
16	0	1	Λουλούδι – Ψάρι – Βιβλίο – Πόδι – Μάτι
17	0	1	Πόδι – Μάτι – Αστέρι – Λουλούδι – Ψάρι – Βιβλίο
18	0	1	Βιβλίο – Ψάρι – Καπέλο – Λουλούδι – Πόδι - Μάτι
Παράδειγμα Β			Πόδι – Καπέλο δ (εκθέστε την κάρτα χρωμάτων)
19	0	1	Βιβλίο – Αστέρι (εκθέστε 2 σειρές χρωμάτων)
20	0	1	Λουλούδι – Πό ι (3 σειρές)
21	0	1	Αστέρι – Λουλούδι – Πόδι (2 σειρές)
22	0	1	Μάτι – Καπέλο – Πόδι (4 σειρές)
23	0	1	**Ψάρι – Βιβλίο - Λουλούδι**
24	0	1	**Ψάρι – Λουλούδι – Βιβλίο - Πόδι**
25	0	1	**Αστέρι – Ψάρι – Πόδι - Λουλούδι**
26	0	1	**Ψάρι – Καπέλο – Μάτι – Πόδι – Βιβλίο**
27	0	1	**Πόδι – Αστέρι – Λουλούδι – Βιβλίο – Ψάρι**

Γενική Βαθμολογία

(μέγιστη βαθμολογία: 31)

Ανάκληση Λέξεων: Ποιοτικοί Δείκτες

-Διάσπαση λόγω τεχνικής παρεμβολής

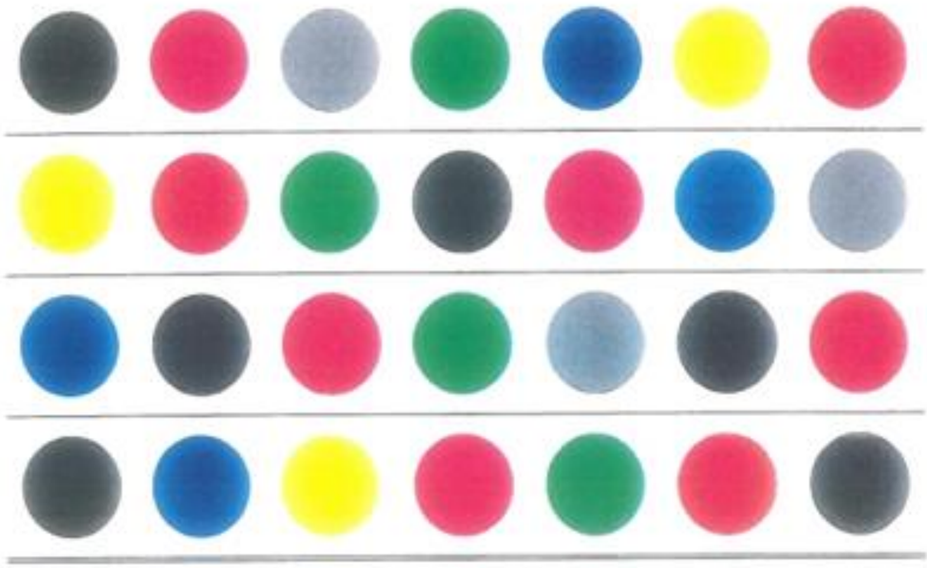
-Αδυναμία συγκέντρωσης προσοχής

-Απαντά παρορμητικά

-Ορθή αναγνώριση λέξεων σε διαφορετική σειρά

+Υψηλός βαθμός συγκέντρωσης

+Γρήγορες και σωστές απαντήσεις



Δοκιμασία Εκφραστικού Λεξιλογίου

Ι. Βογινδρούκας, Α. Πρωτόπαπας, Γ. Σιδερίδης

Ελληνική έκδοση του Word Finding Vocabulary Test (Renfrew, 1995)

Έντυπο βαθμολόγησης

Ονοματεπώνυμο: ....

Ημερομηνία γέννησης: ....

Ημερομηνία εξέτασης: ....

Αρχικός βαθμός: .... Αναπτυξιακή ηλικία: .... Εκατοστημόριο: ....

Παρατηρήσεις:

#		0/1	#		0/1
1	Κλειδί		26	Ρακέτα	
2	Φίδι		27	Θερμόμετρο	
3	Φεγγάρι		28	Φλιτζάνι	
4	Κρεμάστρα		29	Άγκυρα	
5	Παράθυρο		30	Σέλα	
6	Κλόουν		31	Ανανάς	
7	Χαρταετός		32	Τρυπάνι	
8	Πάπια		33	Λαχανικά	
9	Μπλούζα		34	Βίδα	
10	Μανίκι		35	Χάρτης	
11	Κιθάρα		36	Βιολί	
12	Ζάρια		37	Κεραία	
13	Σαλιγκάρι		38	Σκιάχτρο	
14	Ελικόπτερο		39	Κοσμήματα	
15	Κουκουβάγια		40	Μαγνήτης	
16	Γοργόνα		41	Γαλλικό κλειδί / κάβουρας	
17	Κροκόδειλος		42	Κάμπια	
18	Δάχτυλο		43	Αλεξίπτωτο	
19	Καμήλα		44	Φάρος	
20	Κιάλια		45	Πυξίδα	
21	Καγκουρό		46	Ιγκλού	
22	Ποτιστήρι		47	Κυψέλη	
23	Κολιέ		48	Νάρθηκας / επίδεσμος	
24	Βέλος		49	Δοξάρι	
25	Μικρόφωνο		50	Τρούλος	

Σύνολο:

Πίνακας 4. *Συντελεστές αξιολόγησης της συμπεριφοράς των λέξεων της Δοκιμασίας Εκφραστικού Λεξιλογίου με τη μέθοδο Rasch.*

Λέξη	Δυσκολία	Δείκτης InFit	Δείκτης OutFit	Συσχέτιση με Σύνολο
1	-5.57	1.50	**2.12**	0.22
2	-5.84	0.89	0.39	0.33
3	-4.42	1.02	1.22	0.38
4	-2.20	1.19	1.52	0.43
5	-3.26	1.20	**3.68**	0.33
6	-2.26	1.09	1.44	0.47
7	-1.52	1.15	1.06	0.49
8	-2.88	1.47	**4.05**	0.22
9	-2.28	1.43	**4.38**	0.28
10	-0.98	1.23	1.50	0.46
11	-2.55	1.06	1.67	0.46
12	-1.95	1.03	0.88	0.52
13	-3.05	0.96	1.91	0.46
14	-1.86	1.18	1.28	0.45
15	-2.63	0.88	**2.96**	0.51
16	-2.18	0.90	1.12	0.53
17	-2.28	1.10	1.52	0.45
18	-2.28	0.93	1.12	0.52
19	-1.08	1.01	0.96	0.56
20	-0.70	0.95	0.86	0.59
21	-0.98	0.90	0.77	0.61
22	-1.19	0.84	0.68	0.63
23	-0.38	1.20	1.30	0.48
24	-0.10	1.21	1.30	0.48
25	-0.45	1.03	1.04	0.56
26	0.06	0.92	0.80	0.61
27	0.64	1.11	1.03	0.52
28	1.25	1.28	1.33	0.41
29	0.18	0.80	0.66	0.66
30	0.62	0.92	0.76	0.60
31	0.04	0.78	0.64	0.67
32	0.83	0.95	0.82	0.58
33	0.58	0.99	0.94	0.57
34	0.69	0.95	0.83	0.58
35	0.59	0.80	0.69	0.64
36	1.16	0.87	0.71	0.60
37	1.81	0.93	0.69	0.53
38	1.05	0.74	0.54	0.65
39	2.33	0.99	0.65	0.48
40	2.53	0.88	0.50	0.50
41	4.25	0.95	0.61	0.30
42	2.24	1.06	0.71	0.46
43	3.51	0.93	0.58	0.38
44	2.23	0.69	0.39	0.60
45	2.86	0.72	0.34	0.53
46	3.51	0.77	0.32	0.45
47	4.62	0.91	0.34	0.30
48	4.40	0.98	0.42	0.30
49	5.79	1.04	0.81	0.13
50	7.08	0.94	0.08	0.13

Σημείωση: *Με έντονα στοιχεία εμφανίζονται δείκτες προσαρμογής μεγαλύτεροι του 2.*

Ποσοστιαίες Τιμές (εκατοστημόρια)

Πίνακας 5. *Ποσοστιαίες τιμές του αρχικού βαθμού της Δοκιμασίας Εκφραστικού Λεξιλογίου κατά ηλικιακή ομάδα.*

Εκατοστημόριο	4:0-4:5	4:6-5:0	5:1-6:0	6:1-7:0	7:1-8:0
5	3	7	11	15	17
10	8	12	14	19	23
20	12	15	20	22	27
30	14	19	23	28	30
40	16	20	26	30	32
50	17	22	28	32	34
60	20	25	30	33	36
70	21	27	31	35	38
80	24	29	34	37	40
90	28	33	36	39	42
95	30	36	38	40	44

Πίνακας 6. *Ποσοστιαίες τιμές του αρχικού βαθμού της Δοκιμασίας Εκφραστικού Λεξιλογίου για τα* ***αγόρια****.*

Εκατοστημόριο	4:0-4:5	4:6-5:0	5:1-6:0	6:1-7:0	7:1-8:0
5	2	11	11	15	23
10	8	13	14	16	27
20	10	15	18	22	29
30	14	19	26	28	30
40	15	21	27	30	32
50	18	26	30	32	36
60	20	27	31	35	37
70	22	28	34	37	39
80	24	30	35	38	41
90	28	34	38	39	43
95	29	38	42	43	45

Πίνακας 7. *Ποσοστιαίες τιμές του αρχικού βαθμού της Δοκιμασίας Εκφραστικού Λεξιλογίου για τα* ***κορίτσια****.*

Εκατοστημόριο	4:0-4:5	4:6-5:0	5:1-6:0	6:1-7:0	7:1-8:0
5	5	5	4	17	16
10	8	8	15	19	19
20	12	14	20	23	26
30	15	18	22	27	28
40	16	20	25	29	30
50	17	21	26	32	33
60	20	23	28	33	35
70	21	25	30	34	36
80	24	26	32	36	39
90	28	31	34	39	41
95	31	35	36	39	42

Πίνακας 8. *Ισοδυναμίες αναπτυξιακής ηλικίας κατά φύλο.*

Αγόρια	Αρχικός βαθμός	Κορίτσια
3:4	14	3:8
3:6	15	3:9
3:7	16	3:11
3:9	**17**	**4:1**
3:11	**18**	**4:3**
4:1	**19**	**4:5**
4:3	**20**	**4:8**
4:5	**21**	**4:10**
4:7	**22**	**5:0**
4:9	**23**	**5:3**
5:0	**24**	**5:6**
5:2	**25**	**5:8**
5:5	**26**	**5:11**
5:7	**27**	**6:2**
5:10	**28**	**6:5**
6:1	**29**	**6:8**
6:4	**30**	**7:0**
6:7	**31**	**7:3**
6:10	**32**	**7:7**
7:1	**33**	**7:11**
7:5	**34**	8:2
7:9	**35**	8:7
8:0	**36**	8:11
8:4	37	9:3
8:8	38	9:8
9:1	39	10:1

Αναπτυξιακές ηλικίες

Ισοδύναμες αναπτυξιακές ηλικίες εκφραστικού λεξιλογίου, κατά φύλο, για κάθε αρχικό βαθμό μεταξύ 10 και 35. Οι αναπτυξιακές ηλικίες δίνονται κατά προσέγγιση και η ακρίβειά τους είναι περιορισμένη, καθώς το εύρος αναμενόμενης απόκλισης δεν μπορεί να είναι μικρότερο από τη διαφορά διαδοχικών εκτιμήσεων, δηλαδή 3 μήνες.

Με έντονους χαρακτήρες σημειώνεται η περιοχή τιμών που αντιπροσωπεύεται στο δείγμα στάθμισης. Τιμές έξω από αυτήν την περιοχή παρέχονται για χρήση με πολύ μεγάλη επιφύλαξη διότι δεν είναι γνωστό το σχήμα της καμπύλης αντιστοίχισης έξω από το εύρος της δειγματοληψίας. Η ανάπτυξη του εκφραστικού λεξιλογίου ενδέχεται να ακολουθεί διαφορετικούς ρυθμούς μέσα στο εύρος ηλικιών που εξετάστηκαν απ' ό,τι σε μικρότερες ή μεγαλύτερες ηλικίες.

Η χρήση του πίνακα αυτού πρέπει να γίνεται με ιδιαίτερη προσοχή, λόγω των σημαντικών περιορισμών που έχουν διαπιστωθεί αναφορικά με τη χρήση των ισοδυναμιών ηλικίας. Για παράδειγμα, αν ένα αγόρι ηλικίας 4 ετών λάβει αρχικό βαθμό 27 στη δοκιμασία εκφραστικού λεξιλογίου αυτό δεν σημαίνει ότι είναι στα ίδια επίπεδα με ένα μέσο αγόρι ηλικίας επτά ετών σε οτιδήποτε άλλο πέραν της κατονομασίας απεικονίσεων.

Η ερμηνεία των ισοδυναμιών αναπτυξιακής ηλικίας πρέπει να γίνεται με πάρα πολύ μεγάλη επιφύλαξη, λαμβάνοντας υπόψη τη φυσιολογική διακύμανση των επιδόσεων, ώστε να αποφεύγονται παραπλανητικά συμπεράσματα. Πρέπει να λαμβάνεται υπόψη ότι η τυπική απόκλιση στους αρχικούς βαθμούς των ηλικιακών ομάδων είναι περίπου 8 μονάδες (βλ. Πίνακα 2), οι οποίες αντιστοιχούν σε διαφορά μέσης επίδοσης ενός έως δύο ετών, ανάλογα με την ηλικία (Πίνακας 8). Άρα, σε ένα παιδί μέσης επίδοσης για την ηλικία του, εντός μιας τυπικής απόκλισης από το μέσο όρο της ηλικιακής ομάδας του, μπορεί να αντιστοιχεί ισοδύναμη αναπτυξιακή ηλικία μέχρι και δύο ολόκληρα χρόνια λιγότερα ή περισσότερα από τη χρονολογική ηλικία του, χωρίς αυτό να αποτελεί λόγο ανησυχίας. Με άλλα λόγια, διαφορές ισοδύναμης αναπτυξιακής ηλικίας μικρότερες από δύο έτη μπορεί να είναι κλινικά ασήμαντες και δεν πρέπει να αξιολογούνται διαγνωστικά χωρίς να συνεκτιμώνται άλλοι παράγοντες της κλινικής εκτίμησης.

Όνομα /Τάξη:

Βλέπω την κίνηση του PanBoy και γράφω τη λέξη στο κουτάκι

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APPENDIX V - Students' Attitudinal Scale

Διάλεξε την απάντηση που ταιριάζει περισσότερο.

Α/Α	Ερώτηση	Όχι καθόλου	Λίγο	Αρκετά	Πάρα πολύ	Δεν ξέρω/Δεν απαντώ
1.	Σου άρεσε που έκανες το μάθημα με αυτό τον τρόπο; (Did you like the lesson in this way?)	☺	☺	☺	☺	☺
2.	Πιστεύεις ότι το μάθημα με τη βοήθεια αυτών των τεχνολογιών έγινε πιο διασκεδαστικό; (Do you think that your lessons became funny?	☺	☺	☺	☺	☺
3.	Πιστεύεις ότι με αυτό τον τρόπο έμαθες πιο πολλά πράγματα; (Do you think that you learn more things in this way?)	☺	☺	☺	☺	☺
4.	Είχες δυσκολία στο τι έπρεπε να κάνεις κατά τη διάρκεια του μαθήματος; (Do you encounter difficulties?)	☺	☺	☺	☺	☺
5.	Σου άρεσε που έκανες κινήσεις με τα χέρια και το σώμα σου; (Did you like do activities using body movements in and hands?					

APPENDIX VI - Semi-structured Interview Protocol

Thank you for your participation in this interview. We would like to hear your ideas and opinions about your experiences during this intervention period**.**

WHAT IS SAID IN THIS ROOM STAYS HERE. Although the interview will be videotaped, your responses will remain confidential. We don't identify anyone by name in our report. You will remain anonymous.

The interview will last 30 minutes. You can choose not to participate. You can interrupt or stop the conversation whenever you want.

Questions in Phase A, B and C

Προσωπικά στοιχεία – πληροφορίες

Εκπαιδευτικό υπόβαθρο (πτυχίο, μεταπτυχιακό κτλ.)

Χρόνια υπηρεσίας στην εκπαίδευση.

ΜΕΡΟΣ Α - Η εμπλοκή των παιδιών στην έρευνα σε σχέση με τις τεχνολογίες.

1. Συναισθηματική κατάσταση των παιδιών κατά τη διάρκεια της παρέμβασης (θετικά/αρνητικά συναισθήματα, επιζητούσαν τα kinems; βαριόντουσαν;)

2. Η συγκέντρωση και η προσοχή των παιδιών πώς ήταν;

3. Η επίδοση τους από τη μια συνεδρία στην άλλη; (υπήρχε βελτίωση, στασιμότητα…)

4. Τα παιδιά είχαν ενεργό συμμετοχή στη διαδικασία του μαθήματος; Αυξήθηκε η συμμετοχή τους με αφορμή τα παιχνίδια kinems;

5. Δυσκολεύτηκαν τα παιδιά να κάνουν τις κινήσεις που έπρεπε;

6. Σε τι τους βοήθησε η ενασχόλησή τους με το unboxit?

7. Νομίζετε ότι βοηθά στη μνήμη;

8. Το lexis σε τι βοηθά τα παιδιά; Μάθαιναν νέες λέξεις

9. Το zoko write?

10. Υπήρχαν και παιδιά που είχαν κινητικά προβλήματα; Πώς το χειριστήκατε;

11. Πιστεύετε ότι αυτά τα παιχνίδια βοηθάνε τα παιδιά να κατακτήσουν τη γλώσσα; Με ποιο τρόπο;

12. Πώς έπαιζαν όλοι μαζί στην τάξη; Ήταν εύκολο ή δύσκολο;

13. Παρατηρήσατε κάποιου είδους συνεργασία;

14. Από την εμπειρία σας ως εκπαιδευτικός, εφαρμόζατε παρόμοιες δραστηριότητες που να εμπλέκουν το σώμα και τις αισθήσεις των παιδιών στο μάθημα της γλώσσας;

15. Αν ναι, ποιες; Με τη χρήση τεχνολογίας ή χωρίς;

16. Πιστεύετε ότι έχει κάποια προστιθέμενη αξία η εμπλοκή του σώματος και της κίνησης στη διαδικασία της μάθησης; Εξηγήστε.

17. Έχουν εκφράσει την επιθυμία να συνεχίσουν να κάνουν το μάθημα με αυτό τον τρόπο;

18. Ποιο/Ποια από τα παιδιά φαίνεται να είχε τη μεγαλύτερη θετική επίδραση από την εμπλοκή του σε αυτή τη διαδικασία; Επιλέξτε 1 ή 2 παιδιά.

19. Αντιμετωπίστηκαν προβλήματα κατά τη διάρκεια των εκπαιδευτικών συνεδριών;

20. Θεωρείτε ότι το εκπαιδευτικό σύστημα της Κύπρου θα μπορούσε να εισαγάγει τέτοιες καινοτόμες μεθόδους στο αναλυτικό πρόγραμμα των σχολείων;

21. Θα θέλατε να υπήρχε ένα πρόγραμμα με συγκεκριμένες οδηγίες/στρατηγικές για το πώς να εφαρμόσετε τέτοιου είδους παρεμβάσεις που να εμπλέκουν σώμα, τεχνολογία και μάθηση νέων λέξεων;

22. Σε ποιες περιπτώσεις μπορεί να εφαρμοστεί αυτή η μέθοδος;

23. Τι πιστεύετε ότι χρειάζονται τα παιδιά για να κατακτήσουν με μεγαλύτερη ευκολία και πιο αποτελεσματικά τη γλώσσα και να εμπλουτίσουν το λεξιλόγιό τους;

24. Τι έχετε να προτείνετε για τη βελτίωση της μεθόδου;

Questions in Phase D

Προσωπικά στοιχεία – πληροφορίες

Εκπαιδευτικό υπόβαθρο (πτυχίο, μεταπτυχιακό κτλ.)

Χρόνια υπηρεσίας στην εκπαίδευση.

ΜΕΡΟΣ Α - Η εμπλοκή των παιδιών με τον PanBoy.

1. Συναισθηματική κατάσταση των παιδιών κατά τη διάρκεια της παρέμβασης (θετικά/αρνητικά συναισθήματα, επιζητούσαν τον PanBoy; βαριόντουσαν;)

2. Η συγκέντρωση και η προσοχή των παιδιών πώς ήταν;

3. Η επίδοση τους από τη μια συνεδρία στην άλλη; (υπήρχε βελτίωση, στασιμότητα…)

4. Τα παιδιά είχαν ενεργό συμμετοχή στη διαδικασία του μαθήματος; Αυξήθηκε η συμμετοχή τους με αφορμή τις κινήσεις του PanBoy;

5. Πώς αντιμετώπισαν τα παιδιά το γεγονός ότι μάθαιναν νέες λέξεις αξιοποιώντας το σώμα τους;

6. Δυσκολεύτηκαν τα παιδιά να κάνουν τις κινήσεις που έπρεπε;

7. Πώς πιστεύετε ότι βοήθησε τα παιδιά να εμπλουτίσουν το λεξιλόγιό τους και να κατακτήσουν τη γλώσσα (προφορικά αλλά και γραπτά);

8. Βοηθάει καθόλου στη μνήμη πιστεύετε; Αν ναι, πώς;

9. Από την εμπειρία σας ως εκπαιδευτικός, εφαρμόζατε παρόμοιες δραστηριότητες που να εμπλέκουν το σώμα και τις αισθήσεις των παιδιών στο μάθημα της γλώσσας;

10. Αν ναι, ποιες; Με τη χρήση τεχνολογίας ή χωρίς;

11. Πιστεύετε ότι έχει κάποια προστιθέμενη αξία η εμπλοκή του σώματος και της κίνησης στη διαδικασία της μάθησης; Εξηγήστε.

12. Ποια ήταν τα σχόλια των παιδιών; Τι τους άρεσε; Τι δεν τους άρεσε;

13. Έχουν εκφράσει την επιθυμία να συνεχίσουν να κάνουν το μάθημα με αυτό τον τρόπο;

14. Ποιο/Ποια από τα παιδιά φαίνεται να είχε τη μεγαλύτερη θετική επίδραση από την εμπλοκή του σε αυτή τη διαδικασία; Επιλέξτε 1 ή 2 παιδιά.

15. Αντιμετωπίστηκαν προβλήματα κατά τη διάρκεια των εκπαιδευτικών συνεδριών;

16. Θεωρείτε ότι το εκπαιδευτικό σύστημα της Κύπρου θα μπορούσε να εισαγάγει τέτοιες καινοτόμες μεθόδους στο αναλυτικό πρόγραμμα των σχολείων;

17. Θα θέλατε να υπήρχε ένα πρόγραμμα με συγκεκριμένες οδηγίες/στρατηγικές για το πώς να εφαρμόσετε τέτοιου είδους παρεμβάσεις που να εμπλέκουν σώμα, τεχνολογία και μάθηση νέων λέξεων;

18. Σε ποιες περιπτώσεις μπορεί να εφαρμοστεί αυτή η μέθοδος; Τι χρειάζεται από πριν;

19. Τι πιστεύετε ότι χρειάζονται τα παιδιά για να κατακτήσουν με μεγαλύτερη ευκολία και πιο αποτελεσματικά τη γλώσσα και να εμπλουτίσουν το λεξιλόγιό τους;

20. Τι έχετε να προτείνετε για τη βελτίωση της μεθόδου;

APPENDIX VII – Observation Protocol

ΠΡΩΤΟΚΟΛΛΟ ΠΑΡΑΤΗΡΗΣΗΣ

Όνομα εκπαιδευτικού/παρατηρητή:

Όνομα παιδιού: **Ηλικία παιδιού/ Τάξη:**

Ημερομηνία:

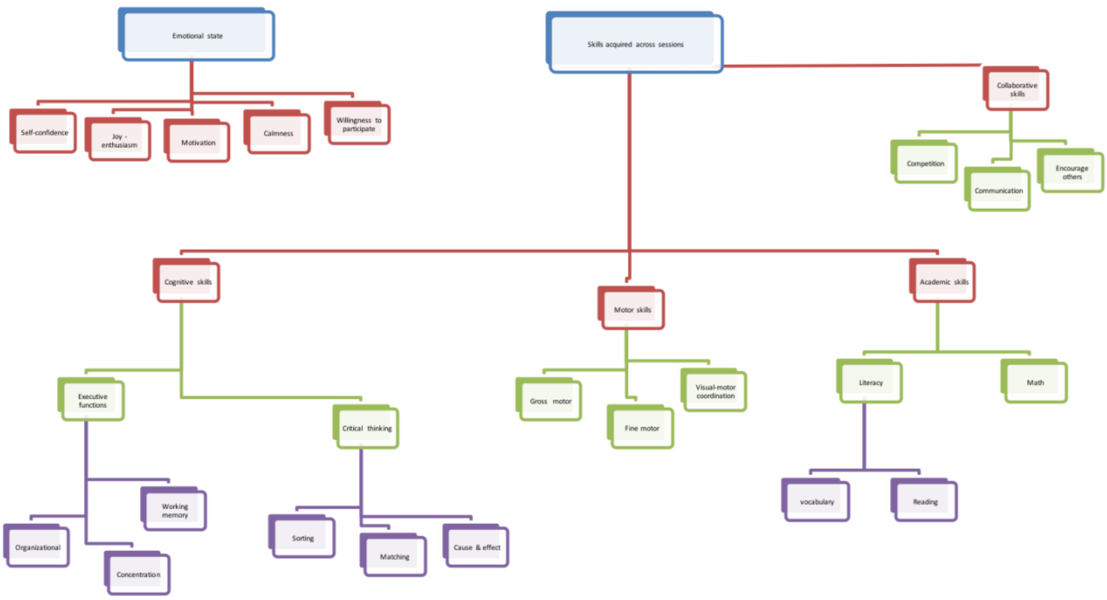
1 = καθόλου 2 = λίγο 3 = αρκετά 4 = πολύ 5 = πάρα πολύ

1.Έναρξη του παιχνιδιού	**Παρατηρήθηκε σε κλίμακα ...**	**Σχόλια και παρατηρήσεις**
Το παιδί εντάσσεται γρήγορα στο μάθημα	1 2 3 4 5	
Το παιδί χρειάζεται βοήθεια για να συμμετέχει	1 2 3 4 5	
Το παιδί χρειάζεται ενθάρρυνση	1 2 3 4 5	
Το παιδί παρουσιάζει πρωτοβουλία ή περιέργεια	1 2 3 4 5	
Το παιδί κατευθύνεται μόνο του	1 2 3 4 5	
Το παιδί δεν μπορεί να ανταποκριθεί στη διαδικασία	1 2 3 4 5	
Το παιδί συμμετέχει με σταθερό ρυθμό	1 2 3 4 5	
Καθώς προχωρά το μάθημα, το παιδί δείχνει περισσότερο ενθουσιασμό	1 2 3 4 5	

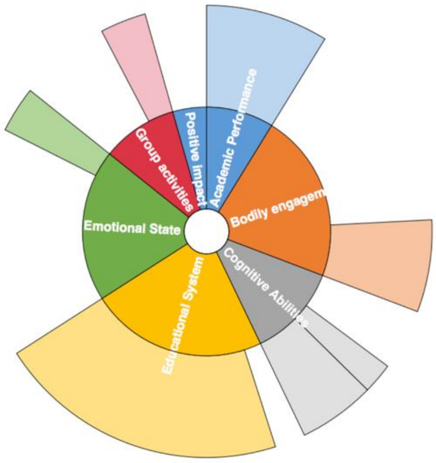
Το παιδί κάνει συντονισμένες και σωστές κινήσεις	1 2 3 4 5	
Το παιδί φαίνεται απαθές και αδιάφορο	1 2 3 4 5	
Το παιδί διατηρεί την προσοχή του	1 2 3 4 5	
Το παιδί αποσπάται εύκολα	1 2 3 4 5	
Το παιδί εξωτερικεύει τις σκέψεις του (π.χ., μιλά μεγαλόφωνα)	1 2 3 4 5	
Το παιδί δείχνει θετικά συναισθήματα για τις δραστηριότητες	1 2 3 4 5	
Οι τεχνολογίες που αξιοποιούνται είναι κατάλληλες για την ηλικία του παιδιού	1 2 3 4 5	

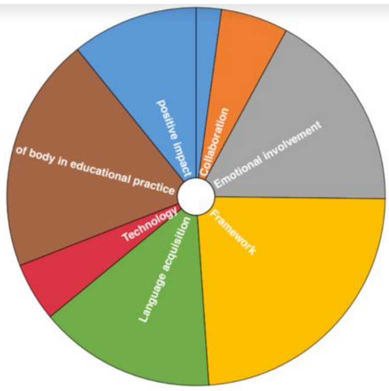
APPENDIX VIII – Qualitative Results

Coding results – Study 1, Study 2



Coding results – Study 3, Study 4





Name	Memo Link	Sources	References	Created On	Created By
Academic Performance		0	0	3 Jan 2018, 17:09:25	PK
Vocabulary acquisition		4	8	3 Jan 2018, 16:04:10	PK
Bodily engagement		4	14	3 Jan 2018, 16:00:57	PK
Movement		3	6	3 Jan 2018, 16:15:09	PK
Cognitive Abilities		2	4	3 Jan 2018, 15:56:03	PK
Learning Difficulties		2	2	3 Jan 2018, 16:09:45	PK
Memory		4	5	3 Jan 2018, 15:57:42	PK
Educational System		2	2	3 Jan 2018, 16:02:08	PK
Framework		4	19	3 Jan 2018, 16:03:14	PK

Emotional State		5	15	3 Jan 2018, 15:54:50	PK
Motivation		2	3	3 Jan 2018, 16:06:40	PK
Group activities		3	6	3 Jan 2018, 16:00:09	PK
Collaboration		2	3	3 Jan 2018, 16:15:28	PK
Positive impact		1	4	3 Jan 2018, 16:28:55	PK

Name	Memo Link	Sources	References	Created On	Created By
Cognition		3	3	3 Jan 2018, 17:56:22	PK
Technology		4	5	3 Jan 2018, 17:59:43	PK
Interaction		2	2	3 Jan 2018, 18:05:48	PK
Collaboration		4	8	3 Jan 2018, 17:51:02	PK
positive impact		6	15	3 Jan 2018, 17:56:50	PK
Emotional involvement		6	18	3 Jan 2018, 17:49:53	PK
Motivation		5	6	3 Jan 2018, 18:00:29	PK
Language acquisition		6	21	3 Jan 2018, 18:01:42	PK
The use of body in educational practice		6	26	3 Jan 2018, 17:52:39	PK

Experiential participation		2	2	3 Jan 2018, 18:20:17	PK
Framework		6	33	3 Jan 2018, 17:55:37	PK

APPENDIX IX – Statistical Results

Psychometric pre-post testing – Study 3

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest	15,04	52	3,731	,517
	PostTest	19,00	52	4,097	,568

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreTest & PostTest	52	,793	,000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PreTest - PostTest	-3,962	2,543	,353	-4,670	-3,253	-11,232	51	,000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest	17,40	52	9,075	1,259
	PostTest	19,92	52	8,851	1,227

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreTest & PostTest	52	,976	,000

Paired Samples Test

		Paired Differences			
					95% Confidence Interval of the Difference
		Mean	Std. Deviation	Std. Error Mean	Lower
Pair 1	PreTest - PostTest	-2,519	1,975	,274	-3,069

Paired Samples Test

		Paired Differences	t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	PreTest - PostTest	-1,969	-9,197	51	,000

Psychometric pre-post testing – Study 4

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRE	22,57	118	8,722	,803
	POST	28,64	118	9,678	,891

Cohen's *d* = (28.64 - 22.57) ⁄ 9.212409 = 0.658894.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PRE & POST	118	,848	,000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	PRE - POST	-6,076	5,161	,475	-7,017	-5,135	-12,789	117	,000

Correlations

		posttest	finaltest
posttest	Pearson Correlation	1	,403**
	Sig. (2-tailed)		,000
	N	118	118
finaltest	Pearson Correlation	,403**	1
	Sig. (2-tailed)	,000	
	N	118	118

**. Correlation is significant at the 0.01 level (2-tailed).