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Affording Embodied Learning in and Beyond the Classroom Environment: A Sample Study in the Belgian Secondary School Landscape

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Introduction

The influence of movement on learning

The traditional approach of educational environments involves learning while seated. Several studies highlighted the negative consequences of prolonged sitting, such as effects on well-being ranging from mood to overall health-related quality of life (Penedo & Dahn, 2005). Being more physically active may enhance well-being (Gomez-Pinilla & Hillman, 2013), and even enhances brain processes related to learning and memory (Colcombe et al., 2004; Praag, 2008; Cotman et al., 2007). Another way to break the sedentary culture is embodied learning. Herewith, the learning process and physical activity are combined simultaneously (Schmidt et al., 2019). Embodied learning derives from the theory of embodied cognition, which underscores the significance of the dynamic interplay between the body and the brain (Wilson, 2002). It emphasizes the integration of cognitive processes into a sensorimotor framework, including sensory input, perceptual processing and muscle control (Koziol et al., 2012). The implementation of embodied cognition and embodied learning seems to positively affect emotions and academic performances: Learners who studied a new foreign language via embodied learning (e.g. gestures or task-related physical activities) where more enthusiastic (Toumpaniari et al., 2015). This positive attitude can benefit the learning performance, but embodied learning also directly affects academic performances. Previous research found positive effects of embodied cognition on the learning outcomes of language courses and mathematics in primary school children (McClelland et al., 2014; Mullender-Wijnsma et al., 2019). Embodied cognition during science classes for toddlers even improves the ability to recall learning matter (Mavilidi et al., 2017). Research of embodied learning in secondary education is limited. Positive but minimal effects on satisfaction and learning outcomes for French and Geography in secondary education were previously found (Everaert et al., 2023).

The influence of the educational environment on learning

The learning environment designed for toddlers and preschoolers is well equipped to enhance a more motion-driven learning process. Especially preschool design is well advanced: play, nature and hands-

on learning is more promoted (Rasmussen, 2021), and flexible spaces are more common to stimulate interactive lessons (Eberhard, 2009; Brock et al., 2013). Unfortunately, the transition from primary/elementary school to secondary school introduces more sedentary behavior (Pearson et al., 2017), causing the classroom environment may not be conducive to a more active environment. However, the typical rows of tables and chairs that fill classrooms can be replaced with flexible furniture. Kariippanon et al. (2017) delves into the perceived connection between flexible learning spaces and their impact on teaching, learning, and overall well-being outcomes in primary and secondary schools. Results indicate that flexible learning spaces 1) support student-centered teaching methods, 2) are more inclusive, and 3) increase student's autonomy, engagement, and enjoyment (Kariippanon et al. 2017). Furthermore, classroom design can even affect learning processes. Using virtual reality, students immersed themselves within different design configurations while completing memory tasks. Results revealed that narrow classroom width and high lighting color temperature negatively affected both male and female students' memory (Nolé et al., 2021). In primary school, academic performances were hampered when 1) insufficient space was available for each pupil or 2) the classroom conditions were too dense (e.g. number of pupils in the classroom) (Maxwell, 2003). Academic performances within primary school pupils are advantaged by following outdoor math and science classes (Khan et al., 2019). Even classroom behavior from pupils (e.g. collaboration and engagement) benefit from flexible learning spaces (Kariippanon et al., 2019).

To explore and incorporate the concept of 'facilitating learning' through design, designers can rely on the affordance theory. This theory builds upon what actions an environment can 'afford' (provide) to its users (Norman, 1999). Affordances connect environments and their respective users through 1) the users' perceptual system, 2) the users' abilities, 3) the characteristics of the environment and 4) the compatibility amongst all the aforementioned elements. In design theory, Norman (1999) was one of the first to discuss and integrate the concept of affordance theory, but many more followed (e.g. Maier & Fadel, 2008b; Rietveld & Kiverstein, 2014). Stevens et al. (2019) applied the affordance theory within an architectural context by underlying that an environment is very rich and abundant in resources, when looked through a designer's point of view. In 2019, the authors launched the concept of 'spatial

flourishing affordance': an *"environmental affordance that invites, incites and enthuses users to undertake activities that the environment enables, in order to fulfill their psychological needs and personal goals"* (Stevens et al., 2019). This concept introduces new perspectives and broadens purposes solely regarding flourishing. Previous research already focused on designing for human flourishing, meaning that environments are designed in order to stimulate the users and fulfill their psychological and emotional needs (Stevens et al., 2019). Using the lens of the embodied learning framework, affordances can be recognized to conduce motion. In other words, to detect and develop spatial motion affordances, referring to stimulating physical motor movements through environmental properties. Here, we believe in the potential of screening our existing school landscape on learning affordances for embodied learning by investigating quick wins. Thus, we do not aim to develop a novel typology of schools. We tend to work with the existing setting, which in Flanders is represented by a rather deferred maintained patrimonium. 50% of the schools are still located in the same type of buildings or have the same interior as during the second part of the 20th century (AGION jaarverslag 2020, 2020; Van Den Driessche, 2009). In that respect, we view our current situation as the status quo, and start from the opportunities that can be present in the building parts of the school environments. Hence, current study focuses on embodied learning and the possible accompanying learning affordances in the environment (i.e. stimulating learning abilities through the environmental design and its properties).

Purpose present study

To recapitulate, firstly, previous research mainly focused on the effects of embodied learning on well-being and academic performances in elementary- or primary school children. Secondly, when zooming in on the school architecture and the design level, rows of tables and chairs still typically fill classrooms, especially in secondary education, and challenge a more dynamic style of teaching and learning. Thirdly, previous research focusing on the influence of the educational environment on the learning process, manifests itself mainly on: 1) furnishing level (i.e. integrating the flexible furniture) and 2) the decorative level (i.e. lighting fixtures). Lastly, to stimulate learning through design, designers can rely on the affordance theory and concept of 'flourishing'. Nevertheless, these concepts are unexplored in

the field of learning affordances for embodied learning in an educational environment. Hence, current study focuses on spatial parameter level as well as the level of the pupils in secondary education. The following two research questions are studied.

1. Which spatial parameters hamper or facilitate embodied learning in a school environment according to pupils and teachers? Herewith, we focus on a spatial and environmental perspective. There will be started from the existing context by assessing if the current secondary school design facilitates embodied learning. It will be assessed which spatial parameters and respectively architectural scale level are imperative.

2. What learning affordances do pupils see and where do they anticipate on, in the current school environment to engage in embodied learning? Herewith, we focus on the perspective of the pupils themselves. It will be explored how the creative view and insights of pupils recognize opportunities in their current school environment to engage in embodied learning.

Methodology

Participating schools

The Flemish educational system consists of following 1) three-and-a-half year of pre-school, 2) six years of primary school and 3) six years of secondary school (Structuur En Organisatie Van Het Onderwijssysteem, n.d.). The secondary school system consists of three grades, each consisting of two grade levels (Het Voltijds Gewoon Secundair Onderwijs, n.d.). Four secondary schools in Flanders, Belgium, participated within the current study: 1) A school offering specialized pedagogical and didactic methods such as Dalton or Freinet, better known as ‘method education’ (Methodescholen, n.d.); 2) a Special Education school giving education to pupils with autism without intellectual impairments; 3) a Catholic Education school and 4) a Community Education School, both following the principles of regular secondary education. None of the four participating schools had prior knowledge of embodied learning. The authors opted to include these four different secondary schools to provide a realistic image

of the diverse Flemish school landscape, characterized by the school's pedagogic vision as well. The latter can influence the vision, insights and creativity of the pupils themselves.

Design

Given the aforementioned research questions, a qualitative research approach was aimed to capture participants' psychological needs, perspectives, thoughts and certain behavior about embodied learning within the school environment. Therefore, we firstly organized an information session towards the participating schools about embodied learning and the study design.

RQ 1. Which spatial parameters hamper or facilitate embodied learning in a school environment according to pupils and teachers?

Sticky note experiment

Teachers and pupils were shown five distinct visual fragments, which are detailly discussed in the result section. Each video fragment took approximately 30 - 60 seconds, and represented persons performing embodied learning. A diverse range of embodied learning examples were shown. Participating teachers and pupils were provided with an amount of red and green sticky notes. Following the screening of one fragment, the pupils and teachers were allotted time to think and wander around the school domain. They were asked to take a detailed approach and look at the entire area of school spaces, fixed elements within a space (e.g. staircases, windows, doors), flexible elements within a space (e.g. furniture) and materials within the school environment, that either facilitated/stimulated (green sticky note) or hindered/hamper (red sticky note) the form of embodied learning shown in the fragment. The researchers underscored that this could include all spaces within the school domain, both indoor and outdoor, that are accessible to pupils. Additionally, when sticking a sticky note to an environmental element, they were asked to briefly write down on the sticky note *why* this environment element either hampers or facilitates the embodied learning method. These procedures were carried out in an individual manner from their own perspective. The sticky notes were systematically anonymously numbered based

on the corresponding fragment, and a distinction was made between responses from teachers and pupils. Participants were free to stick and fill in as many sticky notes they wanted/needed. If the elements were not within reach, sticky notes were pasted in the near area and the participants wrote a detailed description and clarification on the sticky note. The experiment was repeated for each of the embodied learning fragment.

Focus group

Following the sticky note experiment, per class, the participating teachers and pupils engaged in a collaborative discussion on their experiences and responses on the sticky notes, together with the researchers, providing additional insights into elements that are deemed essential for the effective implementation of embodied learning. These dialogues were recorded anonymously through audio recordings, and transcribed verbatim in the analysis phase using NVivo 20.7.1. More information about the focus group progression can be found in the supplementary materials.

RQ 2. What learning affordances do pupils see and where do they anticipate on, in the current school environment to engage in embodied learning?

Learning method experiment

In order to examine what learning affordances the pupils see and where they act on related to embodied learning, we assigned pupils to learn a geography lesson given its comprehensibility and widespread inclusion in the secondary education curriculum. Pupils were presented a world map illustrating continents and oceans, with a maximum allotted time of 10-15 minutes to familiarize themselves with this map through embodied learning. The pupils were free and could be as creative as they wanted to execute embodied learning based on what learning affordances they saw. Researchers conducted anonymous video recordings of the pupils, abstaining from capturing facial features or distinctive attributes, to document their movements, which were visualized afterwards through architectural sketches. There were no requirements for pupils to remain within the classroom where the instruction was provided or to stay indoors. Additional objects were supplied for optional use, such as soccer balls,

a jump rope, cones, and sitting balls. No limits were posed on using objects or on executing several manners of embodied learning. The pupils could switch. The researchers explicitly communicated that pupils would not be scored or evaluated based on which embodied learning forms they would use. The first author observed the pupils if they effectively learned and moved throughout the experiment. The number of participants per school for the sticky note- and learning method experiments, and focus group are represented in Table 1. Pupils in the first grade were aged 12-14 years, and pupils in the second grade were aged 14-16 years.

Table 1: Overview of the number of teachers and pupils participating in the sticky note- and learning method experiment, and focus group.

Sticky note and learning method experiment			
School	Teachers	Pupils first grade	Pupils second grade
Community Education	3	0	6
Special Needs Education	3	5	2
Catholic Education	3	6	0
Method Education	3	6	0
Focus group			
School	Teachers	Pupils first grade	Pupils second grade
Community Education	3	0	6
Special Needs Education	3	11	4
Catholic Education	3	6	0
Method Education	3	6	0

Results

RQ 1. Which spatial parameters hamper or facilitate embodied learning in a school environment according to pupils and teachers?

Two experiments and a focus group were conducted in which school spaces were discussed. A comprehensible photo collage of these spaces can be found in Figure 1.

Figure 1: Overview of the discussed school spaces throughout the sticky note- and learning method experiment, and focus group. 1 - Big classroom according to the participants' opinion; 2 - Small classroom, used for language courses, according to the participants' opinion; 3 - Technique room with high tables and chairs; 4 - Science room with high tables and chairs; 5 - Science room; 6 - Technique room; 7 - Kitchen; 8 and 9 - Study/learning area outside the classroom.

Sticky note experiment

For every discussed fragment, firstly, a short description is given of what was showcased in the fragment. Secondly, we report on where the sticky notes were found and what keywords the participants

wrote. Thirdly, the framework of architectural levels (Table 2 supplementary materials) was used to structure the findings. Examples of how sticky notes were sticked are represented in Figure 2.

Figure 2: Examples of the sticky note experiment. Green or red sticky notes were pasted on materials, furnishing, spaces and so on in the school environment.

Fragment 1

Fragment 1 showed two individuals: one sitting on a wobble chair and one sitting on a sitting ball while studying subject matter. For all participating schools, sticky notes were found scattered throughout the entire school complexes: regular classrooms, learning/study areas beyond the classroom, hallways, and outdoor environments. Pupils provided remarks on these sticky notes regarding the **size and spatial proportions of the spaces**, hinting that the space needs to provide enough free space to use a sitting ball. If that was the case, a green sticky note was given (figure 1.1 and 1.8). Numerous sticky notes were found on the level of **'properties of materials'**. Pupils pasted red sticky notes on carpet floor finishings, since the carpet would hamper the free movement of the sitting ball because of resistance. On the other hand, hard floor finishing, such as ceramic tile, would allow the sitting ball to move much smoother (green sticky notes). However, it would create a great deal of collateral noise that, in turn, disturbs other pupils their learning processes.

Fragment 2

Fragment 2 shows learning individuals using a bicycle desk (stationary bike combined with a desk) or walking desk (a slow treadmill combined with a desk). For all participating schools, participants did

not see the use of walking- and bicycle desks as feasible in their current small classrooms because of the limited ground surface area and so-called sensed ‘overload’ of tables and chairs. However, instructional spaces or learning areas - larger in surface area to move - were deemed more suitable. Furthermore, regarding the architectural level of ‘**properties of space’** some pupils noted on the sticky notes that areas with bad acoustics hinder the use of walking- and bicycle desks since both may produce noise. Especially the pupils in the special education school indicated that too much noise pollution can distract them from learning. In addition, few pupils mentioned on the sticky notes that the walking desk is difficult to use for mathematics or language courses because the movements may hinder writing and drawing. Also, practical lessons in kitchens or science instruction rooms are not seen as ideal to implement this form of embodied learning because a large enough desk is needed to execute the practical sessions (figure 1.4 and 1.7).

Fragment 3

Fragment 3 shows a teacher which divides the chalkboard in two sections: ‘false’ and ‘true’. The teacher asks the pupils ‘true-false’ questions about the subject matter. Pupils jump towards left (=false) or towards right (=true). Pupils in all schools wrote on the green sticky notes that this form of embodied learning is ideal to implement at the playground when the weather allows. Furthermore, numerous sticky notes were found regarding the levels of ‘**types of spaces’ and ‘design elements’.** The fragment would be implementable in study areas and all classrooms if tables and chairs are loose elements. However, pupils mentioned that science, arts or technology classrooms (figure 1.5 and 1.6) are hindering because of the fixed furniture. Furthermore, the areas need to be large enough (in terms of surface) to put furniture aside in order to make place to jump and move.

Fragment 4

The fragment shows a teacher which divides the chalkboard into two sections by writing ‘false’ and ‘true’. The pupils formed a row. The teacher asked every pupil one question and threw a small ball towards the first pupil in the row. When the pupil thought the answer was false, they caught the ball and raised his/her left hand in the air. When the answer was true, the pupil caught the ball and raised

his/her right hand up. According to the participants, this type of embodied learning is possible in several **types of spaces**; ranging from regular classrooms, learning/study areas, playgrounds to sports halls. Important to note: pupils and teachers of all schools indicated on the green sticky notes how crucial an enough space – space between tables and chairs to form a row - is to implement this fragment. Therefore, green sticky notes were pasted on the study area spaces. Some pupils - especially the students of the special education schools - indicated on the sticky note that this type of embodied learning makes them focused on both the subject matter and catching the ball. Therefore, they see this form of embodied learning as stimulating to keep their focus on the subject matter. Rooms where the practical subject matter was taught, such as the kitchen or science room, are seen as hindering because of loose elements (e.g. cooking gear, lab material), which may be dangerous to overthrow, related to the **'design elements'** part of the architectural level. Small classrooms (figure 1.2), with lots of chairs and tables are also seen as hindering.

Fragment 5

Embodied learning took place while seated, offering two variations. The first involved moving a soccer ball forth and back using one of both feet of the pupils, while the second variation showcased the individual in the video moving one foot up and down using the tip and ankle of the feet while seated. Pupils and teachers were the most positive of this form of embodied learning in terms of being 'implementable' in all classrooms. Participants did not paste red sticky notes on classrooms regarding classroom space and surface as for the other video fragments. Furthermore, study/learning areas and instruction rooms were also seen as suitable. Despite these positive opinions, pupils often wrote on the red sticky notes that the sound of the movement of the feet or the movement of the ball may produce too much noise (e.g. pounding), which in turn can lead to reduced focus. These factors are linked with the **'properties of space'** and **'properties of materials'** regarding the architectural level. The technique and science classrooms were also seen as hindering because of high tables and chairs, since the feet of the pupils cannot be placed on the ground (figure 1.3 and 1.4). The playground areas are also seen as not suitable given the limited possibility to sit.

Focus group

During the focus group discussion, following aspects were noted: teachers and pupils discussed the **use of objects in relation to their properties.** For instance, they mentioned a ball, a walking- and a bicycle desk, and a sitting ball in combination with acoustic characteristics during use. By assessing where these objects could be used, the acoustics seemed to be a crucial factor. According to the pupils and teachers, balls made of a soft material were preferred as this causes less noise pollution. Throughout the focus group, pupils indicated they would like to execute embodied learning using a walking- or bicycle desk, but mentioned their concerns about possible noise pollution. Secondly, **limited space in terms of ground surface** was also assessed as a factor hampering the usage of sport objects:

> *"Pupils are already sitting with 23 of them in one small room. If we would execute embodied learning using a sitting ball, it is not possible, it is impossible." - I., teacher.*

In relation to surface restrictions, pupils linked the available **ground surface to the furnishing** present in the particular space, as one stated:

> *"Some classrooms are full with tables while not always every table is used by a pupil. We could miss some tables in order to have more space to execute embodied learning." - E. and L., pupils.*

In addition, some participants (pupils and teachers) indicated that the **proportions of the space** are also important in facilitating movements:

> *"A narrow deep classroom is hindering to implement embodied learning, since it is very difficult to move like that and to set aside tables and chairs in order to move." A., teacher & L., pupil.*

These aforementioned aspects all relate to spaces that were instinctively sensed and labeled by pupils as rather 'small', see figure 1.2. On the other hand, the pupils in the focus group also mentioned the rather 'large' areas in their schools, such as 'study areas' or 'learning areas' or 'cafeterias', that were often used as spaces in which they can study independently (figure 1.8 and 1.9). These areas consist of more ground surface and were therefore indicated as more suitable for embodied learning. For example,

bicycle desks and walking desks could certainly have a place here, according to the pupils. Thirdly, other aspects regarding **adjustable or flexible furniture** were also discussed. The classical row set-up (Figure 3 - left) of tables was mentioned as hindering embodied learning because of a lack of free space to execute movements, with or without objects. Tables placed in islands (Figure 3 - middle) would provide more freedom for movement according to the pupils. A combined arrangement (Figure 3 - right) in which, for example, benches are placed on the side of the space so that movement can take place in the middle of the learning space, is a suggestion made by one of the teachers. Fourthly, during the discussions on the (lack of) available ground surface and the link with noise pollution, some teachers and pupils steered to the outdoor spaces. Pupils also indicated that they would like to learn outside, but are not familiar with it. However, teachers of the 'method education school' actively use the outdoor space:

> *"We teach outside regularly, when the weather permits it. Regarding the embodied learning, I think it would be much easier to create an 'embodied learning space' outside the classroom without disturbing other classes. Learning outside is different, it is not a classical teaching event in a classroom." - A., teacher.*

Finally, regarding the **objects for embodied learning**, the sitting ball was very popular. Pupils and teachers of all four schools see this object as stimulating to execute embodied learning. A pupil of the special education schools explicitly said:

> *"The biggest advantage of the use of the sitting ball is the choice of movement. I can choose when to stop, when to move and what movements to make." - R., pupil*

Figure 3: Table set-up in the school environment. Left - row set-up; middle - island set-up; and right - combined arrangement.

RQ 2. What learning affordances do pupils see and where do they anticipate on, in the current school environment to engage in embodied learning?

Learning method experiment

Table 3 presents how often pupils chose a particular form of embodied learning when executing the task that was given to them. Distinction is made between whether or not an object was used and, if applicable, which objects pupils chose. Firstly, it was noticeable that in all four schools, pupils were little intended to leave the classroom spontaneously to execute the task, even though it was explicitly mentioned that pupils had the opportunity to execute the embodied learning throughout the entire school environment, indoor and outdoor spaces included. Pupils seemed to be searching for a spot within the classroom space and were hesitant and even reluctant to leave the classroom to explore other spaces. Secondly, pupils seemed more willing to use physical objects to execute embodied learning: objects provided by the researchers as well objects found in the environment by pupils. In Figure 4, a series of visualizations of pupils executing their task are presented. Regarding the choice of objects, pupils spontaneously reached for the sitting ball or soccer ball in all participating schools. Regarding the sitting ball, all pupils who used this object moved in a similar way: wobbling up and down, and moving forward/backward (Figure 4, illustration 1). Regarding the soccer ball, one pupil diagnosed with autism in the school for special education (Figure 4, illustration 2) and one community education pupil (Figure 4, illustration 3) used their hands to pass the soccer ball. Another pupil from the ‘method education school’ placed the subject matter on the chalkboard and bounced the soccer ball against the same board to learn the subject matter (Figure 4, illustration 4). The other pupils who used the soccer ball moved the ball from one foot to the other one (Figure 4, illustration 5). Standing or using cones are both forms of embodied learning used less. One pupil diagnosed with autism (Figure 4, illustration 6) chose to walk between the cones, and one student learned the subject matter while skipping ropes (Figure 4, illustration 7).

Table 3: Overview of the number of chosen objects and forms of embodied learning for the learning method experiment by pupils.

		Special Needs Education	Method Education	Catholic Education	Community Education
Objects	Sitting Ball	2	2	3	2
	Soccer ball	2	1	4	1
	Cones	1	/	1	/
	Rope	/	2	/	1
No Objects	Walking	2	/	1	2
	Standing	/	1	1	/
Classroom		7	6	10	6
Other areas except classroom		/	/	/	/

Note: Pupils could have used multiple objects since they sometimes changed their chosen form of embodied learning or combined two objects.

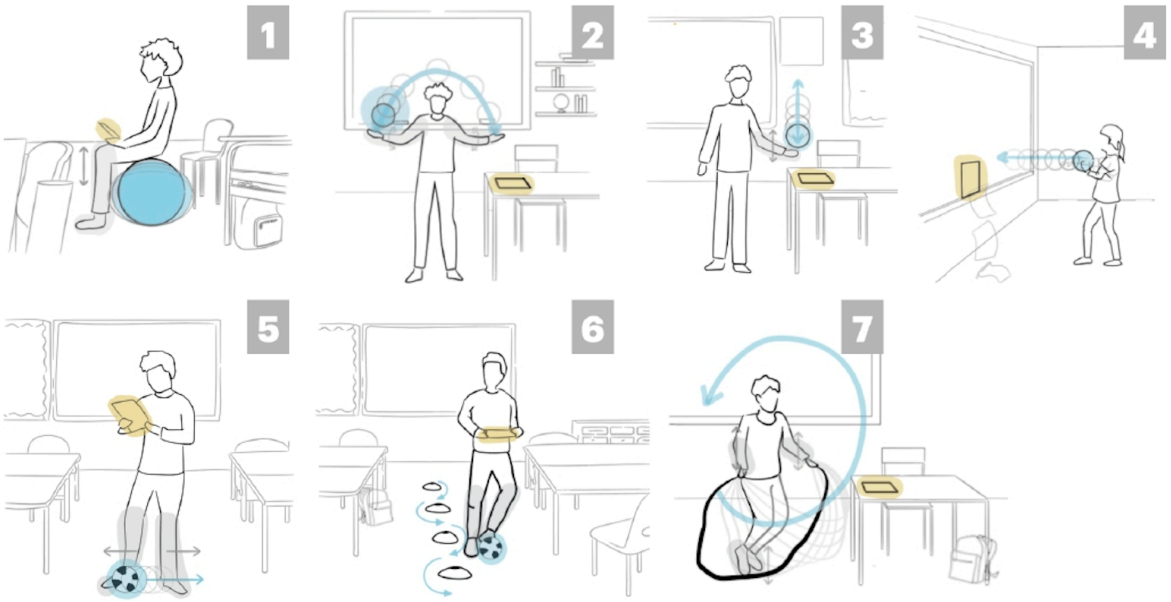

Figure 4: Illustrations of pupils executing the learning method experiment. The light grey-colored zones cover the body parts of the pupil that are in motion when executing the embodied learning task; blue-colored zones cover the used object that is in motion, and the yellow-colored zones represent the subject matter. 1 - A pupil uses a sitting ball to learn the subject matter by wobbling up and down, and moving forwards and backwards; 2 - A pupil uses their hands to alternately catch the ball; 3 - A pupil uses their hand to throw up the ball; 4 - A pupil uses their hand to bounce the ball against the chalkboard; 5 - A pupil uses their feet to move the soccer ball from one foot to the other; 6 - A pupil uses their feet to move the soccer ball between several cones; 7 - A pupil uses a skipping rope to learn the subject matter.

Discussion and conclusion

Current study investigated 1) 'Which spatial parameters hamper or facilitate embodied learning in a school environment according to pupils and teachers?' and 2) 'What learning affordances do pupils see and where do they anticipate on, in the current school environment, to engage in embodied learning?' Hence, a reflection on the results was made through the lens of 'learning affordances through the environmental design' which was introduced earlier on in this paper. Consequently, interesting links were found regarding some architectural levels.

On a **'design elements - furnishings'** level, objects that had the explicit and sole purpose of eliciting movement were positively encountered by pupils and teachers, such as the sitting ball (learning method experiment). But, when looking through the lens of 'learning affordance', it became clear that the sitting ball was used mostly in its most common use, to wobble up and down, and to make circular motions while sitting on it. Pupils did not further experiment with the spatial characteristics of the ball and link it to their needs with regards to movement. For instance, using it as a gigantic football or rolling over it with the entire body. Overviewing the data of the experiments, it can be concluded that within the researched population, little alternative affordances were picked up regarding alternative movements that a predestined object could enhance. Hence, the pupils did not feel the need to move when trying to learn. This may be explained by the fact that the participants have not yet experimented enough with studying various courses while being aware that one is executing some form of physical activity. Secondly, on a '**properties of materials'** level, pupils made the connection with soft flooring such as carpets that could 1) complicate the free movement of a sitting ball in use and 2) having the ability of muffling the ambient noise caused by a sitting ball in action. Hard floorings were assessed as a better type of furnishing to facilitate sitting ball movements, but cause ambient noise, which hampers the participants. Thus, the pupils showed ability to assess properties and characteristics of two materials that are in contact (e.g. hard floorings and bouncing items) in function of a particular task (e.g. hampering moving around) or in function of comfort (e.g. noise disturbance). Items on the level of **'properties of space'** were approached by the participants equally as the aforementioned level of

‘properties of materials’. Concretely, sufficient available square surface or size proportions of a particular space seemed to be the first precondition in order to consider executing embodied learning (sticky note experiment and focus groups). When deemed ‘large’ enough in square meters floor surface, participants marked entire spaces with a green sticky note. However, it became clear to the researchers that the participants’ assessment was based on other variables as well once the ‘size’ aspect was ticked off. Relating to the architectural level of **‘design elements - furnishings’**, we could notice that the interpretation of ‘large enough’ was endorsed by the visual image of an open space. Too much furniture or fixed objects lead pupils to define the space as ‘not large enough’, hindering embodied learning. During the focus group discussion, these answers were nuanced by solution-oriented lines of thinking, in which for instance the usage of 'adjustable or flexible furniture' were suggested. This could make it easier to create more open space in classrooms for movement and would allow the space to be used for sitting, standing and/or moving. Finally, the level of **‘types of spaces’** had little occurrence in the decision-making process. Strikingly, pupils and teachers clearly indicated during the sticky note experiment that the environment is important to engage in embodied learning, but when given the free choice to select a proper space to execute it, and letting them engage in free choice physical movements by interacting with whatever environmental aspect is available in the environment (learning method experiment), they mostly stayed within their classrooms. Pupils gave the impression of being programmed to take lessons in a traditional classroom environment. Hence, the combination of a ‘classroom’ type of space and the interior packed with tables and chairs is what currently ‘afford’ learning for pupils. Strikingly, pupils from the ‘method education school’ saw more possibilities in receiving embodied learning lessons outside (playground). This finding can be explained by the school vision and education, which is different compared to regular/classic secondary education.

Conclusion

In summary, the first research question stated: ‘Which spatial parameters hamper or facilitate embodied learning in a school environment according to pupils and teachers?’ Herewith, associations between embodied learning and the following architectural layers were found: ‘properties of spaces’ (e.g. enough

space to move, acoustics of the space), ‘properties of materials’ (e.g. noise of embodied learning objects, floor finishings) and ‘design elements’ (e.g. furniture, sport objects). Hence it can be concluded that these architectural levels were the most significant for pupils and teachers in order to execute embodied learning. Secondly, the current study investigated: ‘What learning affordances do pupils see and where do they anticipate on, in the current school environment, to engage in embodied learning?’ Based on the results herewith, it can be concluded that the pupils have a limited scope in various types of architectural elements/objects that could intuitively be included in their assessment of ‘affording some form of interacting with it when learning’. The objects that they see fit to afford embodied learning, can almost all be found in two of many architectural levels (i.e. the possibilities in the very specific furniture or flexible objects on the level of ‘design elements - furnishings’). Even in this respect, we could conclude that the spatial learning affordance that was recognized and acted upon, was linked to its intended use. Exceptionally, a small number of pupils searched for more innovative ways to interact with spatial elements while learning, and method education school pupils did feel more comfortable to extend their learning affordances outside the indoor classroom. Hence, there is too much undiscovered potential in the school environment since pupils do not use the whole school environment and all its purposes (e.g. wall, floor, ceiling). Besides, pupils were capable of reflecting on the implications of using a design object for embodied learning in its actual environment. While seemingly being unable to recognize or dare to recognize a variety of possible motions the objects afford, they could see in what way the spatial or material characteristics of an object in relation to the place it is used in, cause conflicts. This connection made by the pupils stretched to incorporate not only the host environment (e.g. furniture present in a space could hamper free movement), but also the other people involved, which is positive. From an affordance perspective, pupils showcased to be able to pick up on spatial aspects that might afford or hinder certain action or comfort in the classroom.

To conclude, while pupils struggle to recognize embodied learning opportunities via what is afforded by objects, elements or spaces, they were able to assess whether the physical properties/characteristics of those objects/spaces/elements might hamper or facilitate physical movement in relation to comfort. Crucial, in the studied population there seems to be a missing link in connecting the act of learning to

the physical properties of the environment one is surrounded with. In a pupils' mind the *learning* environment seems to be delineated to a classroom and does not cover the whole *school* environment. A reason could be that their mindset is on 'learning mode' when they are in their classroom, sitting at their desks. We hypothesize that architectural designers can break open this narrow-minded look on the environment by playing with the atmosphere throughout the entire school environment. A reason for the rather limited proportions of the 'learning environment', can be the fact that the Belgian educational system is based upon a very sedentary learning style once transitioning from preschool to elementary school. The attainment targets of elementary education defined by the government (Onderwijsdoelen, n.d.), emphasize this statement: movement principles and motor skills, for example, are emphasized therein. From elementary school on, the focus increases on the acquisition of theoretical knowledge, which is no different in secondary school. This transition to more acquisition of theoretical knowledge and the ancient classical approach that defends the 'sit down in class to learn' principle, probably makes students' learning affordances limited to a classroom space.

Limitations

Despite the strengths and novelty of the current study, some limitations were encountered.

First, a limited number of teachers and pupils participated within the current study, due to some practical circumstances (e.g. difficulties in bringing pupils and teachers together due to school arrangements, or being in the possibility to skip lessons in order to participate). Secondly, participants were not familiar with embodied learning. Hence, the researchers informed the participants by giving an information session and showing several examples of embodied learning. Perhaps, the pupils were not immersed enough within the embodied learning concept, which could influence their learning affordances. Finally, a limited number of objects were provided during the learning method experiment. These offered objects were also linked to the learning affordances of the pupils. Hence, there is a possibility if the researchers offered more and other objects, the learning affordances may be different.

Future research: How can design contribute?

Current study gave insights into pupils' perspectives and dreams of the classroom space. For future research, firstly, reacting to the finding that pupils delineate their learning environment at school to their classroom space, we find ourselves on the brink between architectural design science and social science. We ought to focus on shifting pupils' fixed mind towards the given that learning is a very personal and that it cannot be facilitated by a one-fits-all spatial solution. Pupils should be instigated to find and embrace their proper learning style. When having an open mind, one can learn wherever affordances for the personal learning behavior can be recognized. As designers, we should attempt to break open this narrow-minded look on the environment by playing with the entire school environment. Secondly, from a design methodological stance, we need to study in what way furniture and fixed elements can be designed while also affording various types of physical movements, as these comprise the architectural levels in which affordances were more easily picked up on. However, even in the early stages of the design process, designers should acknowledge the opportunities of structural elements (e.g. staircases, walls) to broadcast motion affordances, and spark ideas of moving. As first hints thereto were found in our study, architects could incorporate aspects of acoustic comfort and flexibility.

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Ethical Statements

The current study was approved by the Medical Ethics Committee of Hasselt University (CME2022/031).

Conflicts of Interest

The author declares no conflict of interest.

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