Enhancing Holistic Development Though Exergame-Based Learning

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Abstract: With the educational system balancing students' wellbeing and academic performance, being excessively digitalized and less physically active, new ways of active learning designs are needed. As digital tools offer potential for learning, increased screen time also raises concerns about physical inactivity and social disengagement, emphasizing the need for embodied and playful approaches in education. Current play-, game, and design research present today's education as striving for delivering playful and engaging learning experiences that support well-being, social engagement, and personal growth. One way to combat sedentary behavior and equip youngsters with key skills for a democratic society is to integrate movement in the design of academic learning. We suggest exergames as powerful tools as they use bodily movement, playful game experiences and screen-based play as a pathway to knowledge and holistic learning. Yet specific exergame design strategies to combine movement, academic learning and holistic development remain underexplored. Through the lenses of embodied cognition, we combine exergames with learning activities. For this purpose, this study uses constructive design research as a deliberate approach to frame the combination of theory and practice in the development of a design tool that addresses complex human-centered holistic needs and academic learning. This paper contributes by 1) emphasizing co-creation with 15 school children to inform the design process of constructing an exergame through three workshops and, 2) collaborating with a team of game developers in the making of a framework for creating exergame-based learning activities. Co-creating with the children revealed collaborative narratives, energy, and creative freedom as key elements of engaging gameplay and playful interaction. Further these insights were aligned with the game development team at LYMB.iO to create the Design Wheel of Exergame-based Learning (DWEL). DWEL is an eclectic design tool integrating play elements, game- and system mechanics, player aesthetics and aligns with the elementary school curriculum. The tool can be used for designing and evaluating exergames and to inspire future classroom activities when combining movement and technology for learning. Future research should look at the social-emotional, physical, and cognitive effects of using the DWEL developing exergame-based learning, for example, through platforms like Multiball or other exergame platforms.

Keywords: Movement-based design, Exergames, Co-Design, Embodied cognition, CDR, Play

1. Introduction

Integrating movement in the design of academic learning and human growth and wellbeing are challenges met by several researchers and practitioners. Cohen (2006) argues that academic success alone is not enough to prepare children for lifelong well-being and democratic participation, while Eccles & Roeser (2015) and Jessen & Balslev (2003) highlights that schools may go beyond cognitive achievements to foster emotional security, social belonging, and ethical engagement to prepare pupils for adulthood in a complex and democratic society.

Concerns are rising as The Danish Competition and Consumer Authority (2024) highlights how increased screen time contributes to social comparison, distraction, and reduced physical activity. These studies showcase how sedentary habits and social incompetence are negatively affecting overall well-being and human development. In this study we define human development as an embodied and holistic approach to developing affective, physical, and cognitive skills (UNICEF 2024). However, as digitalization reshaped educational environments, Bottino (2020) and Granic, Morita & Scholte (2020) highlight that digital technologies are integral to the cognitive practices embedded in today's classrooms. This is further highlighted by Syaukani, Hashim & Subekti (2023) and Dindler, Smith & Iversen (2020), whose findings align with the potential of digital tools to foster active and collaborative learning experiences when thoughtfully integrated into educational practices.

As play and games, including screen-based games and digital play, occurred as learning activities, schools strive to deliver playful and engaging learning experiences. Aloizou et al (2024) demonstrate that immersive technologies like movement-based learning platforms in kindergarten cultivate cognitive competencies though a one-year case study yet lack results from follow-up studies and control groups. Skovbjerg et al (2024) emphasize that playful learning strategies help establish social bonds, curiosity, and problem-solving skills but specific design guidelines to such strategies are absent. Steenholt (2013) and Händel (2023) frame how play and movement are culturally rooted and embodied practices for both teachers and children but ignore how we become embodied and playfully engaged. Lund et al (2024) conclude that learning with exergames played on the LÜ-platform increases learning motivation and engagement in curriculum topics while increasing participants physical literacy, however no results on softer skills are delivered.

These studies emphasize how play, games and movement – in the term of exergaming - contribute to holistic development by being cornerstones for embodied engagement, physical presence and social interaction in learning processes that enhance educational and personal growth. The studies bring valuable insights into the use of exergame-based learning but underscore the importance of the underlying design considerations.

Thus, we investigate: *What insights have been gained from movement-based co-design processes involving pupils and experts, and how did they inform the development of a exergame-based learning design tool?*

2. Bridging Embodiment to Learning Through Deliberation and Exergame-Based Design

Embodied Cognition (EC) offers a foundational theoretical lens to exergames and learning as embodied activities. Malinin (2019) frames EC as embodied, embedded, enactive, and extended, while Stilwell & Harman (2021) introduce a fifth "E"-dimension—emotive—through making physical engagement a primary agent for knowledge construction. Inspired from Bernard De Koven's work learning in movement-based contexts become playful and holistic through the interplay of connecting socially, engage physically and resonate emotionally (De Koven 2013), which aligns with modern learning theories (Waern et al, 2025; Syaukani et al, 2023; Jensen et al, 2025). Addressing the under-researched area in designing exergame-based learning our study draws on educational motivation and attitudes (Sabirli & Çoklar, 2020), game-based learning principles (Salen & Zimmerman, 2004), exergame design (Müeller et al, 2016), player experiences (Korhonen et al, 2009; Heunicke et al, 2004), child-centered play design (Druin 2001; Feder, 2020), and embodied interaction with technology (Loke, 2009; Segura et al, 2016). We believe exergames are powerful tools as they use bodily movement, playful game experiences and screen-based play as a direct pathway to knowledge and holistic learning (Oh & Yang, 2010; De Koven 2013; Kaos et al, 2019; Gao et al, 2018).

As seen, creating a design tool for developing and evaluating holistic development through exergame-based learning can be approached qualitatively (Skovbjerg et al, 2024; Aloizou et al (2024) and quantitatively (Goncalves et al, 2024; Gao, 2019). Koskinen (2011) and Emans & Murdoch-Kitt (2018) suggest constructive design research as a balanced and mixed method that intertwines theories and practices to add tolerance in the traditional field of science and design. We align with Koskinen (2011) and Emans & Murdoch-Kitt (2018) suggest that there is a need for different methods and methodologies in design practices and considerations, as the main difficulty is understanding how design research works and what value it brings.

Constructive design research often builds on experimental research with the involvement of user groups (Koskinen 2011). Taking inspiration from Bernard DeKovens' philosophy of learning and playfulness (2013), we align with his idea that *deliberation* is the deep engagement, the shared communities and the transcendence that arises when working and playing well together (De Koven, 2013). For this reason, constructive design research as a deliberate approach to working and playing with people offers the most sustainable path for enhancing both holistic development and academic learning as it integrates the body, mind and spirit of those you work with (Koskinen, 2011; Feder 2020, DeKoven 2013).

This paper first suggests that children as co-designers contribute to developing well-designed exergames by enlightening the early design process, and second, how the development of such exergames can be de delivered in form of a wall-sized screen-based exergame informed by game design experts. This paper contributes with new perspectives and guidelines that emphasize a holistic approach to design for academic learning and human development by developing the Design Wheel of Exergame-based Learning.

3. Case Description: From Ideation to Construction of Exergames for Multiball

The concept of bridging movement, learning, and technology emerged from experimenting with the SDU-mounted Multiball®, developed by LYMB.iO. Multiball features a metal frame attached to the wall, equipped with tracking that detects any object hitting the wall. A camera positioned at the top of the frame captures the moving body on the floor. Our passion for learning with technology led us to contact the Langeskov School.

The case involves two phases. First a collaboration with the Human Tech team (HUT) from Langeskov School allowing insights from children's perspectives on playful design to emerge. The second phase was an internship at LYMB.iO that involved expert game developers in the exergame design considerations. HUT was motivated to take part in and inform the project on learning with movement-based technology. HUT comprises 7 boys and 8 girls from 4th to 9th grade participating in the robotics and innovation competition First Lego League. HUT showed interest in movement-based technologies, a previously unfamiliar aspect of their everyday activities. HUT was enrolled in three workshops at SDU during the fall of 2024 (Table 1). As a result, HUT revealed essential insights incorporated into their prototypes of exergames for Multiball®. The prototypes

were planned to be further developed with LYMB.iO through 8 structured workshops and daily meetings during November and December 2024. As LYMB.iO strived to develop educational learning applications for Multiball, insights from the HUT workshops were used for exergame prototype development and informed further exergame design considerations. To renew educational exergames, we used HUT-insights, game knowledge from literature readthroughs and LYMB.iO experts to apply a holistic understanding of designing for exergame-based learning.

4. Methods: Constructive Design Research to Emphasize Co-creation and Exergame Design

The study is informed by Constructive Design Research (CDR) as an overarching methodological framework (Koskinen et al 2011). CDR originates from design practice where knowledge evolves from artifact creations and validations, while the design of the product benefits user needs and experiences, becoming the center of knowledge. Constructive design research (CDR) aligns with project goals of providing insights into exergame creation (Koskinen et al., 2011). CDR emphasizes co-creation and co-design (Sanders & Stappers, 2008), thereby pointing to collaboration between producers and users as a key value for making good design solutions and, in our case, good game design. In our use of CDR we are also informed by DeKovens' (2013) theory on coliberation. Deliberation is "What we have to give each other when we are at our best" (DeKoven 1992). In other words, coliberation is when we play each other well to experience a well-played game (DeKoven, 2023). As collaboration and coliberation were subtle parts of the workshops, focusing on democratic and holistic methods, CDR was well-suited as a design approach for this paper.

This ensured that HUT's voices and experiences played a key role in shaping design outcomes (Emans & Murdoch-Kitt 2018; Druin 2001). Supporting this purpose, Druin (2001) and Feder (2020) emphasize that pupils' participation in design fosters sustainable learning experiences. This aligns with Kumar's (2012) view that innovative processes and methods should be built on experiences, system-thinking, and iterative exploration. The design process involved two interconnected phases: co-design workshops with children and a practice-based internship with the exergame company LYMB.iO, where qualitative observations and interviews served as scientific methods to generate data.

We facilitated three co-design workshops with HUT that was structured as outlined in Table 1. All participants submitted informed consent as well as parental consent forms prior to the workshops and the school was informed. The co-creation workshops were grounded in movement-based design (Waern et al 2025; Segura, 2016) and playful learning principles (Skovbjerg et al, 2023). Movement-based design through 5M framework helped shape the workshop environment (Elbæk et al, 2023, Waern et al, 2025). Mood Setters energized the participants, Movement Methods structured activities, and Modifiers guided creative processes. Play was integrated as a catalyst for exploration, collaboration, and creative thinking (Skovbjerg et al, 2023). Playful activities supported and empowered children to embrace unpredictability and co-create shared ideas (Händel, 2023).

Then we gathered insights from HUT-workshops through semi-structured observations (Blandford, 2013) designed to capture children's physical engagement, social interaction, and input during the workshops. The observation data underwent an inductive thematic analysis (Braun & Clarke 2006) that gained synthesized insights. That to ensure consistency between categories and raw data points. Finally, the HUT-insights were brought to LYMB.iO for further exergame design consideration through an 8-week internship. The HUT-insights were applied in a flexible pattern matching comparison analysis to relate HUT-workshop data with theoretical findings. Using such mixed methods toolkit provided us with a theoretical foundation where emergent and unexpected insights can appear.

Table 1: Day schedule and duration for HUT workshop 1

Activity	Purpose	How
Moodsetting (15 min)	To form a bond and a safe space to be creative in	Clap Cross and Tumbler (MeCaMInD cards)
Introduction (15 min)	Explain, define and the Multibal	Group listening

Activity	Purpose	How
Multiball gameplay **(20 min)**	Exploration and reflection phase	Try, test and refine. Using modifiers to bring attention to various perspectives
Break (15 min)		
Moodsetting **(5 min)**	To sense and socialize	Bubblegum Queen (MeCaMInD cards)
Design phase 1 + playing Multiball **(30 min)**	Discover and reflect on movement ideas to enrich performance and feel in the gameplay	Bodystorming with props Explore movement What can I do with this? (MeCaMInD cards)
Introducing modifiers **(15 min)**		Group listening
Design phase 2 **(30 min)**	Groups explore the given boxes of modifiers. Choose max 15 modifiers. Can you make a game from mod. cards?	Goup work
Lunch (30 min)		
Moodsetting **(5 min)**	To energize	Slow fight (MeCaMInD)
Gameplay **(30 min)**	With their chosen modifiers they discover how their game is played out – others give feedback	Context playing
Sum up **(20 min)**	Take away notes and feedback	Brainwalk (MeCaMInD)

4.1 Workshops with Langeskov School (HUT)

The three HUT workshops were held from primo September to ultimo October 2024 at University of Southern Denmark. Each workshop had its own agenda, yet similar structure. An example can be seen in Table 1.

The workshops aimed to engage children in a playful, iterative design process focused on movement-based digital games using the Multiball system (figure 1). In Workshop 1, children explored and tested existing exergames through hands-on activities and mockups, while being introduced to the MeCaMInD design tools (Elbæk et al 2023). Workshop 2 used case-personas and empathy mapping to guide children in designing games that addressed cognitive, social, emotional, and physical growth potentials. At the final Workshop 3 HUT sketched, prototyped, and programmed their own interactive games in Scratch Jr. The activities encouraged dialogue and playful exploration and were used as context-near experiences to introduce theories (Figure 2).

Figure 1: Children from HUT playing "Countries" on Multiball during W1

Semi-structured guiding observational questions led to descriptions and reflections (Blandford, 2019). Special attention was given to observations focusing on physical gameplay, children's social interaction and their participation during the activities. The observation data went through a thematic analysis that followed Braun and Clarke's six-step framework (2006), ensuring systematic condensation and interpretation of findings. The observations were grouped inductively, allowing patterns and important elements to appear. Then we coded the grouped data into cognitive, socio-emotional and physical categories and cross-referenced them with the observation once again before giving them clear definitions and scope (Braun & Clarke, 2006).

Figure 2: HUT working with exergame design in groupwork session W2

4.2 Workshops with LYMB.iO

Insights from the HUT workshops were brought to LYMB.iO to be further developed. through weekly design sessions with one exergame designer and three exergame-developers. These were iterative sessions focusing on integrating educational elements into exergames using the HUT-workshop insights. This was done by applying a flexible pattern matching comparison analysis (Bouncken et al, 2021), aligning themes from HUT-workshop data with several theoretical underpinnings from game and design literature (Figure 3).

The literature identified relevant constructs and frameworks in exergame design (Mueller 2016; Lund et al 2021; Chow & Mann 2023), movement-based design (Segura 2016; Aloizuo et al 2025; Waern et al 2025; Loke 2009), play design (Feder 2020, Skovbjerg et al 2024), HCI-design (Druin 2001, Sweetser & Ozdowska 2024), gameplay mechanics and digital design (Korhonen, Montola, & Arrasvuori 2009; Schell 2001; Hunicke, LeBlanc & Zubeck 2004).

The literature reading was compared with the insights from HUT-workshops ensuring consistency between empirical data and theoretical patterns (Figure 4). We then integrated overlapping elements into a cohesive framework (Figure 5). Finally, we tested the elements of the framework by applying parts from the framework into a LYMB.iO-developed prototype exergame. This was an iterative process that involved several adjustments that required well-argued design considerations, beta-coding and continuous testing.

To understand how the framework is constructed, the following section describes findings from the HUT-workshops followed by findings from workshops with LYMB.iO. The results are refined in the construction of the framework.

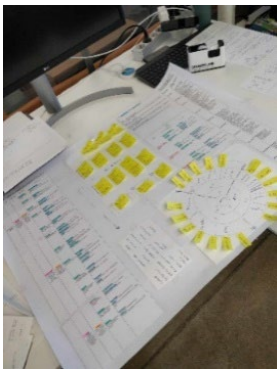

Figure 3: Aligning themes from HUT-workshop data with theoretical underpinnings from game and design literature

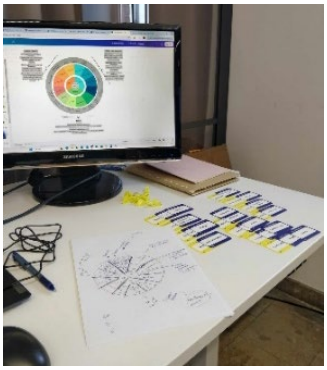

Figure 4: Comparing literature reading with the insights from HUT-workshops ensuring consistency between empirical data and theoretical patterns

Figure 5: Integrating overlapping elements into a cohesive framework

5. Results

The findings contributed to the children's experience of good gameplay and playful interactions. HUT-workshops revealed collaborative narratives, energy, and creative freedom as key elements of HUTs exergame design (Figure 6). Integrating these findings into design considerations, they were used at the LYMB.iO design stages to develop an exergame-based learning framework (DWEL).

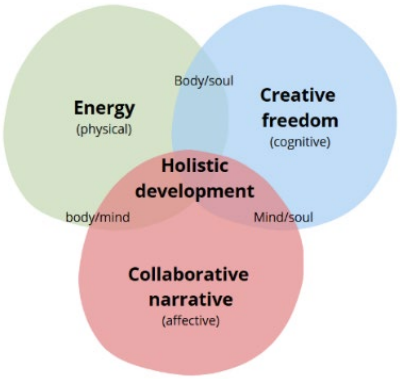

Figure 6: Key elements of HUTs exergame design linked to embodied cognition

5.1 Results from HUT

Informed by the HUTs' participation in the workshops, the semi-structured observational data shred light to what made the Multiball experience meaningful and fostered adherence. The following stages an observation from workshop 2.

> *I wanted to start Connect 4 (a slow-paced two-player game on Multiball). It was met with a "No, not 'four on a row". It's boring..." I asked why and a boy stated:" When something happens, you know, action-like, you really want to keep on playing. This? This is just kinda borring". I started Bombs instead (a high-paced multiple-player game). The teacher asked about the academic games, and I started*

> *Countries. A geography game (slow-paced and allows for collaboration). "That little guy, he's playing along now," says the teacher. (Sequence of the observation notes from W2, 30th September 2024)*

Using Multiball to facilitate learning through movement, we discovered that Multiball can create energy (green color, figure 6). However, energy might set boundaries for everyone to participate in the same game. As the quote shows energy was detected in shifts from high to low activity. It shows that going from *Bombs* (a fast and action-packed game) to *Countries* (a discovery game) sharpened their attention and slowed down the pace presented by their physical impression. The quote further shows that some exergames contributing to collaborative engagement when the game can be done together (red color, figure 6). The "little guy", that the teacher refers to, did not want to join the fast-paced games. But as he sees that he can contribute, he joins. When I asked him why he joined this game and not the other, he said:" The *best is that we can collaborate to get something done. I am good at geography, so I know stuff." (Boy, 11 yo)*.

In a sequence from workshop 3, they were presenting their prototypes. I noticed every pitch started with a storyline. They have all created a common narrative that was important to them, and one they all could relate to. The quote shows that playing action paced exergames encouraged more active physical play. The action games enhance uncontrolled play, while slow-paced and more strategic games require very precise action and are restrictive to where you can hit a target. The action games thereby allowing the players to throw at any target having more freedom to choose where to go in the game. Another time creative freedom (blue color, figure 6) was present when using the MeCaMInD-modifiers. They offered a structured, yet restricted way to apply ideas and thoughts into design considerations. This obstacle was to some extent "… *a little annoying (…), a little difficult to figure out." (Girl 14 yo).* However, as they kept playing with the modifiers and came to understand what they were used for. The girl later stated; "… *it was pretty cool to figure out that you were able to create something. They [the modifiers] were inspiration and we found out that we could be really creative with them. Sometimes silly creative." (Girl 14yo).*

As shown in Figure 6, these insights strengthen the bridge between embodied cognition and practical examples of holistic development. Energy (green) was found to be expressed through the physical body but was also connected to the emotions of the pupils. A sedentary brainstorming-task expressed less bodily interaction, while twisting brainstorm to brainwalk forced the pupils to move around while placing sticky notes around the room, created shared laughs and physical touches. This shows energy as embodied as enactive and embedded actions emphazises dynamic interaction between environments and agents that supports exploration and making sense of the world through sensorimotor interactions (Stilwell & Harman (2021).

Creative freedom (blue) was a way to express themselves either through the body or through their reasoning in deeper tasks. As HUT got to play with various tools and materials to physically build their re-constructed exergame (workshop 1), they utilized external objects to extend their cognitive abilities. Relying on extended and embedded perspectives the insights show how cognitive processes are shaped by the contexts, the environment and opportunities that can extent our cognitive abilities Elbæk et al, 2022; Stilwell & Harman (2021).

Collaborative Narrative (red) was generated through bodily awareness when playing together but was also tied to connecting emotionally with a task. Using case-personas with problems which were familiar to the HUT, they deeply intertwined with the case-persona influencing their perception and decision making towards creating solutions that could help them. This shows that affective development is deeply intertwined in the emotive perspectives of learning Elbæk et al, 2022; Stilwell & Harman (2021).

It is by linking mind/body, mind/soul and body/soul that we claim that holistic development occurs (the overlapping center in Figure 6) through extended, embodied, enactive, emotive, and embedded interference with the object and world around us (Stilwell & Harman (2021), Elbæk et al, 2022).

In the last workshop HUT were prototyping their own exergame in Scratch. It was by reviewing and cross-refering the themes from the observational data concerning physical, cognitive and socio-emotional elements with the themes emerged in HUT prototypes we defined energy (green), collaborative narrative (red), and creative freedom (blue) as being essential insights for playful interactions and for the feeling of good and engaging gameplay. These insights were used in later workshops with LYMB.iO.

5.2 Results, LYMB.iO

As energy, collaborative narrative, and creative freedom was insighs that formed HUTs idea of exergames their protoypes were delivered to LYMB.iO. However LYMB.iO prefered to use the HUT co-design insights to inform

the future design process of educational Multiball exergames. This stimulated the creative process of drafting the *Design Wheel of Exergame-Based Learning* (DWEL) – an eclectic tool designed to integrate holistic development and academic learning.

The following section describes the process of creating DWEL as a part of the results in the design sessions with LYMB.iO.

5.3 The Design Wheel of Exergame-based Learning

The multiple sessions with LYMB.iO resulted in the development of the *Design Wheel of Exergame-Based Learning (Figure 7).* The HUT-insights and the literature pattern matching fueled LYMB.iO's own desire to make educational exergames founded on the principles of playful and holistic learning. Aiming to assist LYMB.iO construct and design such exergame, a framework was made in a wheel format. DWEL is made of four circles integrating school subjects, playful elements, game and system mechanics, and player aesthetics representing holistic learning opportunities.

The outer circle represents the school subjects. The aim is to select a specific subject within the curriculum that game design should meet. The second outer ring is playful elements (Feder, 2020; Elbæk et al, 2923). These represent the connection between play, movement and learning. Placing the playful elements here forces the designer pay attention to a holistic approach in game design. For instance, incorporating "Mastery" into the game experience can enhance the feeling of success. "Communication" can improve the conversation and collaboration between participants during gameplay. "Performance" can support the effort to strive or playing each other well. The second inner ring is game mechanics and structures (Korhonen, Montola & Arrasvuori, 2009) Multiball® offers. The designer can choose to add "Rewards" or "Quests" to increase adherence or add "Time" or "Points" to enhance immersive and engaging gameplay. This circle contains elements and game mechanics that keep challenging the players by making them concentrate for longer. However, it does not contribute to a well-played game itself (DeKoven 2013). The inner ring the 'player aesthetics (Hunicke, LeBlanc & Zubeck, 2004)', describes how the player should feel while playing. Choosing, e.g., "Discovery" lets the player feel a sense of exploring uncharted territory in the game. "Submission" as an aesthetic to support the feeling of playing might reduce boring spare time. Letting the participant engage emotively with the game make a pleasurable experience for the player (Loke 2009).

Figure 7: The Design Wheel of Exergame-based Learning

The wheel-form makes the framework adjustable and informs design points. As an iterative activity, the design process utilizes the DWEL adjustable feature, allowing the designer to choose any starting point. DWEL ensures that each design choice supports the overall balance of academic learning and human growth by using the core-colored themes of energy, collaborative narrative, and creative freedom as guidelines for the design. We provide an example of the use in the following discussion and concluding section.

6. Concluding Remarks and Future Perspectives

Grounded in Constructive Design Research as a deliberate approach, co-design workshops with HUT and LYMB.iO, showed the bridging holistic potential of exergame-based learning design as it combines movement, technology and academic learning.

We saw how holistic development occurred through playful approaches grounded in creative embodied cognition (Malinin 2016). The design of movement-based learning environments, as used in the HUT-workshops, should inspire future classroom sessions to emphasize co-creation and coliberation. HUTs insights of energy, collaborative narrative, and creative freedom were central to generating important insights into holistic domains of child development. To guide such learning environment exergame developers and designers are invited to use DWEL as it frames play and movement into socially embedded practices in educational settings. This was tested throughout an early-stage prototype for the Multiball at LYMB.iO.

The exergames success on holistic development depends on how exergames are designed, integrated, and moderated within the educational context. Trying to do so, we worked strategically with DWEL to develop a math-game. Note that the wheel has been adjusted after this game was created (Figure 8). Starting from the outer ring, we literately constructed our game. We chose the school topic we wanted to address. Then we chose how we wanted the player to feel while playing. Then what opportunities Multiball could give us from the mechanics. And lately what playful elements we wanted to incorporate. When these characteristics were chosen, we started to draw our game. First on paper and then made a prototype in Unity®. We ended up with the game in Figure 9.

Figure 8: First version of using DWEL

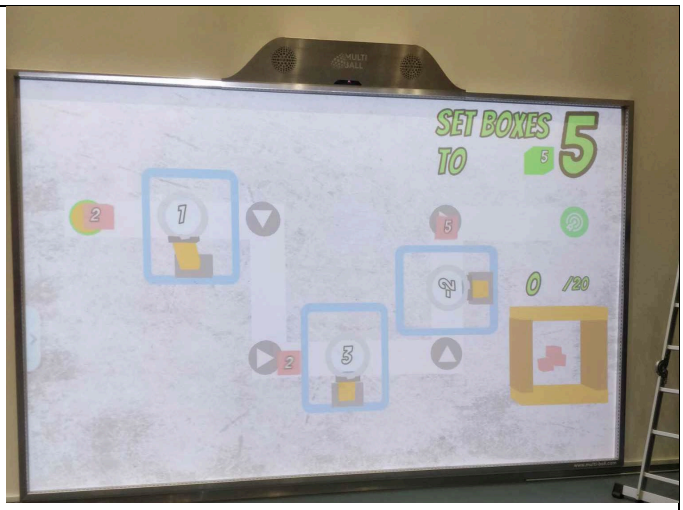

Figure 9: Math Game prototype

As stated in the introduction; a critical question for moving forward is whether we can design exergames to become sustainable tools for cultivating not just knowledge, but whole-child development in schools (Aloizou et al, 2024, Skovbjerg et al 2024, Steenholt, 2023, Händel, 2023, Lund, 2024). DWEL covers the gap between strategic exergame design and children's learning opportunities in the 21st century. Thereby contributing to the field of movement-based learning designs that provide practical guidance for developers, educators, and researchers to create playful, holistic, and educational exergame experiences that meet the evolving needs of children in today's schools.

The study suggests that integration of digital technologies and exergames holds considerable promise for fostering holistic development, when integrated and monitored thoughtfully. Digital tools are no longer external additions to learning environments but are embedded in both cognitive and social fabrics of today's classrooms (Aloizou et al, 2024, Dindler, Smith & Iversen, 2020). Our study showed that playing well-designed exercises can

support collaboration, creativity, and personalized learning pathways when facilitated properly. As we saw in the HUT-workshops, exergames can be powerful tools for immersing students through interactive, playful experiences that seem to engage them in their activities throughout the workshops. However, the potential for exergames must be balanced against concerns around unstructured use, lack of digital competencies and implementation obstacles (Bottino, 2020; Dindler, Smith & Iversen, 2020). That made us use the insights from HUT-workshops to reflect core dimensions of holistic development and serve them as foundational pillars in creating the Design Wheel of Exergame-Based Learning (DWEL).

We recommend that future design adopt the DWEL framework as a tool for balancing educational aims with playfulness, bodily engagement, and movement-based activities. Games in the format of our exergame-based learning should not be seen merely as gamified activity but as a strategic, holistic approach to 21st-century education as Dindler, Smith & Iversen points out (2020). While DWEL offers a promising framework for bridging movement, play, and learning, it raises important questions for future research: Can exergame-based learning promote sustained holistic well-being and academic success over time? How do different school environments, cultural contexts, and technological access impact its effectiveness? Longitudinal studies and real-world applications are needed to assess whether exergames can move beyond short-term engagement to foster lasting physical, cognitive, and emotional development in children.

Ethics declaration: This study involved workshops with schoolchildren and followed University of Southern Denmark's Ethics Committee guidelines.

AI declaration: ChatGPT has been used for adjustments e.g. merging text pieces and spell- and grammar checking during the writing of this article. The adjustments suggested have been used as inspiration and informed the content rewritten in own words.

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