Learning Environment on the Move: First Design Concepts to Embrace Embodied Learning in Secondary Education

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Abstract
Embodied learning is a recent educational approach that combines learning with simultaneous execution of physical activity. It can enhance well-being and academic performances of pupils. However, in contemporary secondary educational settings, the conventional practice still involves students receiving instruction while being seated. A crucial goal therein is to explore whether classrooms of secondary education schools, given their current architectural design and construction, can embrace the implementation of embodied learning. In pursuit of this goal, a two-track exploratory study was conducted: 1) surfacing which architectural elements in the current classroom environment encourage or restrict the execution of embodied learning, and 2) developing solution-oriented design ideas to facilitate embodied learning. The research focused on secondary school classrooms in Flanders and considered the perspectives of both students and teachers. The results indicated that current classroom environments are not yet optimally equipped to facilitate all forms of embodied learning. However, the solution-oriented designs represented design alterations on diverse architectural scale levels to modify classroom environments, making them more welcoming to embodied learning principles. This exploratory study underscores the need for a more comprehensive focus on embodied learning implementation, the required design adaptations, and further exploration of it.

Keywords: Embodied Learning, Learning Environment, School Architecture, Classroom Design, Secondary Education

Introduction

Movement-Based Learning

Prolonged sitting when learning subject matter in a seated position, is a contemporary phenomenon in secondary education. Extended periods of inactivity are linked with various adverse effects, including low back pain (Mahdavi et al., 2021), alterations in hemodynamic parameters (Tao et al., 2020), increased risks of obesity and insulin resistance (Sisson et al., 2013), and it even affects aspects of well-being such as mood state (Penedo & Dahn, 2005). These consequences explain why it can be beneficial for pupils to implement more active teaching methods at school, such as the integration of physical activity before or during the lessons. Mavilidi et al. (2018) discussed the implementation of school-based physical activity integration for better learning and cognition performances, and mentioned improved cognitive functioning of executive functions such as problem solving, planning, and memory. When learning is combined simultaneously with executing physical activity, it's referred to as embodied learning (Schmidt et al., 2019), deriving from the principle of embodied cognition which emphasizes the importance of the interplay between body and brain (Wilson, 2002). Toumpaniari et al. (2015) found that acquiring a new foreign language using embodied cognition techniques (such as engaging in task-related physical activities), exhibits a significant increase in enthusiasm, which can benefit learning performances. Furthermore, the implementation of embodied cognition caused improvements in learning outcomes of English and mathematics (McClelland et al., 2014), and recalling science course contents (Mavilidi et al., 2017).

Architectural School Landscape

While the learning environments of young children embrace interactive teaching and learning (e.g., learning via playing and outdoor learning) (Rasmussen, 2021; Eberhard, 2009; Brock et al., 2013), the sedentary behavior of secondary school pupils increases (Pearson et al., 2017). This sedentary way of receiving instructions is architecturally linked with classrooms where tables and chairs are prominently present. Unfortunately, these two furniture elements are often not designed to meet the physical and mental needs of every pupil since every individual is different (e.g., posture or supporting optimal performance of school tasks) (Wingrat & Exner, 2005). A solution may be the change towards using flexible furniture. Flexible learning spaces and furniture deviate from passive teaching methods and thus embrace pupil-centered approaches, increasing engagement and autonomy (Kariippanon et al. 2017). This change from traditional passive approaches, which are based on a sedentary classroom environment, to a more inclusive and flexible environment, constitutes a considerable challenge for designing and realizing 'optimal' school environments. A knowledge base for this is still lacking. However, research of the past years focuses on emerging the built environment and the effects on learning and teaching (Gislason, 2010; Tapia-Fonllem et al., 2020), such as 'Teaching Green School Building' where design improves education about sustainability (Cole, 2012). This type of research should be expanded to gain more empirical evidence that links didactical approaches with the classroom environment in which well-being of the users (e.g., teachers and pupils) is incorporated in the built design. Creating environments that foster well-being aligns with the principles of "Design for Human Flourishing" in architecture (Stevens et al., 2019). This approach advocates for the development of design strategies that enable individuals to let them flourish in their environment (Stevens et al., 2019).

Current Study

Research focusing on embodied learning and embodied cognition showed positive results in terms of emotions and academic performances. Pre- and primary school learning environments are well-equipped to support this type of more active learning approaches. However, learning while seated is still the norm in secondary education. A change from these traditional sedentary approaches to a more inclusive, flexible and moving-friendly classroom environment that embraces pupil-centered approaches, constitutes a considerable challenge for designing, building and realizing 'optimal' school and classroom environments, keeping in mind the requirements of its users. A knowledge base and research in this field is lacking.

Current research investigates if classrooms of secondary schools in Flanders (Belgium), based on their current architectural design, are welcoming to embodied learning. Additionally, we seek to enlighten the perspective of teachers and pupils related to this. Based on the aim, the research is divided in a two-track exploratory study: 1) objectifying which architectural elements in the current classroom environment encourage or restrict examples of embodied learning, and 2) developing solution-oriented design ideas to facilitate embodied learning. Hence, the current study screens the present Flemish classroom environment through the lens of its users by addressing design and furnishing on different architectural scale levels. A qualitative research approach, combined with visualization techniques, were used as it is crucial to capture users' perspectives and thoughts about embodied learning within the classroom environment.

Methodology

Design

The current study involved two secondary schools in Flanders, Belgium. Both schools had no expertise or knowhow of embodied learning. In total, eighteen participants of which six teachers and twelve pupils (aged twelve till sixteen), participated in the current study. The Medical Ethics Committee of Hasselt University approved the current research.

Sticky Note Experiment

Conduct of the Experiment.

To objectify which architectural elements in the current classroom environment encourage or restrict embodied learning based on the user's perspective, a sticky note experiment was conducted. Teachers and pupils viewed five distinct photos or video clips of a diverse array of embodied learning examples. Participants were given red and green sticky notes. After viewing each example of embodied learning, they were allotted time to reflect and explore their current classroom. Pupils and teachers were instructed to examine fixed elements (such as windows and doors) and flexible elements (such as furniture) within the classroom, noting which elements either encouraged (green sticky note) or hindered (red sticky note) the example of embodied learning. Additionally, participants were asked to briefly note why each element either encouraged or hampered the example of embodied learning. This process was conducted individually, with each participant's perspective considered. The sticky notes were anonymously completed. The responses from teachers and pupils were put together. The method was repeated for each embodied learning example, for each classroom. In total, the sticky note experiment was repeated three times in three different classrooms. Participants were free to use as many sticky notes as they deemed necessary. If certain architectural elements were out of reach (e.g., ceiling), participants placed sticky notes nearby and provided detailed descriptions.

Video and Photo Fragments.

Fragment one depicted two individuals sitting on a wobble chair and on a sitting ball while studying subject matter. *Fragment two* featured individuals learning while moving on a bicycle desk (a stationary bike combined with a desk) or a walking desk (a slow treadmill combined with a desk). *Fragment three* showcased a teacher dividing the chalkboard into ‘true’ and ‘false’ sections while asking the pupils 'true-false' questions. Pupils indicated their answers by jumping left (false) or right (true), with no equipment involved. During *fragment four*, a small ball was introduced into the embodied learning activity. A teacher divided the chalkboard into two sections, labeled as 'false' and 'true'. The pupils arranged themselves in a row setup. The teacher then proceeded to ask each pupil a question and tossed the small ball towards the first pupil in the row. If the pupil believed the answer was false, they caught the ball and raised their left hand. Conversely, if the answer was true, they caught the ball and raised their right hand. Finally, during *fragment five*, participants engaged in embodied learning while seated. One individual quietly moved a soccer ball back and forth using one or both feet, while another person moved one foot up and down using the tip and ankle while seated.

Solution-Oriented Designs

To develop solution-oriented designs, (interior) architecture design experts and researchers, as well as a researcher in educational studies, compared the participants' answers on the sticky notes together with the floor plans and images of the classrooms discussed (architectural lay-out of the classrooms). These results gave a clear view of encouraging or hindering elements in the classrooms to engage in embodied learning. After this thorough analysis, several possible scenarios for the space were devised, which were brought together in drawn designs to allow more movement. Herewith, possible safety issues and practical feasibility were considered.

Results

For every discussed classroom, firstly, a short description was given of the architectural lay-out of the current state of the room. Secondly, findings were reported of the sticky note experiment. Finally, a solution-oriented design outline was created by combining the architectural lay-out with the sticky note results.

Classroom 1: Technical Classroom

Description Classroom.

The technical classroom is a 7.5-meter by 11-meter space, currently divided into two areas. This division is made by using tables and a movable whiteboard to have a physical boundary between the teaching/theoretical area and the practical area. Within the teaching area, eight double desks are available for sixteen pupils to follow lessons. However, regarding the practical zone, six higher square desks without seating possibilities, fill the room to work on practical subjects. Finally, the practical area where technical labs are executed, is occupied by large closets containing practical materials. Artificial light as well as natural light brighten the room (Figure 1).

Figure 1: Architectural lay-out of the technical classroom.

Sticky Note Experiment.

It was noticeable that many red sticky notes were found on technical infrastructure and equipment in the technical classroom, for fragments one till four. Red sticky notes were also found on the wall which, according to the participants, indicated the poor acoustics of the classroom. Concerning fragment five (embodied learning was executed while seated), green sticky notes were found on tables and chairs. Pupils and teachers indicated that this example of embodied learning would be possible in the current classroom because of sufficient space available for the body to move while sitting on the chairs and using the desks (Table 1).

Solution-Oriented Designs.

The current architectural lay-out of the room and findings of the sticky note experiment were used as a stimulus to develop design alterations for the technical classroom (Figure 2). The purpose of these design efforts was to introduce suggestions for more mobility into the area where theoretical learning is implemented (left area in Figure 2). First, the traditional desks can be replaced with mobile desks that can be placed at the back of the classroom, within the closet that functions as a division between the theoretical and practical area. Secondly, the room can be equipped with an interactive board (e.g., smartboard) on which subject matter is shown (e.g., calculations and outcomes; definitions about technical concepts; …). Pupils can throw a ball (size is of their own choice) in the direction of the board and try to hit the correct answer. Hence, the ball will interact with the board upon impact. A second proposal takes this further, involving a flat board or a wall without a smartboard to which velcro or another substance is attached that can catch and allow a ball to hang. The area where practical subject matter is organized (right area in Figure 2) was more or less retained in order to maintain the goal of executing practical sessions. However, larger tables were designed to create more space for technical infrastructure. Concluding, the design offers a classroom place to sit, stand and move while learning.

Fragment 1: Wobble chair and sitting ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too little space between pupils sitting at the same desk.
	Slippery floor may cause safety issues when using the wobble chair or sitting ball (e.g., falling).
Fragment 2: Walking and bicycle desk	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too much infrastructure (e.g., technical equipment) available in the room causes lack of space for EL.
	Bad acoustics of the room make that the produced noise of EL may hamper focus and concentration.
Fragment 3: Standing without using objects	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too much infrastructure (e.g., technical equipment) available in the room causes lack of space for EL.
Fragment 4: Standing using a ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too much infrastructure (e.g., technical equipment) available in the room may be dangerous for bumping.
Fragment 5: Seated	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
Applicable in the classroom because of sufficient space available.	/

Note: EL: embodied learning. When the same perspectives were given by multiple participants, these results were combined and represented as one row.

Table 1: Overview findings of the sticky note experiment for the technical classroom.

Figure 2: Solution-oriented design for the technical classroom.

Classroom 2: Language Classroom

Description Classroom.
The language classroom has a surface of 6.5 on 10 meters, consisting of fourteen double desks to accommodate 28 pupils. A teacher's desk and whiteboard with beamer projection is even present. A large decorated closet covers the entire right side of the classroom. Two prominent windows above the closet connect the room with the hallway, while the windows on the other side of the room connect the room with the outside environment. Both artificial light and natural light brighten the room (Figure 3).

Figure 3: Architectural lay-out of the language classroom.

Sticky Note Experiment.
According to the pupils and teachers, the language classroom was too small (surface) and too dense (desks/chairs) to execute the shown examples of embodied learning. Hence, a lot of red sticky notes were found scattered throughout the room. However, green sticky notes were pasted on chairs or desks for fragment one (wobble chair) and fragment five, both examples of embodied learning while seated. Participants indicated that sufficient space was available for the seated form (Table 2).

Fragment 1: Wobble chair and sitting ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
Wobble chair is possible to use as an alternative for a chair.	Sufficient space is needed to make room for the sitting ball. Sufficient space is not available.
Fragment 2: Walking and bicycle desk	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too little space in the room for walking- as well as bicycle desks because of the small surface.
	A walking desk is not suited to absorb new subject matter when writing (e.g. fill-in book or making notes) because of the hindering movements made during the example of EL.
Fragment 3: Standing without using objects	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too little space in the room (due to surface and furniture) to jump to the left or right.
Fragment 4: Standing using a ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Too little space in the room because of tables and chairs.
Fragment 5: Seated	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
Sufficient space available.	Moving the feet underneath the desk may produce hindering movements causing difficulties with writing for a language course.

Note: EL: embodied learning. When the same perspectives were given by multiple participants, these results were combined and represented as one row.

Table 2: Overview findings of the sticky note experiment for the language classroom.

Solution-Oriented Designs.

A new solution-oriented design was created by combining the current architectural lay-out of the room and the sticky note experiment's results (Figure 4). The sticky note experiment indicated the lack of space to execute this form of embodied learning in the current classroom. Hence, the novel design allows to create more learning space that goes beyond the boundaries of the traditional classroom. The idea is that the boundary (closed wall) between the classroom and the hallway (2.26m width) becomes an intermediate zone, to create a relationship between these two. Hence, the furniture has the function of a closed wall, a closet and a desk. Furthermore, the design allows the use of closet doors as extra working desks, by horizontally hanging panels, for the pupils if more work space is needed (e.g., group tasks). Some pupils can take place in the hallway and see their fellow classmates through the opened closet. To link the design with embodied learning, this extension between the classroom and hallway can generate interaction by - for example - throwing a ball to each other to rehearse subject matter or to question each other. Walking or bicycle desks and even other materials can be placed underneath the pupils' desk. Hence, this design adopts a classroom with varying combinations in which the classroom can be more broadened and can be a place to sit and move while learning.

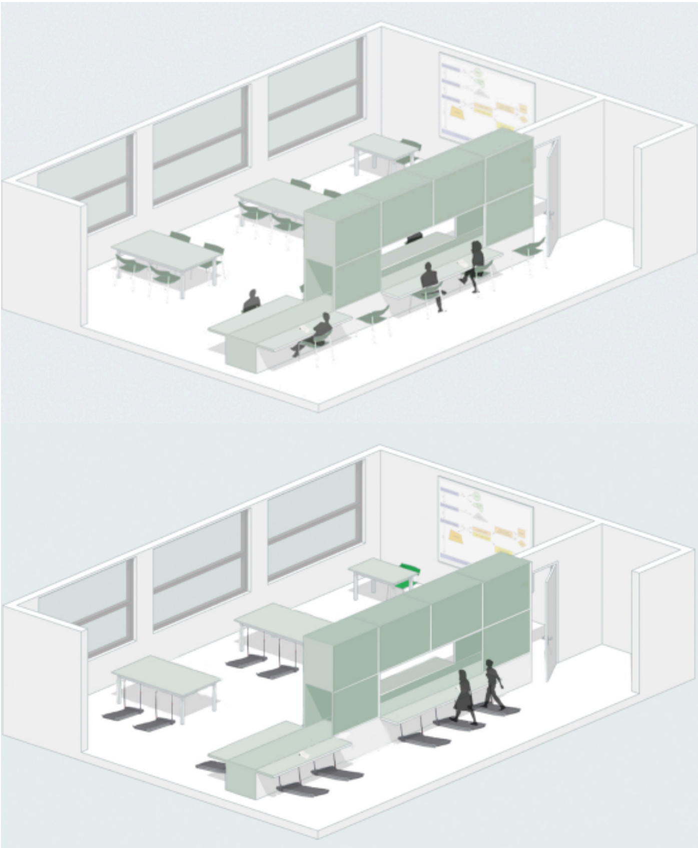

Figure 4: Solution-oriented design for the language classroom.

Classroom 3: Science Classroom

Description Classroom.

The science classroom offers an 8 meter on 11 meters' surface for theoretical as well as practical sessions. At the back of the room, a small storage space (width 2.3 meter) is accessible for teachers and staff. The room is filled with four rows of tables that are higher compared to traditional classroom desks, of which some of them contain a gas valve to be used in practical sessions. Besides the desks, the chairs are higher, compared with the height of a crutch. A large closet with lab material - shielded with closet doors - occupies one side of the classroom wall. The windows on the other side of the room connect the science room with the outside environment. The back of the room is filled with some lab coats and small open closets (Figure 5).

Figure 5: Architectural lay-out of the science classroom.

Sticky Note Experiment.

In comparison to the previously discussed classrooms, the science classroom provided sufficient space (surface and design) for the non-seated examples of embodied learning. However, red sticky notes were pasted on the closet with lab materials (knocking over lab materials) and the high desks (not suitable for executing embodied learning while seated) (Table 3).

Solution-Oriented Designs.

The findings of the sticky note experiment and the present architectural lay-out of the space were combined to develop a new design (Figure 6). The designers opted to ensure that several active learning methods can be executed in this classroom such as practical sessions, groupworks, and embodied learning. The classroom will be equipped with rings, nets will be placed on the walls, and soft balls with a little bounce will be provided. Pupils can throw a ball to the ring or net during rehearsal of subject matter (e.g., interactive quiz) or by classical moments together for studying matter (e.g., every student summarizes subject matter verbally while throwing a ball through a ring - the ball will be passed between students). The lab materials in the closets are protected by a net. Because of the increased height of the pupil’s desks, it can also be used as a standing desk. Hence, this classroom offers several opportunities to sit, stand and move to learn.

Fragment 1: Wobble chair and sitting ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
The room provides enough space (surface) for using the sitting balls.	The desks are too high causing a wobble chair or sitting ball cannot be used together with these high desks.
Fragment 2: Walking and bicycle desk	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
The tables are high enough to locate the treadmill (walking desk) or stationary bike (bicycle desk) underneath them.	The bicycle or walking desks can produce noise disturbance causing difficulties with focus and concentration.
	This form of EL is not useful for practical sessions since the movements made during this form of EL may disturb the precision needed for practical sessions.
	The narrow width of the classroom may not be suited to place enough walking or bicycle desks.
Fragment 3: Standing without using objects	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
The room provides enough space (surface).	The group of pupils need to be small enough since the narrow width of the classroom may hinder jumping of the pupils.
Fragment 4: Standing using a ball	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
The room provides enough space (surface).	It may be dangerous to throw a ball (e.g., knocking over lab materials).
Fragment 5: Seated	
Green sticky note (encouraging EL)	**Red sticky note (hindering EL)**
/	Because of the high chairs, the feet of the pupils do not touch the ground. Hence this form of EL is not suitable in this classroom.

Note: EL: embodied learning. When the same perspectives were given by multiple participants, these results were combined and represented as one row.

Table 3: Overview findings of the sticky note experiment for the science classroom.

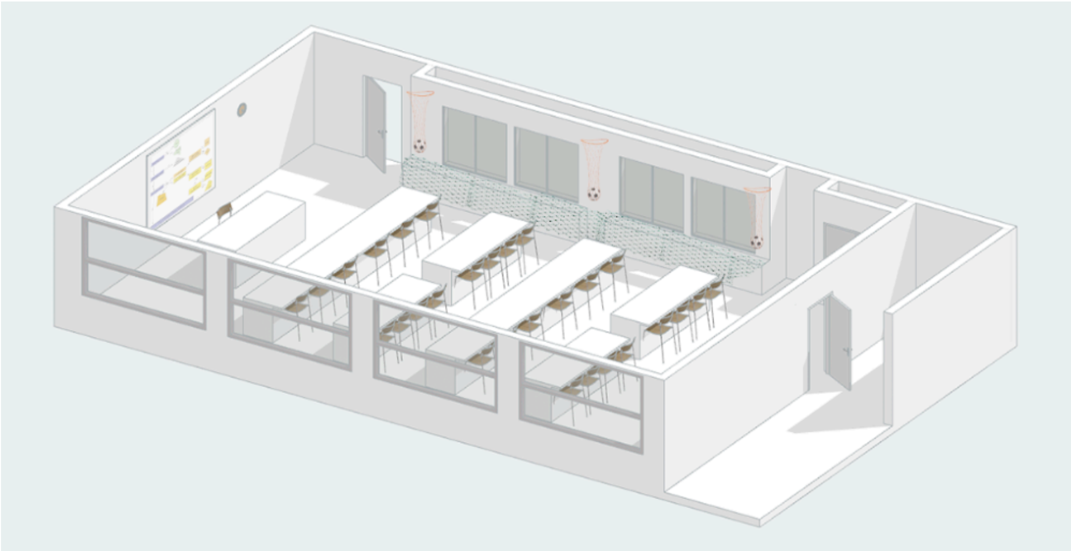

Figure 6: Solution-oriented design for the science classroom.

Discussion and Conclusion

Main Findings

Current research investigated if classrooms of secondary schools in Flanders (Belgium), based on their current architectural design, are welcoming to allow embodied learning to be implemented in the current classroom environment. Based on the aim, the research was divided in a two-track exploratory study: 1) objectifying which architectural elements in the current classroom environment encourage or restrict examples of embodied learning (based on the user's perspective), and 2) developing solution-oriented design ideas to facilitate embodied learning.

The results from current research showed that the examples of embodied learning that were executed while standing, are the most difficult to implement in the current classroom environments due to limited space (surface) as well as the layout and furniture that restricts available space. Forms of embodied learning that involved the use of materials such as walking or bicycle desks, were seen as potentially disruptive for concentration and focus by the pupils and thus making it difficult to pay attention to learn. Finally, embodied learning while seated can mostly be implemented in the current classroom environments as chairs are a part of the traditional classroom equipment in secondary education, and because less surface is needed to execute movements.

Given these results, the solution-oriented designs aimed to offer a range of sitting, moving and standing options to execute embodied learning, but also a range of quick win designs as well as innovative and bigger modifications in the school architecture itself. Hence, the broad range of the designs enhanced the free choice of the pupils to find their ideal learning method to focus in the classroom and it helps to end the prolonged sitting behavior.

Implications

The critical analysis in the current paper of 1) the architectural elements that are encouraging or hindering embodied learning as well as 2) the solution-oriented designs have tried to offer a wide range of possibilities for the teachers and pupils to find their 'ideal' embodied learning implementations. Research by Putman et al. (2024) supports the reflection that well-being and design are linked with each other. Their study focused on the integration of flexible seating: standard chairs and tables are replaced by different options such as stools, coaches, and standing desks. Higher education students scored better on focus, positive emotions and engagement (Putman et al., 2024). Clear conflict-synergy analyses such as these are important research since design interventions can be linked to user's well-being (Putman et al., 2024).

Furthermore, our solution-oriented designs have sought to provide a mix between gross changes (e.g., extending the language classroom into the hallway), as well as quick wins by rethinking and reusing the purposes of current furniture. An example is the use of the higher desks as standing desks in the science classroom. Such interventions take less effort and are less financially impactful for schools. Within the current school landscape, such quick wins are the way to go to embrace and apply embodied learning. Delving deeper into this, the solution-oriented designs can also serve as a starting guide for designers to design other interventions that have lower financial costs (e.g., one piece of furniture that has multiple purposes, such as the high desk of the science classroom). Other architectural elements that were not adequately discussed (e.g., floor, ceiling) need also be considered more into design processes to delve deeper in all architectural scale levels. Nevertheless, it remains a question to what extent interventions can go (e.g., financial or practical limits through constructive interventions). Furthermore, new solutions and new designs may bring new challenges. An example of the science classroom: the designers wished to implement the use of a ball, so safety solutions have been devised to protect the lab material. The use of other materials such as a wobble chair or sitting ball can also bring safety issues. For designers, this could potentially lead to an intensive process of designing, testing, anticipating and going through the same cycle over again.

Limitations and Strengths

The current research uncovered new innovative designs to implement embodied learning in secondary education through the perspectives of teachers and pupils. The designs even went beyond the classroom space by including other areas of the school space. It should be noted that the designers did not have to take into account financial limits or the cost of interventions, meaning that the in-reality realizations of our designs can be expensive in for example a renovation project. However, the designs provide a knowledge base of inspiration that can be taken into account for new school realization projects. The current study represented a limited number of participants and classrooms. However, both were representative of the average Flemish school landscape, making the findings generally valid. The participants had no prior knowledge about embodied learning, resulting that not every architectural scale level was discussed in detail (e.g., ceiling and floor) during the sticky note experiment. The solution-oriented designs were created by bachelor students in (interior)architecture who were adequately versed in knowledge and regulations of school architecture and furniture, as well as the standards of materials in such buildings.

Conclusion and Future Research

Although embodied learning is very beneficial for the learner, we can conclude that the current secondary school landscape in Flanders, specifically the classrooms, are not yet equipped for this educational approach. Classroom's surfaces are too small, or design elements or furniture limit the freedom of movement. Embodied learning while seated requires minor adjustments and are therefore easier to apply immediately in the current school environment as a quick win. The current study gave insights into which adaptations are necessary and possible. A question that remains is how feasible these adaptations are (e.g., financially and practically). Future research should therefore focus on typological research of school buildings in Flanders, as well as on their users and policy. What are their views on these adaptations?

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