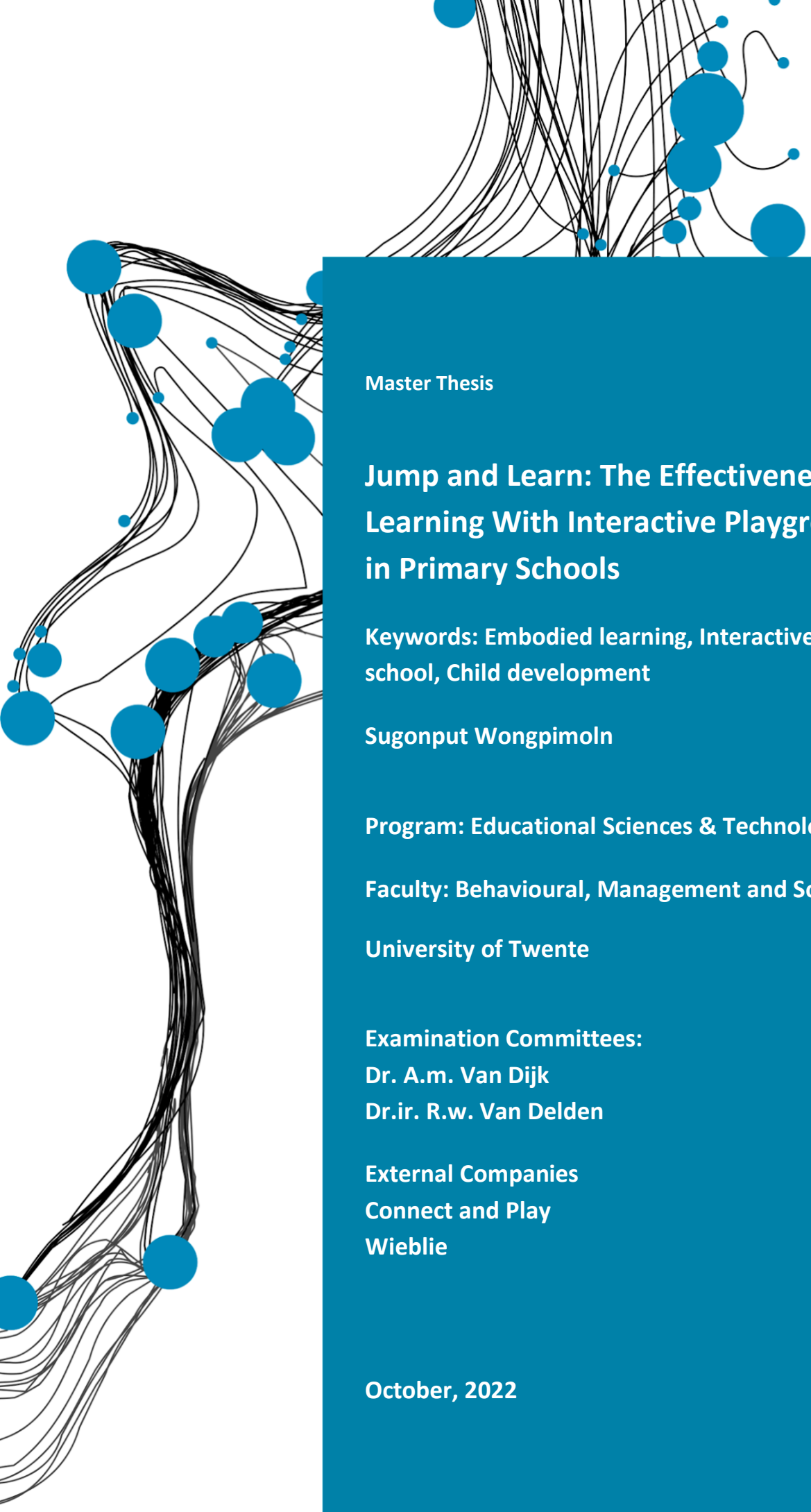

Master Thesis

# Jump and Learn: The Effectiveness of Embodied Learning With Interactive Playgrounds in Primary Schools

**Keywords: Embodied learning, Interactive playground, Primary school, Child development**

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**Abstract**

The purpose of this thesis was to investigate the impact of embodied learning with an Active Floor intervention (an interactive playground that uses a 3D camera and projection material) on an overall child's development that includes physical, cognitive, and social-emotional development. This study used mixed methods with a quasi-experimental design. The research was conducted in two primary schools with nine students in an experimental group and twenty students in a control group. The result showed that embodied learning with Active Floor intervention showed a significant improvement in the child's development when compared to the control group in four weeks. Moreover, the qualitative data also provided insightful information regarding embodied learning and classroom contexts. However, the limitation of this study was the small sample size of the experimental group.

Keywords: Embodied learning, Interactive playground, Primary school, Child development

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# Introduction

## Problem Statement

Moreno et al. (2013) describe an interactive playground as the combination between entertainment and immersive digital games that attempt to tap into the benefit of children's traditional free play. This playground uses an embodied learning (EL) approach which Kosmas & Zaphiris (2018) illustrate as a learning process with understanding and retention that is influenced by the whole sensory system of the human body. To clarify, a player can use some senses, such as touching, hearing and looking from their body while experiencing an external environment. As a result, these senses can affect the cognitive process. Moreover, a recent study from Zhong et al. (2021) states that EL in the technology setting has gained attraction in learning science.

An interactive playground can be designed in many forms (Delden et al., 2017) to engage learning through play and can be used to support learning in EL. Malinverni & Parés (2014) describe interventions in EL that have been designed to enhance children's physical, cognitive and social-emotional development. Based on the previous research, some interactive playgrounds are more likely aimed to promote only a specific purpose (viz., collaborative learning by Birchfield & Megowan-Romanowicz (2009), proxemic behaviour by Delden et al. (2017), and kinesthetic interaction by Grønbæk et al. (2017)). However, there is still a lack of scientific evidence on the effectiveness of the interactive playground on multiple topics simultaneously. Especially, whether they could holistically improve child development, in a school setting, solely by using a single device. Consequently, by obtaining more information from the study on the effectiveness of the interactive playground for school settings, the result could provide and expand the knowledge of using interactive playgrounds in order to create a meaningful learning experience for children. The findings of this study will expand the understanding of embodied learning with interactive playgrounds on a deeper level.

Therefore, the research goal is to investigate whether an interactive playground can improve an overall child's development. The focus of this paper is to investigate the impact of an interactive

playground on child development and explaining the context of schools with and without embodied learning approaches.

## Theoretical Framework

### *Embodied Learning*

Skulmowski and Rey (2018) state that educational research findings from embodied cognition (EC) are often referred to as embodied learning (EL). To illustrate, Kosmas and Zaphiris (2018) explain that EC is how the physical body plays a vital role in shaping the mind. They further state that the EC has been proven as an outstanding part of contemporary theories with a prospective impact in educational settings. The EL approach is then based on the strong link between body and mind in learning (Kosmas et al., 2019). Lindgren & Johnson-Glenberg (2013) state that the term EL is formed by the arrival of new technologies and interfaces that accept natural bodily movements, which are gestures, touching, and the positioning of the body, as the input into an interactive digital environment to learn the contents. Learning through a material that contains a visual embodied component with action that a learner can define their own gesture may support a higher level of memorability and enjoyment (Junokos et al., 2018). The action gesture can improve the retrieval of mental or lexical items for the recall of learning contents (Johnson-Glenberg et al., 2014).

According to the EL approach, Kosmas et al. (2019) explain that incorporating physical interaction into learning allows both the body and the mind to significantly produce knowledge. They further present that EL views the term “body” in practice as the whole learner’s personality in various aspects, which are the physical body, the sensory system, and the brain. Mcclelland et al., (2015) explain that the sensorimotor system (e.g., sensory input, perceptual processing, and muscle control) in a physical learning activity intervention can suggest a significant effect on educational performance. The effectiveness of EL on a theoretical level can be expected as Skulmowski and Rey (2018) state that the most impactful factor for EL is task integration with high bodily engagement. According to Zhong et al. (2021), the benefit of EL in a technological setting or technology-based embodied learning from empirical studies includes increasing learners’ knowledge understanding, enhancing their long-term

memory retention, fostering learning transfer, and supporting their positive learning attitude. Moreover, in a perfect EL environment, the roles of learners are a sensorimotor body, reflective minds, and social beings at the same time (Nguyen & Larson, 2015).

Moreover, Georgiou and Loannou (2019) systematically reviewed empirical research of EL in K-12 education in which interactive playgrounds were present in 26.8 % of research papers between 2008 to 2017. The research shows the positive results of EL mostly in STEM education. In addition, Johnson-Glenberg et al. (2014) explained that three core elements of EL include the amount of motoric engagement through locomotion, the link between gesture and learning content (i.e., gesture congruency), and the perception of immersion that a device is providing. However, the effect of the three core elements needs more empirical evidence. The researchers have also categorised the degree of EL into four levels based on the three core elements. The four degrees can further describe interactive playgrounds which are usually different from each other. First, a learner is usually seated with partial movement from the upper learner's body. This learning environment has no gesture congruency and it is not perceived as immersive from a learner's perspective. Second, there is a general lack of locomotion but an upper body movement appears. The gesture congruency is missing in this learning environment and it is not perceived as immersive from a learner's perspective. Third, there is unsustained locomotion which partly has gesture congruency in the learning environment. However, it is perceived as immersive from the student's perspective. Fourth, there is a high degree of motoric engagement in this learning environment. The gestures are also linked to learning content and there is a high level of immersion.

In summary, the main characteristic of EL in the context of an interactive playground is an active learning activity that requires moving with gestures and integrating learning contents, where learners can act as players, to gain the desired learning outcomes.

***Child's Development***

Doherty and Hughes (2014) explain in general that development entails changes in human growth as a result of the process of maturation and learning over the lifespan. According to their statement, a child's development contains three main broad areas or domains of development. Firstly, *physical development,* this area contains the growth of body and motor capacities. Secondly, *cognitive development*, this area contains intellectual processes, such as memory retention, knowledge, problem-solving, and communication. Thirdly, *social-emotional development,* this area contains the understanding of oneself and the relationship with others in society.

Many interactive playgrounds in the EL approach had been used to develop at least one instead of multiple domains of the child's development in empirical studies. For instance, a game-based device called "ASUS Xtion Pro" was used in a gesture interactive game-based learning approach (Hasiao & Chen, 2016). This experiment at the kindergarten level aimed to develop cognitive performance in colour recognition and physical skills with significant improvement using a game called "The Goalkeeper'' (physical and cognitive development). Next, an interactive simulation of planetary astronomy called the "MEteor project" was used in an experiment with students aged between twelve to thirteen from the middle school level (Lindgren et al., 2016). It significantly improved learning gains in astronomy (cognitive development). Finally, a full-body interaction system called "Lands of fog" from the Echoes Project was used for children with Autistic Spectrum Disorder (ASD) and typically developed children between ten to fifteen years old (Mora-Guiard et al., 2016). The intervention aimed to develop motivation, social initiation and collaborative behaviour with all significant improvements (cognitive and social-emotional development). All in all, those previous studies still leave more space to investigate the impact of interactive playgrounds on the child development perspective from a single device at the primary school level.

**Research Questions and Hypotheses**

In this research, the experimental group which used an Active Floor device (an interactive playground with a 3D camera and projection material) was compared to a control group. The difference between the two conditions was that the Active Floor condition implemented embodied learning with an Active Floor device and accompanying games in their classroom, while the Non-Active Floor condition was not using embodied learning with an Active Floor device at all in their classroom. The two main research questions are *"To what extent does an overall child's development level profit from working with an Active Floor device and accompanying games compared to children that did not work with such the device and accompanying games, measured in a four-week experiment? '' and* "*What are the student's characteristics, physical activities, and embodied learning activities in Active Floor condition and Non-active floor condition, measured in a four-week experiment?*".

Based on the research by Tomporowski et al. (2011), a physical activity intervention (i.e., exercise) can expect a possible significant impact on three domains of a child's development. Therefore, for the first research question, it is expected that the Active Floor condition has a significant improvement in the overall child's development when compared to the Non-Active Floor condition within four weeks. Finally, for the second research question, it is expected that the outcome will explain the contexts of schools and EL in the two conditions.

# Method

## Research Design

This study was mixed methods research that combined both quantitative and qualitative data collection as suggested by Zhong et al. (2021). This quasi-experimental research was designed in order to compare the effect of the interactive playground on all three domains of the child's development, in the context of the authentic classrooms. The use of embodied learning with an interactive playground was an independent variable, and child development was a dependent variable. One classroom in a primary school that used an Active Floor device was chosen as the Active Floor condition to compare with the Non-Active Floor condition in another primary school without having the implementation of the interactive playground in their lesson plans. The Active Floor condition used the embodied learning activities with the Active Floor device for approximately one and a half hours per week for four weeks. The child development instrument was provided as a pre-test and post-test to compare the child's development from within and between the Active Floor condition and the Non-Active Floor condition to answer the research questions. In addition, structured interviews with classroom teachers were conducted to describe the two classrooms of the study regarding embodied learning and classroom contexts.

## Participants

A total of 29 students in group seven (10 to 11 years old) from two classrooms in two primary schools in the Netherlands participated in this study. The Active Floor condition consisted of nine students ($n_{boy}$ = 5, $n_{girl}$ = 4, $\overline{X}_{age}$ = 10.89, SD = 0.33) and the Non-Active Floor condition consisted of 20 students ( $n_{boy}$ = 9, $n_{girl}$ = 11, $\overline{X}_{age}$ = 10.60, SD = 0.50). However, since the students in Active Floor condition were part of a mixed-age classroom consisting of students aged between 10 to 13 years old in a total of 16 students, only students who aged between 10 to 11 years old were the participants in this study. All students from the Non-Active Floor condition fitted within the age range and participated in this study, a total of 25 students. Due to the incompleteness of some instruments by the participants, a total of six questionnaires, one from the Active Floor condition and five from the

Non-Active Floor condition, were excluded from the study. For the interview section, the participants were the two classroom teachers, who were each responsible for their conditions. The participant from the Active Floor condition was a male classroom teacher with 20 years of teaching experience. The participant from the Non-Active Floor condition was a female classroom teacher with 10 years of teaching experience. The Active Floor condition was chosen due to their frequency of using the Active Floor device, as the classroom of the study has been using the device every week. For the Non-active Floor condition, the participant was chosen due to the absence of their use of the Active Floor device within their classroom, even though the device was present in their school. Finally, before the intervention began, the consent form (see Appendix A) was distributed to and returned from the children's parents prior to the study.

**Instrumentation**

***Active Floor Device***

An interactive projection device called "*Active Floor*" (Connect and Play, 2022) was used in the embodied learning environment as illustrated in Figure 1 (see also at Appendix B). It provided a sensor projection device and an online environment that entailed diverse games and game templates. A teacher could bring learning goals and integrate them into many different learning activities with the end-user customisation feature where they could add music, voices, and pictures. Thereafter, the teacher projected the tailored activities on the floor where a learner could interact with sensor systems that generated fluid interaction.

**Figure 1**

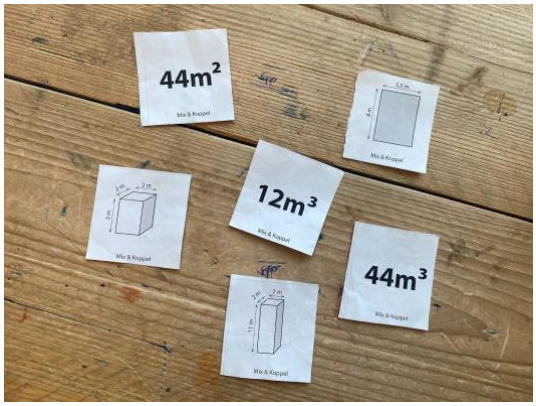
*Active Floor Device*

***Embodied Learning Activities***

The focus of the activities was to integrate learning contents to the Active Floor environment. For example, students learned content in their classroom, then played games that were related to the topic on the Active Floor devices which took place in a common area of the school, located outside the classroom. Figure 2 shows examples of how embodied learning activities were used in the Active Floor condition, both in traditional EL without educational technological devices (not apart from the focus in this study) and also with an Active Floor device. The two learning styles of EL could also be connected to the same learning content. For clarification, in the Active Floor condition, the pieces of paper contained pictures and numbers were placed around the classroom. The students would match the pictures and the numbers together using their knowledge about the area and dimensions that they had learned previously. Meanwhile, the Active Floor device was used to integrate the learning about the portion in a game template called “Gevaar in de jungle”. In this game, students stood in two lines under the teacher’s supervision and took turns competing with each other in order to gain points.

**Figure 2**

*Two Different Examples of Embodied Learning Activities in Mathematics Classroom Between Traditional Embodied Learning and Technology-based Embodied Learning*




***Child's Development Questionnaire***

The child's development questionnaire in this paper (see appendix C) was adapted from the TNO-AZL Children's Quality of Life questionnaire (TACQOL) - Parent form, (The Netherlands Organisation for Applied Scientific Research (TNO), (1999). This instrument measured the health-related quality of life among children and was applied to evaluate child development as the dependent variable in this study. The original questionnaire included 63 questions consisting of seven parts: body (emotional impact of physical complaints), motor (motoric functioning), autonomy, cognition, social (interaction with peers and parents), positive emotions, and negative emotions. However, this instrument was adapted for its suitability for the teachers, which could prevent the drop-off rate by evaluating situations that could happen in school settings rather than in home settings. The adapted version used new questions (i.e., item number six, seven, 10, 14, 19, 20, and 21 ) and other items from the original questions. As a result, it contained motor (seven items), cognition (seven items), social scale (seven items), and finally had a total of 21 questions, based on the three-domain of child development in physical, cognitive and social-emotional development. Examples of the questions were "How well this student balances their body?" (physical development), "How well this student performs in mathematics?" (cognitive development), and "This student was at ease with other

children." (social-emotional development). In addition, the current measure level in this study used the semantic differential scale as follows: always (one point), very often (two points), sometimes (three points), rarely (four points), and never (five points). Another set of labels of the scale used in the questionnaire was: extremely poor (one point), below average (two points), average (three points), above average (four points), and excellent (five points). The maximum score in each question was five points and the minimum was one point. As a result, the total score from one questionnaire can range from 21 to 105 points from 21 questions. In addition, the total score of each student directly represented their child's development in all of the studied domains.

The reliability analysis was run to test the internal reliability of the new child's development questionnaire which contains 21 items in total. Cronbach's α including both conditions were .88 (pre-test) and .90 (post-test) respectively. In addition, all domains in the child's development also had Cronbach's α ranging from .73 to .90.

***Interview Question***

The list of structured interview questions (see Appendix D) was created to gather information on both schools of the study regarding how teachers implemented embodied learning and the characteristics of their classroom settings. The sessions were conducted with classroom teachers by the researcher. There were 13 questions in total that were based on three categories, for example, characteristics of students, physical learning activities, the implementation of EL activities. The examples of the questions were "What are the characteristics of students in your classroom in terms of nationality, and background?" (student's characteristics), "In general, in what way do students in your classroom engage in physical activities?" (physical learning activities), "How often do you integrate embodied learning into your teaching" (EL activities).

**Procedure**

Two primary schools were contacted and invited to participate in this study. The data collection duration took four weeks of school days (18 May to 18 June 2022). First, the instruments, including pre-test and post-test, were sent to both school classroom teachers at the beginning of May. It took approximately five minutes to complete a questionnaire per student by a teacher. During the intervention period, the school of the Active Floor condition was asked to remain using embodied learning and increased the learning time with the Active Floor. The Non-Active Floor condition was also asked to refrain from starting to use the Active Floor device in the classroom during the study. Then, the answered questionnaires were collected from both conditions, approximately one week after the intervention period. Finally, the interviews were conducted in person, separately, at both schools of the study, which took approximately 20 minutes to complete for each school.

**Data analysis**

This research collected and analysed both qualitative and quantitative data from the Active Floor condition and the Non-Active Floor condition. The quantitative data were analysed by descriptive statistics and Welch's t-test on SPSS. To clarify, due to the unequal variances between the two sample sizes, the Welch's t-test was used to analyse the different scores in pre-test and post-test (improvement score) between the two conditions (Active Floor condition and Non-Active Floor condition). Meanwhile, for the qualitative data, coding was used to analyse the data. The aim of coding was describing the context of the classrooms and EL activities in each structured interview question. The coding procedure was firstly recording answers and coded by filling answers in a comparable table during the interview sessions. The table compared the conditions between two columns and represented the data. This coding style was chosen because it was more convenient for the short interview sessions.

## Results

This research aimed to find the impact of embodied learning with Active Floor Intervention on the child's development holistically. In this section, the research findings will be reported based on the two research questions.

Table 1 represents descriptive statistics of the total mean pre-test and post-test score from both the Active Floor and Non-Active Floor condition. For the total mean improvement score (different scores between pre-test and post-test), the Active Floor condition had a total mean improvement score at 6.11 with the standard deviation at 2.42. For the Non-Active Floor condition, the total mean improvement score was at 2.50 with standard deviation at 1.99. Moreover, the Active Floor condition had the mean improvement score of the child's development level in each domain as follows: physical development (M = 1.56, SD = 1.01), cognitive development (M = 2.44, SD = 1.13), and social-emotional development (M = 2.11, SD = 1.54). In contrast, the Non-active floor condition had the mean improvement score of the child's development level in each domain as follows: physical development (M = .95, Sd = 1.23), cognitive development (M = 1.05, SD = 1.23), and social-emotional development (M = .50, SD = 1.32).

**Table 1**

*Descriptive Statistic for Child Development Level in Both Conditions*

| Domain | Pre-test | | Post-test | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Active Floor Condition (n=9) | | | | |
| Physical development | 29.56 | 3.58 | 31.11 | 3.10 |
| Cognitive development | 23.22 | 3.42 | 25.67 | 3.57 |
| Social-emotional development | 30.11 | 3.06 | 32.22 | 2.64 |
| All domain | 82.89 | 4.40 | 89 | 3.81 |
| Non-Active Floor condition (n=20) | | | | |
| Physical development | 23.90 | 5.42 | 24.85 | 4.84 |
| Cognitive development | 22.35 | 5.53 | 23.40 | 5.43 |
| Social-emotional development | 26.60 | 3.07 | 27.10 | 3.49 |
| All domain | 72.85 | 11.56 | 75.35 | 11.64 |

***Embodied Learning and Child Development Level***

The Welch's T-test was run to investigate the overall child's development level using improvement scores. According to the data analysis, there was a significant difference ($t(13.08) = 3.92$, $p = .00$) in the total mean improvement score of the child's development at p-level < .05 between the Active Floor condition and the Non-Active Floor condition. Moreover, there was a significant difference ($t(16.85) = 2.99$, $p = .01$) in the mean improvement score of cognitive development at p-level < .05 between the Active Floor condition and the Non-Active Floor condition. Next, there was a significant difference ($t(13.55) = 2.73$ , $p = .02$) in the mean improvement score of social-emotional

development at p-level < .05 between the Active Floor condition and the Non-Active Floor condition. However, there was an insignificant difference ($t(18.73) = 1.39$, $p = .18$) in the mean improvement score of physical development at p-level < .05 between the Active Floor condition and the Non-Active Floor condition.

**Classroom Context Between two Groups**

Both Active Floor and Non-Active Floor conditions shared similarities in characteristics of students (diverse nationalities and social-economic backgrounds). For the physical activities, the playtime (45 minutes), gym class (two times per week) and the missing afterschool sports activities provided by schools during the intervention were exactly the same in both conditions. For the implementation of EL in general, the teacher from the Active Floor condition explained the reason why they integrated EL because of the availability of Active Floor in the school. The feedback from the teacher in the Active Floor condition, regarding the EL-related activities, was that the students were absolutely motivated to learn. “They like it and they are always asking for the Active Floor.” the teacher said. In contrast, the implementation of EL from the Non-Active Floor was missing. Therefore, there were no reasons or examples of EL activities explained by the teacher in this condition. Furthermore, for the typical mathematics classroom of the Active Floor condition, the teacher used a digital platform called “Snappet” to assign and instruct the tasks, while the students interacted and completed those tasks on both iPad and paper. The learning activities in the Active Floor device were also usually linked to the learning content in Snappet in the Active Floor condition. Meanwhile, the teacher in the Non-active Floor condition introduced some short exercises, assigned and instructed the tasks, and provided extra support to the students by themselves. The students in Non-Active Floor condition had mostly worked on paper and partly on computers without the implementation of the Active Floor device.

## Discussion and Conclusion

The purpose of this study was to find the effectiveness of EL approach with an interactive playground called “Active Floor” on an overall child's development. Moreover, another purpose was to find the information between the two conditions on the student’s characteristics, physical activities, and how teachers implemented EL in their daily teaching.

The result of the study showed that at the beginning of the intervention, the pre-test level from both the Active Floor condition and Non-Active Floor condition was different. The analysis during the intervention from this study which included an unconstant traditional EL also showed a significant difference in the total mean improvement scores between the Active Floor condition and the Non-Active Floor condition. The variables that may affect the differences could be the learning activities, teachers, number of students, and characteristics of students. Therefore, this result explained that using the Active Floor device in EL approach showed a significant improvement in a child’s development and could be beneficial to students in the Active Floor condition. The hypothesis from the first research question that expected a significant improvement of the Active Floor device on the overall of a child’s development in the Active Floor condition when compared with the Non-Active floor condition during four weeks was confirmed. Moreover, the mean improvement scores for the cognitive and social-emotional development also had significant differences between the Active-Floor condition and the Non-Active Floor condition. However, the mean improvement score from the physical development had an insignificant difference. The reason behind this insignificant result could be the fact that developing physical development takes time based on the stage of development (Doherty & Hughes, 2014) and this intervention was also relatively short. The students in this intervention may also had different body fitness, diverse health statuses, and other phycho-social factors. Which Tomporowski et al. (2011) used those variables to explain the complexity of using physical activity to impact mental functioning.

Lastly, the finding from the interviews illustrated classroom contexts between the Active Floor condition and Non-Active Floor condition. The result highlighted the similarities and contrasts

between the two conditions and described how the teachers facilitate learning and implemented EL in their classes. The overall characteristics of students and physical activity were similar. The main contrast was the implementation of EL with the Active Floor device. The interview of the teacher from the Active Floor condition showed a strong motivation from the teacher, effort and time that was spent on implementing EL and the student's feedback from the teacher's perspective. On the other hand, the teacher from the Non-Active Floor did not implement EL in general nor EL with the Active Floor device at all. The more elaborated information from both conditions were also lacking from just the teachers' perspective instead of including data from observation by the researcher and student's perspective.

**Theoretical and Practical Implications**

The impact of EL approach with an interactive playground in an authentic classroom was previously missing. However, the significant improvement from the Active Floor device can benefit educational scientists and educators. First, there was a need for a new implication of the EL approach in an authentic school environment (Lindgren & Johnson-Glenberg, 2013; Osgood-campbell, 2015; Skulmowski & Rey, 2018). The theoretical impact of this study is how the educational scientists can use the result of this study to further showcase the effect of the technology-based embodied learning and also the embodied cognition field in a closer look that a new technology like the Active Floor in embodied learning activities can improve a child's development holistically in an authentic classroom. Second, as many installations had been designed and tested for a specific technical feature (Lindgren & Johnson-Glenberg, 2013) but have not yet been proven in educational design research. As a result, the outcome from this study can be an example to show how an interactive playground can improve a child's development, including their educational performance. In addition, the educators can use the holistic result of this study to consider whether they need an interactive playground in their schools to improve their teaching performances and motivate students to learn better.

**Limitations and Recommendations**

One of the major limitations of this study was the sample size. Finding a school with an Active Floor was challenging because there were limited schools at the time of starting this study in the Netherlands, teachers were busy during the Covid-19 pandemic, and school administrators preferred not to put extra tasks on their teachers. However, for future research, it should include multiple schools with Active Floor devices because every school implements EL with the devices differently and has a different amount of students and classroom arrangements. Another limitation was the short data collection. The duration should also be longer with a constant amount of embodied learning activities and gathering more information from different perspectives from teachers, and students and from observation by a researcher in case there is discrepancy. Next, due to the teachers might use EL differently. The teachers should also receive an orientation or a workshop session on what is and how to integrate EL with Active Floor similarly to the study by Kosmas et al. (2019) to investigate the impact with fewer confounder variables from the teachers. In addition, due to the child's development is a broad concept. The dependent variables can be the executive functions, especially self-regulation skills to extend the understanding of EL toward another narrower direction. According to the statement from the teacher in the Active Floor condition, the students were motivated to learn more. More information related to teacher and student's intrinsic motivation should be further studied by using such questionnaires and observation in the topic because there is a strong link between motivation and learning process (Gopalan et al., 2017). In addition, educational performance, especially in STEM education, is also a fascinating topic that EL in a technology-enhanced learning environment as recommended by Zhong et al. (2021) can also be used to motivate students to learn better as well from an interactive playground with 3D camera and projection material.

**Conclusion**

This study presents the impact of EL with Active Floor intervention on a child's development. The results showed that EL with Active Floor intervention had a holistic significant improvement in an overall child's development (i.e., physical, cognitive, and social-emotional development) in four weeks

when compared to the Non-Active condition. Although, when investigating closer, the improvement scores were significant only in the cognitive and social-emotional development but not for the physical development when compared between the two conditions. Furthermore, the finding also illustrated how teachers facilitate learning activities especially the implementation of Active Floor with EL in both conditions. The implication of this research can benefit educational scientists, and teachers to understand more that the impact of an interactive playground with 3D camera and projection material through EL approach in school settings can improve an overall child's development. Although the result in this study was significant with the small sample size of nine students in the Active Floor condition, the larger group size might facilitate a more convincing result. Future research should include more schools, extend the intensity of time for EL activities, and involve more perspectives from student and researcher's observation. Also, focus on the impact of interactive playgrounds with 3D camera and projection material on developing executive function, such as self-regulation skills and STEM education in the technology-based embodied learning approach.

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# Appendices

## Appendix A

Parental consent form
University of Twente

Research title: Jump and Learn: The Effectiveness of Embodied Learning by Using Interactive playground in School Settings

Description of the research

Your child is invited to participate in a study conducted by Sugonput Wongpimoln. Please read the following instructions carefully, as it informs you about the purpose of the study, the way we would like to use your child's information and how you can benefit from this study.

The purpose of this study is to investigate the effectiveness of embodied learning with an interactive playground called "ActiveFloor". In this way of learning, students can use their whole body to learn and integrate learning contents in an active and meaningful way. This study will investigate the impact of ActiveFloor on child development. Two conditions will be compared between an experimental group (a classroom with ActiveFloor) and a control group(a classroom without ActiveFloor) by using a Child's development instrument. The classroom teacher will evaluate your child's development twice in a pre and post-test. The study will be implemented in 4 weeks. More details will be listed here:

- Your child will participate in a control group as a daily routine.
- No intervention or extra tasks from this study will be implemented.
- All the data will be collected anonymously.
- No risk is associated with this research.
- Your child's participation is voluntary. You as a parent can withdraw at any time without stating your reasons.

In addition, parents and their children can benefit from this study by helping to bring new knowledge on how educators can improve learning and teaching. Consequently, benefit your child and society in the future.

Contact detail for further information

If you have further questions, please contact by email:

Researcher: Sugonput Wongpimoln ( s.wongpimoln@student.utwente.nl)
1st Superviser: Dr. A.m. Van Dijk (a.m.vandijk@utwente.nl)
2nd Superviser: Dr.i.r R.w. Van Delden (r.w.vandelden@utwente.nl)

Contact Information for questions about your rights as a research participant

If you have questions about your rights as a parent's research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl.

I have read and agree with the conditions and terms.

( )

Signature of parent

Parent's name_____

Student's name_____

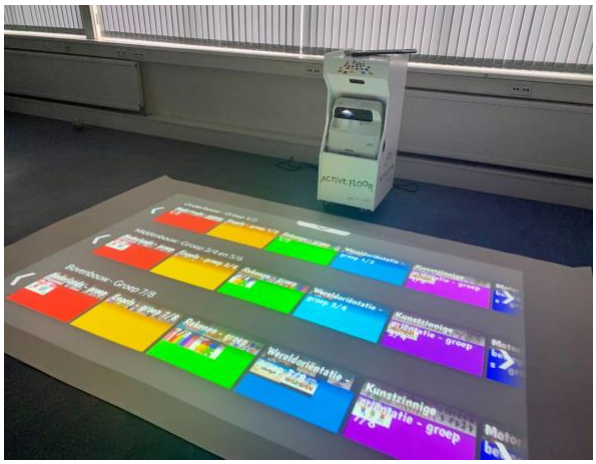
**Appendix B**

## Active Floor's information

Active floor device is an interactive playground with 3D camera and projection material. The installation can be located in both mobile and constant versions as represented previously in Figure 1 and also by Figure 3 below. In "My floor", there are three types of games that are sensory games, activity games and learning games. For the learning games, there are approximately 16 learning games which teachers can use or create a new game to integrate their learning contents in the platform by, for example, recording voice, adding music or adding pictures. Moreover, there is also an environment where teachers can share their games and learn more about Active Floor.

**Figure 3**

*Active Floor Device in Mobile Version and Constant Version Located on the Wall*




**Appendix C**

Post-test

**Child Development Questionnaire**

---

Information and Instruction

This questionnaire is aimed to evaluate the child development of your student. It is adapted from TACQOL questionnaire and contains 3 domains of child development, such as physical development, cognitive development and social-emotional development. The total questions are 21 questions. The responder can choose the most appropriate answer and place a cross in the box along the answer. In addition, it takes approximately 5 minutes to complete this questionnaire per student. Please be aware of reverse answers with underline questions. Any further issues can be written on the note section.

---

Complete details of student

Age:

- 10
- 11

Gender:

- Boy
- Girl
- Other

Note:

**Physical development**

In recent weeks, does the student have difficulty with these aspects or how well they can perform these tasks?

1. Difficulty with walking?

□ always □ very often □ sometimes □ rarely □ never

---

2.Difficulty with running?

□ always □ very often □ sometimes □ rarely □ never

---

3.Difficulty with standing still?

□ always □ very often □ sometimes □ rarely □ never

---

4.How well can this student balance their body?

□ extremely poor □ below average □ average □ above average □ excellent

---

5.Difficulty with doing things handily or quickly?

□ always □ very often □ sometimes □ rarely □ never

---

6.How well can this student jump to a wanted position?

□ extremely poor □ below average □ average □ above average □ excellent

---

7.Difficulty when following instruction on physical activities?

□ always □ very often □ sometimes □ rarely □ never

---

**Cognitive development**

In recent weeks, does the student have difficulty with these aspects or how well they can perform these tasks?

8. Difficulty with paying attention or concentrating?

□ always □ very often □ sometimes □ rarely □ never

---

9.Difficulty understanding schoolwork?

□ always □ very often □ sometimes □ rarely □ never

---

10.How well can this student perform in a creative task?

□ extremely poor □ below average □ average □ above average □ excellent

---

11.How well can this student perform in mathematics?

□ extremely poor □ below average □ average □ above average □ excellent

---

12.How well can this student perform in reading?

□ extremely poor □ below average □ average □ above average □ excellent

---

13.How well can this student perform in writing?

□ extremely poor □ below average □ average □ above average □ excellent

---

14.How often does this student show a positive attitude on learning new things?

□ always □ very often □ sometimes □ rarely □ never

---

**Social-emotional development**

In recent weeks, does the student have difficulty with these aspects or how well they can perform these tasks?

15. This student can play or talk happily with other children.

□ always □ very often □ sometimes □ rarely □ never

---

16.This student can stand up for himself/herself with other children.

□ always □ very often □ sometimes □ rarely □ never

---

17.Other children asked this student to play with them.

□ always □ very often □ sometimes □ rarely □ never

---

18.This student was at ease with other children.

□ always □ very often □ sometimes □ rarely □ never

---

19.This student was able to play or talk happily with the classroom teacher.

□ always □ very often □ sometimes □ rarely □ never

---

20.This student was uncommunicative or quiet with the classroom teacher?

□ always □ very often □ sometimes □ rarely □ never

---

21.This student was defiant with the classroom teacher?

□ always □ very often □ sometimes □ rarely □ never

---

This is the end of the questionnaire and thank you for completing it!

**Appendix D**

**Interview Instrument**

| **Characteristic of students** | | |
|---|---|---|
| Questions | Active Floor | Non-Active Floor |
| -What educational concept does your school use? | | |
| -What are the characteristics of students in your classroom in terms of nationality and background? | | |
| **Physical learning activities** | | |
| -In general, in what way do students in your classroom engage in physical activities? | | |
| -Do they have after-school classes like clubs/associations regarding sports or physical activities? | | |
| **Embodied learning** | | |
| -How often do you integrate embodied learning into your teaching? | | |

| | | |
|---|---|---|
| -Why do you integrate embodied learning? | | |
| -In what topics do you usually integrate embodied learning? | | |
| -Can you give an example of learning activities with embodied learning that you have used? | | |
| -In general, what is the feedback from students of Embodied learning-related activities? | | |
| -In general, how do you teach mathematics in your classroom? | | |
| -To what extent and how do you use Embodied learning with mathematics? | | |
| -What is the feedback from students about mathematics with Embodied learning? | | |

| | | |
|---|---|---|
| -In the last 4 weeks, does anything regarding your teaching in mathematics has been changed significantly from your general teaching? | | |
| **Note/remarks** | | |