Author(s): Hartikainen, Jani; Poikkeus, Anna-Maija; Haapala, Eero A.; Sääkslahti, Arja; Finni, Taija

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Article

Associations of Classroom Design and Classroom-Based Physical Activity with Behavioral and Emotional Engagement among Primary School Students

Jani Hartikainen [1,*], Anna-Maija Poikkeus [2], Eero A. Haapala [1,3], Arja Sääkslahti [1] and Taija Finni [1]

[1] Faculty of Sport and Health Sciences, University of Jyväskylä, 40014 Jyväskylä, Finland; eero.a.haapala@jyu.fi (E.A.H.); arja.saakslahti@jyu.fi (A.S.); taija.m.juutinen@jyu.fi (T.F.)
[2] Department of Teacher Education, University of Jyväskylä, 40014 Jyväskylä, Finland; anna-maija.poikkeus@jyu.fi (A.-M.P.)
[3] Institute of Biomedicine, University of Eastern Finland, 70211 Kuopio, Finland
* Correspondence: jani.p.hartikainen@jyu.fi; Tel: +358-406-260-393

Abstract: Educational reforms worldwide have resulted in schools increasingly incorporating open and flexible classroom designs. Open learning spaces may contribute to a student's behavioral and emotional school engagement directly and by facilitating classroom-based physical activity (CPA). We investigated the associations between accelerometer-assessed CPA and student ratings of task-focused behavior and attitude towards school as indicators for behavioral and emotional engagement, respectively, with the associations of gender, grade, and classroom design on CPA among 206 3rd and 5th grade students in open learning spaces and conventional classrooms. Structural equation modelling showed open classroom design to be directly associated with better attitude towards school (B = −0.336; CI95% −0.616 to −0.055), but not with task-focused behavior. The relationship between task-focused behavior and attitude towards school was statistically significant (B = 0.188; 95%CI 0.068 to 0.031). CPA was not associated with task-focused behavior and attitude towards school, while classroom design (B = 1.818; 95%CI 1.101 to 2.536), gender (B = 1.732; 95%CI 20 1.065 to 2.398), and grade (B = 1.560; 95%CI 0.893 to 2.227) were statistically significantly associated with CPA. Open learning spaces seem to be associated with better emotional engagement, which is associated with behavioral engagement. Longitudinal studies investigating associations of open learning spaces and CPA on students' behavioral, emotional, and cognitive engagement concurrently are warranted.

Keywords: classroom; open learning space; physical activity; school engagement; behavioral engagement; emotional engagement

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1. Introduction

Based on educational reforms in countries worldwide, including for example Finland, the United Kingdom, Germany, and Spain, schools have increasingly begun to incorporate non-partitioned, open, and flexible designs and principles with an emphasis on fostering student autonomy, self-regulated learning, collaboration, and digital competences [1–3]. After the most recent curriculum reform of Finnish basic education was introduced in 2014 (issued in 2016), conventional self-contained classrooms have increasingly been replaced by more flexible, multipurpose, informal, and transformable open learning spaces [2,4]. Students attending schools with open learning spaces are typically encouraged to collaborate with peers, engage in self-directed learning, and optimally are also granted greater freedom of movement [1]. For teachers, working in open learning spaces typically also implies re-distribution of roles and responsibilities towards working as a team sharing space and resources [1,2]. Working in open learning spaces may also challenge teachers, as they need to balance between facilitating autonomous student learning, while managing shared spaces and resources in their pedagogical practice [1].

School engagement is typically conceptualized as a multidimensional construct including behavior, emotions, and cognitions, which are considered interrelated [5–8]. Students' behavioral engagement refers to the range of actions that reflect involvement in school activities and it is commonly assessed via indicators of students' classroom behavior, time on-task, and concentration [5]. Emotional engagement and disengagement encompass positive and negative affective reactions to school, such as enjoyment and experience of belonging, while cognitive engagement refers to investment in learning, which involves motivation, strategic learning skills, and problem solving [5]. Behavioral and emotional engagement have been suggested to be related bidirectionally, while behavioral engagement influences cognitive engagement [9].

The varied, adaptable, and flexible learning spaces, coupled with the use of student-centered pedagogies, are expected to facilitate a higher proportion of class time with students interacting, collaborating, and engaging with the lesson content, which may, in turn, translate into beneficial long-term learning outcomes [10]. Classroom design is posited to foster engagement through low-cost learning tools, and a flexible, open, student-centered space may afford a variety of active learning strategies [11]. Furthermore, open learning spaces may enhance opportunities to increase classroom-based physical activity among students, as the goals set for interior design of the open learning space bear resemblance to activity permissive classrooms with respect to including multipurpose and adaptable spaces [1,12].

Higher levels of physical activity, defined as any bodily movement produced by skeletal muscles that results in energy expenditure, have been associated with better cardiometabolic, vascular, bone, and mental health in children [13–15]. Furthermore, decreasing sedentary time and duration of sedentary bouts may confer health benefits regardless of the type of physical activity [16–19]. Thus, public health guidelines recommend that children and adolescents should accumulate on average 60 min of moderate-to-vigorous physical activity daily and engage in limited total sedentary time [20]. Children are shown to spend 40 to 60% of their waking time, equaling 5 to 8 h day, in sedentary pursuits, and less than half of the children in Western countries achieve the recommended levels of daily PA [21–24]. European primary school children aged 10–12 years have been reported to spend 65 to 70% of their school time sedentary and approximately 5% in moderate-to-vigorous physical activity, boys accumulating less sedentary time and more moderate-to-vigorous physical activity than girls [25,26]. Current evidence suggests that both in and out of school time sedentariness increases, while moderate-to-vigorous physical activity decreases, and these changes emerge from the early elementary school years [27–30].

In addition to various physical and mental health benefits, habitual physical activity has positive relationships to cognitive functioning among youth [14,15], while there is some evidence that classroom-based physical activity has a positive impact on academic-related outcomes and students' on-task behavior [31,32]. Current evidence suggests that students who are physically more active are also more engaged in their classroom lessons, with increased engagement considered as a possible mechanism by which physical activity could have a positive influence on academic achievement [32–34]. Physical activity integrated with instruction of academic subjects can positively impact children's academic motivation, however, it is not possible to draw definitive conclusions about this link due to the level of heterogeneity in the assessment of intervention components of classroom-based physical activity and academic-related outcomes [32]. Thus, objective (i.e., device-assessed) measures of physical activity are warranted [32,35]. Furthermore, there seems to be only a few studies examining associations of physical activity on emotional and cognitive engagement [36], while there seems to be a single study examining associations of physical activity on behavioral, emotional, and cognitive engagement all together [33].

There is some evidence that emotional engagement can be improved by integrating physical activity into classroom lessons [35], while moderate-intensity activity prior to mathematics lessons could improve students' cognitive engagement [33].

Current information is limited on the extent to which open learning spaces exert direct and indirect effects via classroom-based physical activity on student' school engagement. As behavioral engagement and emotional engagement have been shown to be related bidirectionally and behavioral engagement to influence cognitive engagement [9], while classroom-based physical activity seems to be associated with mainly behavioral and emotional engagement [32,35], the associations of accelerometer-assessed classroom-based physical activity and student ratings of task-focused behavior and attitude towards school as indicators for behavioral and emotional engagement, respectively, were investigated. Furthermore, associations of gender, grade, and classroom type on classroom-based physical activity were investigated.

2. Materials and Methods

Data for this study were collected from 15 classrooms of 3rd and 5th grade students from three different schools and two different provinces in Finland. Schools were chosen first on voluntary basis first by permission from principals and teachers, after which students were recruited. In one of the schools, the students attending 3rd and 5th grades, 70–80 students in each grade, had most of their lessons in open learning spaces. Both grades had three teachers responsible for teaching the student group of the grade as a collective teacher team. The open learning environments of each grade contained a large space with mobile furniture which afforded multiple options for classroom layout, as well as a quiet work room. Students did not have an assigned place, such as a designated desk, in the open learning space. The school with open learning spaces was chosen as we have previously conducted a study in same school before and after renovation from conventional classrooms to open learning spaces [37]. In the other two schools, students attended most of their lessons in conventional classrooms with designated desks for each student and one teacher was responsible for teaching a classroom of 20–25 students. Figure 1 illustrates an example of an open learning space and a conventional classroom.

Figure 1. Illustration of open learning space (**left**) and conventional classroom (**right**). The picture from the open learning space shows one of the several areas for work allowing division of the class of about 70–80 students to smaller groups with mobile and dynamic furniture. The picture of a conventional classrooms represents the typical smaller self-contained rooms for around 20 students with a designated desk for each student.

The data were collected during years 2018–2019 and each participating class was assessed once during the data collection. Assessments were conducted for each class during one school week. On Monday, accelerometers were distributed for students to use continuously during the measurement week and anthropometric assessments were obtained from the participants. Body weight and stature were assessed using standard procedures. Age- and sex-adjusted body mass index (ISO-BMI), which adjusts children's and adolescents BMI to correspond to that of adults, was calculated using Finnish references on BMI standard deviation score [38]. During the measurement week, students filled out the school engagement rating scale. Students and their parents or legal guardians kept a diary during the school week of measurement. Classroom teachers were asked to provide a curriculum of the activities for the week. Accelerometers and diaries were collected from the participants at end of the measurement week on Friday. During the measurement weeks, contents of instruction followed the curriculum of the grades in question and instruction was not in any way altered by the researchers.

Physical activity was measured by a waist mounted triaxial accelerometer (RM42, UKK Terveyspalvelut Oy, Tampere, Finland, Range ±16g, sample rate: 100 Hz, A/D conversion: 13-bit). Data included in the analyses were determined based on the teacher-reported weekly schedule of classroom time. Only the time spent inside in the classroom during times of general education was included in the analysis, while Physical Education lessons and recess were excluded. Furthermore, possible absences from school, for example due to illness or visits to health care appointments during school hours, were identified from diaries and excluded from the analysis.

The data were first visually inspected to ensure that accelerometers were worn as reported by the participants. The resultant acceleration of the triaxial accelerometer signal was calculated as $\sqrt{x^2 + y^2 + z^2}$, where x, y, and z are the measurement samples of the raw acceleration signal in x-, y-, and z-directions. Mean amplitude deviation (MAD) was calculated from the resultant acceleration in non-overlapping 1 s epochs on the supercomputer of CSC, the Finnish IT Center for Science. MAD is described as the mean distance of data points about the mean of the given epoch,

$$\text{MAD} = \frac{1}{n}\sum_{i=1}^{n}|r_i - \bar{r}|$$

where n is the number of samples in the epoch, r_i is the ith resultant sample within the epoch, and $\bar{r}$ is the mean resultant value of the epoch. The MAD-method used for assessing physical activity has been shown to be an accurate method across different accelerometer brands [39,40].

MAD values were averaged over 15-s intervals with Matlab R2018a (The MathWorks Inc., Natick, MA, USA). The cumulative sum of 15-s intervals was calculated in G for each participant and divided by the duration of time spent in the classroom to calculate physical activity level for each participant for the whole school week. Total physical activity level was expressed as accumulated G per 60 min spent in classroom to be used as a single parameter for structural equation modeling. The method captured the overall intensity of movement throughout the entire school week. As students tend to be sedentary for the majority of their time during school days [25], this method provides a finer granularity of physical activity, while the method has been used in a study investigating associations of office workstation type on physical activity and stress [41]. An analysis method that does not require the use of fixed cut-offs was chosen as increasing evidence suggests that estimating physical activity intensities using specific fixed thresholds could cause remarkable errors in intensity estimation between individuals and, for example, underestimate moderate and vigorous intensity activity in low fit and less motorically competent children [42–44].

Children's engagement was assessed using two scales. Task-focused behavior as an indicator of behavioral engagement was assessed with a scale based on the Achievement Beliefs Scale for Children, which has been used to assess primary school students in Finland [45–47]. Children were presented with seven statements regarding their typical task motivation with respect to approaching or avoiding challenging academic tasks (e.g., "I enjoy working with challenging school tasks"; "Difficult tasks make me try hard"). Attitude towards school as an indicator of emotional engagement was assessed using three statements regarding their typical thoughts about school (e.g., "It is nice to come to school"). Answers were coded on a Likert scale 1–5 with a higher value presenting higher task focused behavior or a more positive attitude towards school. Negatively worded statements were reverse-coded. The internal consistency of items as assessed with Cronbach's alpha was 0.799 for task-focused behavior and 0.677 for attitude towards school.

Structural equation modeling was chosen as a statistical analysis method as it can be used to study the relationships among latent constructs that are indicated by multiple measures [48]. Furthermore, this multivariate statistical analysis technique allowed for the exploration of complex relationships between types of classrooms, individual characteristics, physical activity, task-focused behavior, and attitude towards school with a single model [48]. Task-focused behavior (seven items) and attitude towards school (three items) were modeled each as a latent construct, and all the other constructs in the structural model were directly assessed. Our hypothesized model is illustrated in Figure 2.

The lavaan package in R was used for model fit and validation. Full information maximum likelihood estimation was used to estimate the significant path coefficients in the model. Missing values were not replaced or imputed but handled within the analysis model. The Comparative Fit Index and Standardized Root Mean Square Residual were used to estimate model fit. The hypothesized model exhibited poor model fit as Comparative Fit Index was 0.764 and Standardized Root Mean Square Residual was 0.130. To achieve the recommended levels on the Comparative Fit Index (>0.95) and Standardized Root Mean Square Residual (<0.08), covariances between items assessing latent constructs were added by estimating modification indices and adding covariances with highest modification indices one at a time.

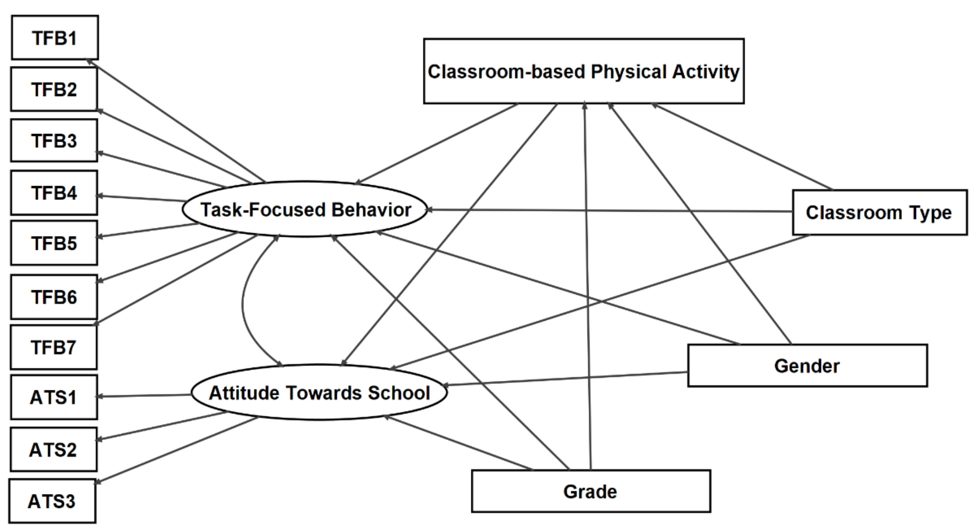

Figure 2. The hypothesized structural equation model. Latent factors are represented as ovals and observed variables as rectangles. Straight lines indicate hypothesized paths and curved lines indicate covariance between variables. TFB = task-focused behavior, ATS = attitude towards school. Grade: 5th vs. 3rd grade, gender: girls vs. boys, and classroom type: open learning space vs. conventional classroom. Comparative Fit Index: 0.764; Standardized Root Mean Square Residual: 0.130.

3. Results

3.1. Participants

A total of 206 students gave consent for participation representing approximately 50% of the students attending classes where recruitment took place. From this sample, questionnaire ratings were obtained from 204 students and physical activity assessments from 195 students. Participant characteristics and descriptive data for measures of interest are provided in Table 1.

Table 1. Participant characteristics and descriptive data.

School Classroom Type	Missing N (%)	All	School 1 Open		School 2 Conventional		School 3 Conventional	
Grade			3rd	5th	3rd	5th	3rd	5th
N		204	40	26	52	34	25	27
Girls (%)			40	50	59.6	52.9	44	44.4
Age (y)	10 (4.9)	10.3 (1.0)	9.3 (0.3)	11.2 (0.3)	9.5 (0.3)	11.5 (0.3)	9.7 (0.3)	11.2 (0.3)
Height (cm)	3 (1.5)	142.4 (8.2)	136.5 (4.5)	148.0 (5.2)	137.0 (4.6)	150.2 (6.9)	139.0 (6.8)	149.2 (6.0)
Weight (kg)	3 (1.5)	36 (8.6)	31.8 (5.6)	39.5 (6.7)	31.6 (4.2)	41.0 (9.7)	34.8 (9.8)	41.7 (10.0)
ISO-BMI (kg/m^2)	10 (4.9)	21.5 (3.1)	21.7 (3.5)	21.4 (2.5)	21.0 (2.4)	21.3 (3.4)	21.7 (3.5)	22.2 (3.7)
TFB (mean score; 1 to 5)	1 (0.5)	3.7 (0.8)	3.8 (0.6)	3.6 (0.8)	3.6 (0.8)	3.6 (0.7)	3.9 (0.7)	3.6 (0.9)
ATT (mean score; 1 to 5)	1 (0.5)	3.9 (0.8)	4.2 (0.8)	4.1 (0.5)	3.7 (0.8)	3.7 (0.8)	4.1 (0.8)	3.8 (0.9)
CPA (G/60min)	9 (4.4)	9.568 (2.709)	9.493 (1.809)	6.966 (1.891)	10.085 (2.879)	9.016 (2.823)	10.345 (3.227)	9.846 (2.066)

Values presented are means and standard deviations. Girls (%) refers to percentage of girls. Age- and sex-adjusted body mass index (ISO-BMI), which adjusts children's and adolescents BMI to correspond with adults, was calculated using Finnish references on BMI standard deviation score [35]. Mean scores for task-focused behavior (TFB) assessed with seven items and attitude towards school (ATT) assessed with three items on a 5-point Likert-scale (Cronbach's α TFB =.799, ATT=.677). Classroom-based physical activity (CPA) assessed with mean amplitude deviation method (40) and expressed as accumulated G per 60 min spent in classroom.

3.2. Structural Equation Model Results

The final model is shown in Figure 3. The hypothesized and final models were compared using the Chi-squared difference test which indicated significant (Chi-squared difference = 313.62, df = 6, $p < 0.001$) improvement with model fit. The final model exhibited good model fit with a Comparative Fit Index of 0.977 and a Standardized Root Mean Square Residual of 0.079. In Figure 3, solid lines represent significant paths ($p < 0.05$) with unstandardized coefficients shown with their standard errors (dotted lines represent non-significant paths). Curved lines indicate covariance between variables.

Classroom type was associated with student ratings of attitude towards school (B = −0.336; CI95% −0.616 to −0.055) with students in open learning spaces reporting a more positive attitude towards school than students in conventional classrooms. Classroom type was not associated with task-focused behavior. Relationship between task-focused behavior and attitude towards school was statistically significant (B = 0.188; 95%CI 0.068 to 0.031).

Classroom-based physical activity was not associated with task-focused behavior and attitude towards school, while classroom-based physical activity was associated with grade, gender, and classroom-type. Third grade students were more physically active than 5th graders (B = 1.560; 95%CI 0.893 to 2.227), while boys were more physically active than girls (B = 1.732; 95%CI 1.065 to 2.398). Students in conventional classrooms were more physically active than students in open learning spaces (B = 1.818; 95%CI 1.101 to 2.536).

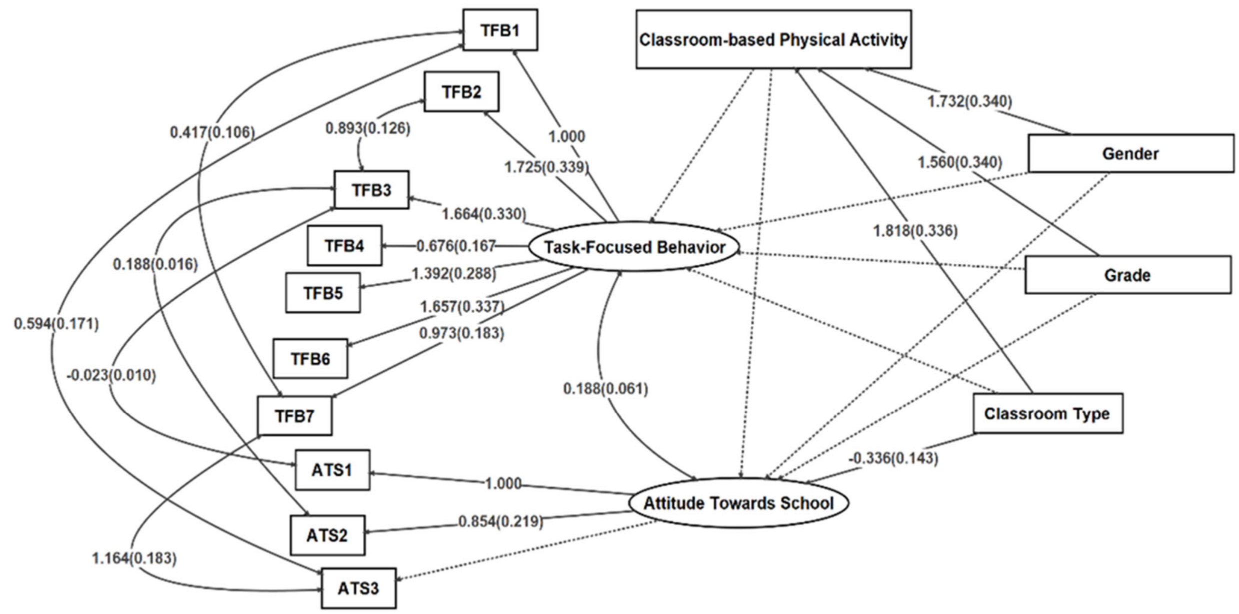

Figure 3. Structural equation model results. Latent factors are represented as ovals and observed variables as rectangles. Solid lines represent significant ($p < 0.05$) (and dotted lines nonsignificant paths), the former include unstandardized coefficients (and standard errors). Curved lines indicate covariance between variables. TFB = task-focused behavior, ATS = attitude towards school. Grade: 5th vs. 3rd grade, gender: girls vs. boys, and classroom type: open learning space vs. conventional classroom. Comparative Fit Index: 0.977; Standardized Root Mean Square Residual: 0.079.

4. Discussion

One of the goals of designing schools with open learning spaces is to allow for and foster student collaboration, self-regulated learning, and autonomy [1]. It can be presumed that students in these environments may be more inclined than in conventional classrooms to experience emotional engagement as indicated by a positive attitude towards school and higher task motivation (i.e., task-focused behavior). We found an association between classroom type and students' self-reported attitude towards school favoring open learning environments, but the association between classroom type and task-focused behavior was not statistically significant. Attitude towards school was, however, associated with task-focused behavior, which supports interrelatedness of these dimensions reflecting school engagement and motivation [5]. These findings suggest that classroom design itself does not have direct strong links with students' task-focused behavior which may, however, be influenced indirectly via attitude toward school as behavioral and emotional engagement have been shown to be related bidirectionally [9].

Classroom-based physical activity was not associated with task-focused behavior or attitude towards school. This finding contradicts our hypotheses and previous findings that have suggested that students who are physically active in classroom are more engaged in their classroom lessons [32,34,35]. This contradictory finding may be caused by different approaches on classroom-based physical activity as it can take multiple forms such as active breaks with or without curriculum content and physically active lessons [32]. Therefore, suggested associations between classroom-based physical activity and school engagement may be related to promotion of different types of classroom-based physical activity rather than sheer amount of classroom-based physical activity. Although the dimensions of school engagement, emotions, behavior, and cognitions are considered to be interrelated, they are typically assessed as separate constructs, and it is possible that different types, intensities, and frequencies of physical activity are beneficial for different dimensions of school engagement [33,36].

Students were physically less active in open learning spaces, which contradicts our hypotheses that open learning spaces should enable more classroom-based physical activity. We have previously observed that open learning spaces were not associated with less sedentary time, while they may facilitate breaks from sedentary time and moderate-to-vigorous physical activity [37]. These findings may be related to either challenges in utilizing these novel spaces or barriers for promoting classroom-based physical activity. We observed that teachers' adaptation has been demanding and regardless of change in the physical learning space, teachers have continued utilizing same pedagogical practices that were used in conventional classroom settings [1,2,49,50]. Furthermore, difficulties in changing institutional routines, creating coherent pedagogy for open learning spaces, clashes between the teaching team, and deficiency in teachers' skills for manipulating the environment, while mastering multiple ongoing engagements have been reported as negative outcomes during implementation of open learning spaces [51–53]. Additionally, barriers for organizing classroom-based physical activity include both institutional, i.e., administrative support, and personal, i.e., personal perceptions of value of physical activity, factors [54], that were not investigated in this study.

Both findings that open learning spaces were not associated with more classroom-based physical activity and that classroom-based physical activity was not associated with school engagement may be partly explained by the already active promotion of overall school-based physical activity in Finland. The national action program, Finnish Schools on the Move, aiming to establish a physically active culture in Finnish comprehensive schools, is already widespread across the country as approximately 90% of Finnish elementary schools and 95% of pupils are involved in the program [55]. Thus, the majority of Finnish children are already participating in this nationwide program, which potentially reduces disparities in school-based physical activity between students in different schools. Reduced disparities in physical activity may cause statistical analyses to be unable to detect the relationship between physical activity and school engagement. Furthermore, possible active promotion of classroom-based physical activity, regardless of classroom type, may influence our results. As schools and municipalities participating in the program implement their own plans to enhance physical activity during the school day, mostly during recess and academic lessons [55], there may be significant differences in the activities performed during the school week, which were not controlled in this study.

The methodology used for assessing both school engagement and classroom-based physical activity pose both strengths and limitations for this study. Studies assessing school engagement, academic achievement, and classroom-behavior have used various outcome measures such as questionnaires, direct observation, and standardized tests [32]. The use of student-reported task-focused behavior limits comparisons between other studies; a lot of studies in this field use observation to assess time on-task [32]. Furthermore, as students' ratings for task-focused behavior and attitude towards school were used, it is possible that those ratings were subject to social desirability, although the scales utilized produced internally consistent scores.

Physical activity itself can be assessed in multiple ways such as via questionnaires, direct observation, and accelerometer assessments, which makes comparison of different studies difficult. This study used device-assessed measures of classroom-based physical activity and thus measures of physical activity were not influenced by students' abilities to recall or estimate the frequency and intensity of their physical activity. Furthermore, as increasing evidence suggests that estimating physical activity intensities using specific fixed thresholds could cause remarkable errors in intensity estimation between individuals [42–44], a method that does not use of fixed cut-offs was used. In turn, as we assessed only accelerometer-derived data, we do not have information on the forms of classroom-based physical activity and the extent to which physical activity was promoted during general education.

Structural equation modeling was chosen as a statistical analysis method as it can be used to study the relationships among latent constructs that are indicated by multiple measures, and it allows for the exploration of complex relationships between types of classrooms, individual characteristics, physical activity, task-focused behavior, and attitude towards school with a single model [48]. As our sample size was relatively small, the number of variables that we could include in the structural equation model was prioritized to those with the strongest theoretical relevance and support from prior findings, and covariates were limited to a minimum required to achieve sufficient model fit. Furthermore, our sample size of 15 classes and unbalanced design, that included one school with open learning space and two schools with conventional classroom, reduces statistical power and possibilities for clustering students within classes and schools for using a more sophisticated approach such as multilevel structural equation modeling [56].

Our model did not include an indicator for cognitive engagement, as we hypothesized behavioral engagement and emotional engagement to be related bidirectionally and behavioral engagement to influence cognitive engagement [9]. Furthermore, as classroom-based physical activity seems to be associated with behavioral and emotional engagement [32,35], these dimensions of school engagement were investigated. As school engagement is typically conceptualized as a multidimensional construct including behavior, emotions, and cognition, which are considered interrelated [5–8], future studies should seek to examine all these dimensions concurrently. Furthermore, our model did not include an assessment of socioeconomic status, which may have an influence especially on the academic achievement of students, although the magnitude of such associations depends on the social context and education system [57]. As the vast majority of research has focused on associations of socioeconomic status and academic achievement rather than school engagement, the assessment of family-level or school-level socioeconomic status was not included in the model.

Other limitations of this study include that this was a cross-sectional study without an intervention so we cannot confirm any causal relationships between the assessed variables. Therefore, studies utilizing longitudinal settings are warranted. As recruitment of this study was based on voluntary participation, there is a risk for volunteer or self-selection bias meaning that those students and their parents that were interested in physical activity, school engagement, and learning spaces were most likely to participate in our study [58]. As only approximately 50% students in participating classes volunteered, our sample does not necessarily fully represent all students and particularly those with low interest in the topic of our study. Furthermore, we did not consider participants' medical background in the presence of conditions, such as attention deficit hyperactivity disorder, influencing academic achievement, and potentially also school engagement [59].

Future research should seek to investigate the effects of open learning spaces and classroom-based physical activity on students' behavioral, emotional, and cognitive engagement concurrently in longitudinal settings. Additionally, effects of different types, intensities, and frequencies of classroom-based physical activity school engagement should be studied more extensively. As open learning spaces were not associated with more classroom-based physical activity, the potential differences in teacher practices in terms of classroom-based physical activity between different types of learning space require further investigation. Further development of teacher practices and school policies is crucial to further capitalize on the full potential of these open learning spaces in terms of both pedagogical goals and classroom-based physical activity to promote school engagement, which could extend further into beneficial long-term learning and health outcomes.

5. Conclusions

The findings of the present study indicated that classroom type was associated with students' emotional engagement, with students in open learning spaces reporting higher emotional engagement. Moreover, attitude towards school was associated with behavioral engagement. Classroom-based physical activity was not associated with either behavioral or emotional engagement, but classroom-based physical activity was associated with classroom type, gender, and grade. Longitudinal studies investigating associations of open learning spaces and classroom-based physical activity on students' behavioral, emotional, and cognitive engagement concurrently are warranted. Furthermore, the differences in teacher practices in terms of classroom-based physical activity between different types of learning space require further investigation.

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Institutional Review Board Statement: The University of Jyväskylä Ethics Committee has approved the research protocol.

Informed Consent Statement: Students and their parents or legal guardians gave their written informed consent for the students' participation in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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References

1. Saltmarsh, S.; Chapman, A.; Campbell, M.; Drew, C. Putting "structure within the space": Spatially un/responsive pedagogic practices in open-plan learning environments. *Educ. Rev.* **2015**, *67*, 315–327, doi:10.1080/00131911.2014.924482.
2. Niemi, K. 'The best guess for the future?' Teachers' adaptation to open and flexible learning environments in Finland. *Educ. Inq.* **2020**, 1–19, doi:10.1080/20004508.2020.1816371.
3. Mäkitalo-Siegl, K.; Zottmann, J.; Kaplan, F.; Fischer, F. *Classroom of the Future: Orchestrating Collaborative Spaces*; Sense Publishers: Rotterdam, The Netherlands, 2010.
4. Ministry of Education. Finnish National Curriculum. 2014. National Board of Education. Available online: www.oph.fi/sites/default/files/documents/perusopetuksen_opetussuunnitelman_perusteet_2014.pdf (accessed on 21 October 2020).
5. Fredricks, J.A.; Blumenfeld, P.C.; Paris, A.H. School engagement: Potential of the concept, state of the evidence. *Rev. Educ. Res.* **2004**, *74*, 59–109, doi:0.3102/00346543074001059.
6. Appleton, J.J.; Christenson, S.L.; Kim, D.; Reschly, A.L. Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument. *J. Sch. Psychol.* **2006**, *44*, 427–445, doi:10.1016/j.jsp.2006.04.002.
7. Jimerson, S.R.; Campos, E.; Greif, J.L. Toward an understanding of definitions and measures of school engagement and related terms. *Calif. Sch. Psychol.* **2003**, *8*, 7–27, doi:10.1007/BF03340893.
8. Archambault, I.; Janosz, M.; Morizot, J.; Pagani, L. Adolescent behavioral, affective, and cognitive engagement in school: Relationship to dropout. *J. Sch. Health* **2009**, *79*, 408–415, doi:10.1111/j.1746-1561.2009.00428.x.
9. Li, Y.; Lerner, R.M. Interrelations of behavioral, emotional, and cognitive school engagement in high school students. *J. Youth Adolesc.* **2013**, *42*, 20–32, doi:10.1007/s10964-012-9857-5.
10. Kariippanon, K.E.; Cliff, D.P.; Lancaster, S.J.; Okely, A.D.; Parrish, A. Flexible learning spaces facilitate interaction, collaboration and behavioural engagement in secondary school. *PLoS ONE* **2019**, *14*, e0223607, doi:0.1371/journal.pone.0223607.
11. Rands, M.L.; Gansemer-Topf, A.M. The room itself is active: How classroom design impacts student engagement. *J. Learn. Spaces* **2017**, *6*, 26. Available online: http://libjournal.uncg.edu/jls/article/view/1286/1028 (accessed on 12 July 2021).
12. Brittin, J.; Sorensen, D.; Trowbridge, M.; Lee,. KK.; Breithecker, D.; Frerichs, L.; Huang, T. Physical activity design guidelines for school architecture. *PLoS ONE* **2015**, *10*, e0132597, doi:10.1371/journal.pone.0132597.

13. Caspersen, C.J.; Powell, K.E.; Christenson, G.M. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Rep.* **1985**,*100*, 126.
14. Janssen, I.; LeBlanc, A.G. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int. J. Behav. Nutr. Phys. Act.* **2010**, *7*, 40, doi:10.1186/1479-5868-7-40.
15. Biddle, S.J.; Ciaccioni, S.; Thomas, G.; Vergeer, I. Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychol. Sport Exerc.* **2019**, *42*, 146–155, doi:10.1016/j.psychsport.2018.08.011.
16. Tremblay, M.S.; LeBlanc, A.G.; Kho, M.E.; Saunders, T.J.; Larouche, R.; Colley, R.C.; Goldfield, G.; Gorber, S.C. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int. J. Behav. Nutr. Phys. Act.* **2011**, *8*, 98, doi:10.1186/1479-5868-8-98.
17. Altenburg, T.M.; Chinapaw, M.J. Bouts and breaks in children's sedentary time: Currently used operational definitions and recommendations for future research. *Prev. Med.* **2015**, *77*, 1–3, doi:10.1016/j.ypmed.2015.04.019.
18. Saunders, T.J.; Tremblay, M.S.; Mathieu, M.; Henderson, M.; O'Loughlin, J.; Tremblay, A.; Chaput, J.-P.; on behalf of the QUALITY Cohort Research Group Associations of Sedentary Behavior, Sedentary Bouts and Breaks in Sedentary Time with Cardiometabolic Risk in Children with a Family History of Obesity. *PLOS ONE* **2013**, *8*, e79143, doi:10.1371/journal.pone.0079143.
19. Carson, V.; Hunter, S.; Kuzik, N.; Gray, C.; Poitras, V.J.; Chaput, J.-P.; Saunders, T.J.; Katzmarzyk, P.; Okely, A.; Gorber, S.C.; et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl. Physiol. Nutr. Metab.* **2016**, *41*, S240–S265, doi:10.1139/apnm-2015-0630.
20. Bull, F.C.; Al-Ansari, S.S.; Biddle, S.; Borodulin, K.; Buman, M.P.; Cardon, G.; Carty, C.; Chaput, J.-P.; Chastin, S.; Chou, R.; et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br. J. Sports Med.* **2020**, *54*, 1451–1462, doi:10.1136/bjsports-2020-102955.
21. Ortega, F.B.; Konstabel, K.; Pasquali, E.; Ruiz, J.; Hurtig-Wennlöf, A.; Mäestu, J.; Löf, M.; Harro, J.; Bellocco, R.; Labayen, I.; et al. Objectively Measured Physical Activity and Sedentary Time during Childhood, Adolescence and Young Adulthood: A Cohort Study. *PLOS ONE* **2013**, *8*, e60871, doi:10.1371/journal.pone.0060871.
22. Aubert, S.; Barnes, J.D.; Abdeta, C.; Abi Nader, P.; Adeniyi, A.F.; Aguilar-Farias, N.; Tenesaca, D.S.A.; Bhawra, J.; Brazo-Sayavera, J.; Cardon, G.; et al. Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis From 49 Countries. *J. Phys. Act. Health* **2018**, *15*, 251–273, doi:10.1123/jpah.2018-0472.
23. Colley, R.C.; Garriguet, D.; Janssen, I.; Wong, S.L.; Saunders, T.J.; Carson, V.; Tremblay, M.S. The association between accelerometer-measured patterns of sedentary time and health risk in children and youth: Results from the Canadian Health Measures Survey. *BMC Public Health* **2013**, *13*, 200, doi:10.1186/1471-2458-13-200.
24. Konstabel, K.; Veidebaum, T.; Verbestel, V.; Moreno, L.A.; Bammann, K.; Tornaritis, M.; Eiben, G.; Molnár, D.; Siani, A.; et al. Objectively measured physical activity in European children: The IDEFICS study. *Int. J. Obes.* **2014**, *38*, S135–S143, doi:10.1038/ijo.2014.144.
25. van Stralen, M.M.; Yıldırım, M.; Wulp, A.; Te Velde, S.J.; Verloigne, M.; Doessegger, A.; Androutsos, O.; Kovács, Éva; Brug, J.; Chinapaw, M.J. Measured sedentary time and physical activity during the school day of European 10-to 12-year-old children: The ENERGY project. *J. Sci. Med. Sport* **2014**, *17*, 201–206, doi:10.1016/j.jsams.2013.04.019.
26. Salin, K.; Huhtiniemi, M.; Watt, A.; Hakonen, H.; Jaakkola, T. Differences in the Physical Activity, Sedentary Time, and BMI of Finnish Grade 5 Students. *J. Phys. Act. Health* **2019**, *16*, 765–771, doi:10.1123/jpah.2018-0622.
27. Trost, S.G.; Pate, R.R.; Sallis, J.F.; Freedson, P.S.; Taylor, W.C.; Dowda, M.; Sirard, J. Age and gender differences in objectively measured physical activity in youth. *Med. Sci. Sports Exerc.* **2002**, *34*, 350–355, doi:10.1097/00005768-200202000-00025.
28. Jago, R.; Solomon-Moore, E.; Macdonald-Wallis, C.; Sebire, S.J.; Thompson, J.L.; Lawlor, D.A. Change in children's physical activity and sedentary time between Year 1 and Year 4 of primary school in the B-PROACT1V cohort. *Int. J. Behav. Nutr. Phys. Act.* **2017**,*14*, 1–13, doi:10.1186/s12966-017-0492-0.
29. Grao-Cruces, A.; Sánchez-Oliva, D.; Padilla-Moledo, C.; Izquierdo-Gómez, R.; Cabanas-Sánchez, V.; Castro-Piñero, J. Changes in the school and non-school sedentary time in youth: The UP&DOWN longitudinal study. *J. Sports Sci.* **2020**, *38*, 780–786, doi:10.1080/02640414.2020.1734310.
30. Harding, S.K.; Page, A.S.; Falconer, C.; Cooper, A.R. Longitudinal changes in sedentary time and physical activity during adolescence. *Int. J. Behav. Nutr. Phys. Act.* **2015**, *12*, 1–7, doi:10.1186/s12966-015-0204-6.
31. Goh, T.L.; Hannon, J.; Webster, C.; Podlog, L.; Newton, M. Effects of a TAKE 10! Classroom-based physical activity intervention on third-to fifth-grade children's on-task behavior. *J. Phys. Act. Health* **2016**, *13*, 712–718, doi:10.1123/jpah.2015-0238.
32. Watson, A.; Timperio, A.; Brown, H.; Best, K.; Hesketh, K.D. Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis. *Int. J. Behav. Nutr. Phys. Act.* **2017**, *14*, 1–24, doi:10.1186/s12966-017-0569-9.
33. Owen, K.B.; Parker, P.D.; Astell-Burt, T.; Lonsdale, C. Effects of physical activity and breaks on mathematics engagement in adolescents. *J. Sci. Med. Sport* **2018**, *21*, 63–68, doi:10.1016/j.jsams.2017.07.002.
34. Mavilidi, M.F.; Drew, R.; Morgan, P.J.; Lubans, D.R.; Schmidt, M.; Riley, N. Effects of different types of classroom physical activity breaks on children's on-task behaviour, academic achievement and cognition. *Acta Paediatr.* **2020**, *109*, 158–165, doi:10.1111/apa.14892.
35. Vazou, S.; Gavrilou, P.; Mamalaki, E.; Papanastasiou, A.; Sioumala, N. Does integrating physical activity in the elementary school classroom influence academic motivation? *Int. J. Sport Exerc. Psychol.* **2012**, *10*, 251–263, doi:10.1080/1612197X.2012.682368.

36. Owen, K.B.; Parker, P.D.; Van Zanden, B.; MacMillan, F.; Astell-Burt, T.; Lonsdale, C.; Physical activity and school engagement in youth: A systematic review and meta-analysis. *Educ. Psychol.* **2016**, *51*, 129–145, doi:10.1080/00461520.2016.1151793.
37. Hartikainen, J.; Haapala, E.A.; Poikkeus, A.-M.; Lapinkero, E.; Pesola, A.J.; Rantalainen, T.; Sääkslahti, A.; Gao, Y.; Finni, T. Comparison of Classroom-Based Sedentary Time and Physical Activity in Conventional Classrooms and Open Learning Spaces Among Elementary School Students. *Front. Sports Act. Living* **2021**, *3*, 626282, doi:10.3389/fspor.2021.626282.
38. Saari, A.; Sankilampi, U.; Hannila, M.; Kiviniemi, V.; Kesseli, K.; Dunkel, L. New Finnish growth references for children and adolescents aged 0 to 20 years: Length/height-for-age, weight-for-length/height, and body mass index-for-age. *Ann. Med.* **2011**, *43*, 235–248, doi:10.3109/07853890.2010.515603.
39. Aittasalo, M.; Vähä-Ypyä, H.; Vasankari, T.; Husu, P.; Jussila, A.; Sievänen, H. Mean amplitude deviation calculated from raw acceleration data: A novel method for classifying the intensity of adolescents' physical activity irrespective of accelerometer brand. *BMC Sports Sci. Med. Rehabil.* **2015**, *7*, 18, doi:10.1186/s13102-015-0010-0.
40. Vähä-Ypyä, H.; Vasankari, T.; Husu, P.; Suni, J.; Sievänen, H. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. *Clin. Physiol. Funct. Imaging* **2015**, *35*, 64–70, doi:10.1111/cpf.12127.
41. Lindberg, C.M.; Srinivasan, K.; Gilligan, B.; Razjouyan, J.; Lee, H.; Najafi, B.; et al. Effects of office workstation type on physical activity and stress. *Occup. Environ. Med.* **2018**, *75*, 689–695, doi:10.1136/oemed-2018–105077.
42. Haapala, E.A.; Gao, Y.; Rantalainen, T.; Finni, T. Associations of age, body size, and maturation with physical activity intensity in different laboratory tasks in children. *J. Sports Sci.* **2021**, *39*, 1428–1435, doi:10.1080/02640414.2021.1876328.
43. Haapala, E.A.; Gao, Y.; Hartikainen, J.; Rantalainen, T.; Finni, T. Associations of fitness, motor competence, and adiposity with the indicators of physical activity intensity during different physical activities in children. *Sci. Rep.* **2021**, *11*, 1–11, doi:10.1038/s41598-021-92040-2.
44. Haapala, E.A.; Gao, Y.; Vanhala, A.; Rantalainen, T.; Finni, T. Validity of traditional physical activity intensity calibration methods and the feasibility of self-paced walking and running on individualised calibration of physical activity intensity in children. *Sci. Rep.* **2020**, *10*, 1–10. 10.1038/s41598-020-67983-7.
45. Kiuru, N.; Pakarinen, E.; Vasalampi, K.; Silinskas, G.; Aunola, K.; Poikkeus, A.-M.; Metsäpelto, R.-L.; Lerkkanen, M.-K.; Nurmi, J.-E. Task-Focused Behavior Mediates the Associations Between Supportive Interpersonal Environments and Students' Academic Performance. *Psychol. Sci.* **2014**, *25*, 1018–1024, doi:10.1177/0956797613519111.
46. Aunola, K.; Viljaranta, J.; Lehtinen, E.; Nurmi, J. The role of maternal support of competence, autonomy and relatedness in children's interests and mastery orientation. *Learn. Individ. Differ.* **2013**, *25*, 171–177, doi:10.1016/j.lindif.2013.02.002.
47. Aunola, K.; Nurmi, J.E. *Achievement Beliefs Scale for Children (ABS-C)*; University of Jyväskylä: Jyväskylä, Finland, 2006, unpublished.
48. Lei, P.; Wu, Q. Introduction to structural equation modeling: Issues and practical considerations. *Educ. Meas. Issues Pract.* **2007**, *26*, 33–43, doi:10.1111/j.1745-3992.2007.00099.x.
49. Carvalho, L.; Yeoman, P. Framing learning entanglement in innovative learning spaces: Connecting theory, design and practice. *Br. Educ. Res. J.* **2018**, *44*, 1120–1137, doi:10.1002/berj.3483.
50. Sigurðardóttir, A.K.; Hjartarson, T. The idea and reality of an innovative school: From inventive design to established practice in a new school building. *Improv. Sch.* **2016**, *19*, 62–79, doi:10.1177/1365480215612173.
51. Campbell, M.; Saltmarsh, S.; Chapman, A.; Drew, C.Issues of teacher professional learning within 'non-traditional'classroom environments. *Improv. Sch.* **2013** , *16*, 209–222, doi:10.1177/1365480213501057.
52. Deed, C.; Lesko, T. 'Unwalling'the classroom: Teacher reaction and adaptation. *Learn. Environ. Res.* **2015**, *18*, 217–231, doi:10.1007/s10984-015-9181-6.
53. Kariippanon, K.E.; Cliff; D. P.;Lancaster, S.L.; Okely, A.D.; Parrish, A. Perceived interplay between flexible learning spaces and teaching, learning and student wellbeing. *Learn. Environ. Res.* **2018**, *21*, 301–320, doi:10.1007/s10984-017-9254-9.
54. Michael, R.D.; Webster, C.A.; Egan, C.A.; Nilges, L.; Brian, A.; Johnson, R.; Carson, R.L. Facilitators and Barriers to movement integration in elementary classrooms: A systematic review. *Res. Q. Exerc. Sport* **2019**, *90*, 151–162, doi:10.1080/02701367.2019.1571675.
55. Blom. A.; Tammelin, T.; Laine, K.; Tolonen, H. Bright spots, physical activity investments that work: The Finnish Schools on the Move programme. *Br. J. Sports Med.* **2018**, *52*, 820–822, doi:10.1136/bjsports-2017-097711.
56. Hox, J.J.; Maas, C.J.; The accuracy of multilevel structural equation modeling with pseudobalanced groups and small samples. *Struct. Equ. Model.* **2001**, *8*, 157–174, doi:10.1207/S15328007SEM0802_1.
57. Broer, M.; Bai, Y.; Fonseca, F. A review of the literature on socioeconomic status and educational achievement. *Socioecon. Inequal. Educ. Outcomes* **2019**, 7–17, doi:10.1007/978-3-030-11991-1_2.
58. Hernán, M.A.; Hernández-Díaz, S.; Robins, J.M.; A structural approach to selection bias. *Epidemiology* **2004**, 615–625. Available online: http://www.jstor.org/stable/20485961 (accessed on 12 July 2021).
59. Rushton, S.; Giallo, R.; Efron, D. ADHD and emotional engagement with school in the primary years: Investigating the role of student–teacher relationships. *Br. J. Educ. Psychol.* **2020**, *90*, 193–209, doi:10.1111/bjep.12316.