Pupils' experiences and perceptions of engagement during the Moving Maths programme

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Abstract

The quantitative effects of classroom-based physical activity (PA) interventions on academic performance have been thoroughly reported in many recent studies globally, but there is a lack of studies on pupil perspectives. This qualitative study from a Finnish primary school focused on experiences and perceptions of engagement during the Moving Maths programme, including physically active math lessons. Data were gathered in focus group interviews with 16 nine-year-old pupils. Pupils in the group with physically active breaks during math lessons expressed mixed experiences, while pupils in the group with PA integrated into math curriculum experienced increased positive emotional and cognitive engagement.

Keywords

mathematics, physical activity, child perspectives, integrated PA, engagement, physically active learning

Introduction

Sufficient and regular physical activity (PA) is recognised as a key determinant of physical, mental, cognitive and social health among children (World Health Organization 2010). Within the past decade, global concerns about low levels of PA of children (Aubert et al. 2018) have resulted in interventions aiming at increasing PA during school days (Norris et al. 2019; Singh et al. 2018). In these interventions, PA has been added to school days in many forms, for example, short breaks during lessons (Howie, Schatz and Pate 2015), activity sessions before, during or after school (da Cruz 2017), extra physical education (PE) lessons (Bugge et al. 2018) or multi-dimensional PA programmes (Resaland et al. 2016). In addition to apparent cardiovascular health benefits (Resaland et al. 2011), PA interventions have also indicated favourable effects on educational outcomes (Norris et al. 2019), in particular, on the mathematics performance of pupils aged 4–16 years (Singh et al. 2018; Sneck et al. 2019).

Mechanisms explaining the positive effects of physically active school days on academic achievement may be complex and still unexplained; however, some tentative suggestions have been brought up. Cognitive functions, for example, attentional inhibition and cognitive flexibility may be enhanced by PA (Drollette et al. 2014; Hillman et al. 2014). It is possible that PA causes changes in the structures and functions of the brain (Gomez-Pinilla and Hillman 2013). In addition to the cognitive and biophysical mechanisms, it is clear that learning in a school environment is a process that involves many behavioural and emotional factors. There is evidence that PA interventions improve students' time-on-task behaviour (Watson et al. 2017) and experiences of enjoyment and engagement (Riley et al. 2017). Even though the effects of recent PA interventions on academic achievement and cognitive outcomes are thoroughly reported, there seems to be a dearth of studies elucidating the perspectives of the participants themselves – the pupils. There is a shortage of

studies about pupils' experiences and perceptions dealing with interventions, and therefore practical applicability of classroom-based PA has remained mainly unanswered.

This study focuses on nine-year-old pupils' perspectives on the Moving Maths programme, including physically active math lessons for a period of nine weeks. The programme took place in a primary school in Finland in autumn 2018. To gain comprehensive theoretical insight into the issue, the construct of student engagement was chosen as a framework to elucidate the experiences and perceptions of the pupils.

Engagement as a framework for understanding pupil experiences and perceptions

Student engagement is regarded as a construct with psychological and behavioural components that are critical for learning (Fredricks, Blumenfeld and Paris 2004). It is believed to be malleable and amenable to improvement via pedagogy and interventions (Lawson and Lawson 2013). Therefore, student engagement is a potential target of interventions designed to minimise students' negative school experiences and outcomes. Engagement is linked to an individual's relationship with school, curriculum and pedagogy. (Fredricks, Blumenfeld and Paris 2004). It can be characterised as the actions and behaviours that are the result of a student's motivation (Attard 2013). Some researchers have defined engagement as energy in action, where action refers to goal-directed emotion-infused behaviour (Skinner and Pitzer 2012).

Several other components have been suggested to be added to the construct of engagement (Fredricks, Filsecker and Lawson 2016), for instance, a social component (Xerri, Radford and Shacklock 2018). However, as concluded by Fredricks and colleagues (2016), not all school-related experiences of students can be viewed through the same theoretical construct and for that reason the social dimension was excluded from the theoretical framework but it is acknowledged that peer

relations may play an important part in engaging students in learning tasks (Pietarinen, Soini and Pyhältö 2014).

In learning situations, behaviour, emotion and cognition are dynamically interrelated within the individual; they are not isolated processes. Therefore, engagement can vary in intensity and duration; it can be short-term and situation-specific or long-term and stable (Fredricks, Blumenfeld and Paris 2004). In this study, the components of engagement are further defined as follows.

Behavioural (operational) engagement refers to the range of actions that reflect involvement in school activities and is most commonly measured by students' classroom behaviour, time on-task and concentration. Positive behavioural engagement encompasses the idea of active participation in learning tasks and positive classroom conduct. Behavioural engagement often includes such motivational constructs as persistence and effort. Self-directed academic behaviours are clearly related to self-regulatory behaviours and strategies, such as intentional and purposeful information seeking (Sinatra, Heddy and Lombardi 2015).

Emotional (affective) engagement and disengagement encompass positive and negative affective reactions to school, such as enjoyment and boredom, respectively (Owen et al. 2016). Emotional engagement includes students' reactions to teachers and peers (Fredricks, Blumenfeld and Paris 2004). Motivational constructs, such as perceptions of value related to school, are often included in the operational definitions of emotional engagement (Sinatra, Heddy and Lombardi 2015). Cognitive engagement involves the idea of recognition of the value of learning; for example, students try to comprehend complex ideas and master difficult skills (Fredricks, Blumenfeld and Paris 2004). A widely used definition of cognitive engagement is psychological investment. A student becomes psychologically invested when she or he expends cognitive effort in order to understand, goes beyond the requirement of the activity and uses flexible problem solving, strategic

learning skills and chooses challenging tasks (Sinatra, Heddy and Lombardi 2015; Owen et al. 2016).

Mathematics learning is affected by many factors

The role of mathematical skills is unquestionable in the information society, and therefore mathematics is one of the core subjects in the school curricula globally (Maass et al. 2019). Successful mathematics learning is a process involving many cognitive processes. Some basic skills contributing to arithmetic learning are spatial, language and memory skills, and rapid automatic naming (Zhang et al. 2017). According to Peng, Wang and Namkung (2018), deficits in processing speed and working memory are the most salient and stable cognitive markers of mathematical difficulties.

Not only subject-specific mathematical skills and knowledge but also psychological and social factors contribute to differences in mathematics achievement, such as intelligence, educational opportunity, attitudes and motivation (da Cruz 2017). Several studies have demonstrated that emotional experiences, such as enjoyment and anxiety, are linked to mathematical achievement (Van der Beek, Van der Ven, Kroesbergen and Leseman, 2017). There is evidence indicating that mathematics can raise feelings of anxiety as early as the age of eight (Sorvo et al. 2017). Thus, the emotional experiences of pupils need to be accounted for when we try to understand the processes of learning mathematics.

Previous studies investigating pupil experiences of PA integrated into academic lessons

Riley and colleagues (2017) introduced an EASY Minds programme for 11-year-old students where various types of PA were integrated into mathematics lessons to improve pupils' engagement levels. In their study, the key benefits perceived by students were improvement in 'on-task' behaviour and increased enjoyment and enthusiasm for mathematics. In the Brain Bites study by Howie and

colleagues (2014), students (age 11 years) participated in 5-, 10- and 20-minute classroom exercise breaks. The students discussed the benefits of the exercise breaks: the physical benefits, the effects on learning and academic tests afterwards and their enjoyment of the breaks. However, some students expressed tiredness after PA breaks. In the study of Vazou and Skrade (2017), fourth and fifth grade students in integrated PA and math classrooms reported high levels of competence in practicing math content through bodily movement, close relatedness with their classmates and high perceived autonomy. Van der Berg (2018) explored 10–13-year-old pupils' perspectives on incorporating additional PA into the school day. In more than half of the groups, pupils believed that PA could lead to cognitive benefits, that is, improving their ability to focus and/or learn in school.

Aims of this study

The aim of this study was to investigate pupils' experiences and perceptions of engagement during the Moving Maths programme, including physically active math lessons. The research questions are as follows:

1) What are the participating pupils' experiences of emotional, behavioural and cognitive engagement during the Moving Maths programme?
2) How do pupils' perceptions of engagement differ in the group in which PA was integrated into math curriculum goals versus the group that performed PA breaks?

Materials and methods

Moving Maths study

The current study was conducted in 2018 as the pilot phase of a larger scale Moving Maths intervention study to be conducted in 2019–2020 (registrations ISRCTN75118772 and

ISRCTN71844310). The Moving Maths pilot study in 2018 involved 36 pupils (22 females, mean age 9.4 years) in a large (1300 pupils) suburban public school in Northern Finland. Three volunteer third grade class teachers were recruited, and their classes were randomly assigned to Intervention Group 1, Intervention Group 2 and Control Group 3. The study design aimed at comparing two kinds of physically active math lessons taught for a period of nine weeks. The aims of the Moving Maths study included gaining an understanding of the effects of physically active math lessons on pupils' engagement and mathematics performance. Ethics approval was sought and obtained from the University of Jyväskylä (28th September 2018). Further details of the programme are found in Appendix 1.

Intervention Group 1 consisted of physically active math lessons in which PA was integrated into mathematics curriculum goals. Intervention Group 2 implemented math lessons with PA breaks, including activities not related to curriculum goals. Each of the 45-minute math lessons included two five-minute PA breaks. The lessons in both groups took place four times a week. Group 3 continued with ordinary math lessons.

The pupils' math performance was measured before the nine-week intervention by a custom-made math test based on the national curriculum (Finnish National Agency for Education 2016) and the local grade three syllabi. Overall test scores were calculated, and the participants of this study were clustered into two groups based on their performance in mathematics: lower in maths (n = 7) and higher in maths (n = 7). None of the participants had statements of special educational needs or were reported to receive regular intensified learning support in school.

The pupils' PA levels were measured with hip-worn accelerometers (ActiGraph) for one week at baseline. Based on their overall levels of moderate to vigorous intensity PA (MVPA), the pupils were clustered into two groups with lower PA (n = 7) or higher PA (n = 7). The pupils in the higher

PA group met the global recommendation of having at least 60 minutes of moderate to vigorous physical activity (MVPA) daily (World Health Organization 2010), while the pupils of the lower PA group had MVPA levels ranging from 31 minutes to 56 minutes per day. The accelerometer data of two pupils was incomplete and reported missing.

Pupil interviews: participants and procedures

Semi-structured focus group interviews were chosen as the method to identify the qualitative experiences and perceptions of the participating pupils in groups 1 and 2. The participants in the control group were not interviewed. The method was chosen as small groups may help to redress the power imbalance between adult and child that exists in one-to-one interviews. The support offered by peers within a focus group allows the children more openness in their response; a safe environment for expression of opinions is created. There is also reduced pressure on individuals to respond to every question. The range of participants (4–5) in the majority of our group interviews has been shown to be optimal in generating good-quality data from children (Agar et al. 2005; Mackintosh et al. 2011).

Altogether 16 pupils were invited and consented to group interviews, eight pupils from Group 1 and eight from Group 2. Informed consent was received from both the pupil and his/her guardian. The first author and a teacher education student facilitated altogether four group interviews, each session involving four participants, about one week after the end of the intervention. The write, draw, show and tell (WDST) method was utilised as a starting point in all interviews (Noonan et al. 2016). The drawings of pupils were not used as data as such but as prompts to give the pupils time to reflect on the programme and to encourage active contemplation (Literat 2013). The participants opted for drawing rather than writing, which was accepted. Example drawings are presented in figures 1, 2 and 6.

Each interview lasted for 25–35 minutes. The semi-structured, mostly open-ended interview questions based on the three-dimensional engagement framework were developed by the research team. In addition to the prepared questions, the pupils were given space to express any spontaneous responses. Owing to the qualitative nature of the study, no response was required from each participant for all questions. Sample interview questions are listed in Appendix 2.

Interview data analysis

The interviews were audio recorded and transcribed verbatim. Group 1 interview data consisted of 211 and Group 2, respectively, of 192 responses. First, the data were analysed through a hypothetico-deductive process (Wengraf 2011) using the dimensions of engagement. When the respondent was not clearly identified, the response was marked 'answer' (A). Both verbatim expressions to illustrate the pupils' unique voices and conclusions on the experiences in each of the three dimensions are presented. The main findings are summarised in Figures 3, 4, 5 and 7. Secondly, a hypothetico-inductivist process (Wengraf 2011) was conducted, which enabled us to further identify and summarise any new themes emerging from the interview data (Vaughn, Shay Schumm and Sinagub 1996).

Results

Experiences and perceptions of engagement during lessons with PA integrated to math

Emotional engagement

Most of the pupils who participated in the integrated PA math lessons expressed positive emotional engagement. They had positive experiences about being able to do a variety of physical and math activities. To be able to leave one's desk, move around the classroom or allowed to leave the classroom and complete activities in the corridor were mentioned several times as positive

experiences. PA activities with throwing balls in different ways and relay type activities were also experienced positively. Next, representative examples of pupil interview responses are presented. The participants' background profiles based on the baseline measurement are presented in brackets, for example, 'lower/higher math' and 'lower/higher PA. Due to confidentiality reasons, the names of the pupils were changed. Then, some illustrations of positive experiences are shown in Figures 1 and 2.

> Anna (lower math, higher PA): At first, I thought this is not much fun, but then I started liking it more and more.
>
> Maria (lower math and lower PA): I enjoyed learning during MM morehan learning 'from the board' and everyone sitting in their place.
>
> Maria: I enjoyed orienteering in the corridor. (Figure 2 describes this activity.)
>
> Anna: I feel it was fun to calculate and do skipping at the same time. (Figure 1 describes this activity.)
>
> Sam (higher math and higher PA): I didn't like the skipping.

[Figure 1]

[Figure 2]

Some negative emotions about the Moving Maths lessons were also expressed. Some pupils did not like the activities where movements had to be repeated many times, and it became tiring.

> Thomas (lower math): I go to football and we have training almost every day and my legs always ache when I go to school.
>
> Sam (higher math, higher PA): It felt kind of hard; I can't explain. And I didn't like the skipping.

Negative emotions arose when the teacher's instructions were unclear, too complicated or for some reason the instructions were not followed by all pupils. Two pupils expressed disappointment since they had expected Moving Maths would happen outside at the sports field.

> Maria (lower math, lower PA): In my mind, I would like to have this in the future, this is fun. Since this finished, we are working in the math book, and it is kind of annoying.
>
> Question: Should this kind of lesson continue?
>
> Several answers: Yes.

When asked what the interviewed pupils thought the other pupils of the class would say about the Moving Maths lessons, they found it hard to answer but assumed that most of the others liked the lessons. They found it hard to tell whether their attitudes towards math lessons had changed during the intervention. To summarise, the participants expressed more positive than negative experiences about the Group 1 lessons (Figure 3). Overall, the intervention seemed to increase the pupils' emotional engagement during math lessons.

[Figure 3]

Behavioural engagement

The interviewed pupils stated that most of the pupils in the class had been actively engaged in the activities and followed the teacher's instructions. However, behavioural engagement was not experienced consistently. In general, the girls stated that it was mostly boys who did not participate according to instructions or behaved disruptively or 'fooled around'.

Maria (lower math, lower PA): Some days not everyone could be bothered to participate properly.

Thomas (lower math): Well, sometimes it got out of control.

Question: Why did that happen?

Thomas: It is hard to concentrate or something. Or if you just have a bad day, or can't be bothered to do things.

Anna (lower math, higher PA): I tried to take part actively, but sometimes my muscles were aching.

Julia (higher ma, lower PA): It is easier to sit at your seat once you have moved first.

Even though several pupils experienced working in small groups positively, sometimes not all pupils in the group were given a turn to do their part of the activity, which reduced the engagement levels of some pupils. At the beginning of the programme, some pupils had started to do their math book work instead of joining the activities, indicating that it was difficult for them to adapt to the new learning method.

Most often, the physically active tasks were placed at the beginning of the 45-minute lesson. The pupils experienced that after physical activities, the rest of the lesson (about 25 minutes) was more peaceful and quieter. Overall, despite some negative experiences, the pupils saw that behavioural engagement had increased during the math lessons (Figure 4). Especially pair or group exercises had increased engagement.

Cognitive engagement

The pupils in the integrated PA group expressed more often than the break group that the intervention had helped their cognitive engagement. They expressed their views in concrete ways rather than being able to analyse the mediating mechanisms behind the effects of PA on cognition. Improved concentration and memorisation and reduced tension or anxiety were spontaneously mentioned by the pupils. Also, working in groups of 4–5 on a regular basis was spontaneously described as being a positive experience. This seemed to play a role for cognitive engagement and emerged as a theme outside the dimensions of the engagement framework. It is notable that most of the responses below were given by pupils with low math performance. See the summary of results in Figure 5.

> Question: How did PA affect thinking and learning?
>
> Maria (lower math, lower PA): At least I could concentrate better on book work afterwards. Throwing a ball when learning times tables helped me to remember the answers better.
>
> Anna (lower math, higher PA): Working together makes you learn better than working alone.
>
> Nick (lower math, higher PA): When I had first practised it with the group, I could do it better in the book.
>
> Maria & Julia (higher math, lower PA): That means you can concentrate better on your (book) work.
>
> Question: How, in which way does PA affect learning? Does it have to do with your brain, circulation, excitement, attitude?
>
> Maria: The pupils get enthusiastic, and it helps us to work in groups.
>
> Anna: I think the same … you learn kind of better if you work as a team.

When asked, to whom and what kinds of pupils these kinds of lessons were best suited, the pupils (note: both high and low math performers) replied:

> Sam (higher math, higher PA): The ones that have difficulties in math, because you learn more, you learn easier.
>
> Nicole (higher math, higher PA) & Emma (lower math, lower PA): The ones who find it (math) hard.
>
> Thomas (lower math): The ones that need a little more practise, so at the same time as you are doing something fun and moving, you learn at the same time.

Experiences and perceptions of engagement during math lessons with PA breaks

Emotional engagement

The interviewed pupils stated that they usually enjoy learning math, and some of them said math is their favourite subject. Positive emotional engagement was connected to activities when they could have a break from math book work, leave their desks and move around in the classroom (Figure 6). In some lessons, they were allowed to leave the classroom to do activities in the corridor, which was mentioned positively.

[Figure 6]

> Question: What kind of breaks did you like?
>
> Lena (lower math, lower PA): The one where we were allowed to run in the corridor.
>
> Tim (higher math, higher PA): The ones where we could leave our desks.

James (higher math, higher PA): When we had to hit each other's knees.

Some pupils expressed negative experiences: 'I got bored with all these little breaks, it was really boring.' (James, higher math and higher PA.) Some pupils stated that they didn't like the activities performed alone next to one's desk as much as activities performed in pairs or together as a group. James and Scott (higher math) suggested having PA breaks meant more homework as less time was left to do the math book work, which gave a negative feeling. Emily (higher math, lower PA), however, felt that despite the break, she could complete the required amount of math book work during the lessons. When the interviewed pupils were asked about the emotions of the rest of the class, none of them could answer. Furthermore, they found it hard to analyse whether their emotions towards math lessons had changed during the nine-week period.

Behavioural engagement

The pupils expressed that the instructions of the breaks were easy to understand. However, they noticed how some pupils participated in the PA breaks more actively than others.

Question: Why didn't everyone follow the teacher's instructions?

Answer: 'Cause they were bored … or they got too excited.

If the break involved activities in the corridor, the pupils said it was difficult for some pupils to return to the classroom. Some pupils felt they had followed the teacher's instructions and class rules well during the lessons, but some expressed mixed experiences.

Question: If physical activity is added to lessons, how does it affect pupils' behaviour? Does it improve it or make it worse?

Vera (higher math, higher PA): Makes it worse if I have to choose one of those.

Tim (higher math, higher PA) & Julia (higher math, lower PA): Yes (agrees with Vera).

Lena (lower math, lower PA): It doesn't affect behaviour.

Question: How about concentration; how did it affect your concentration on math book work?

David (lower math, lower PA): Perhaps after that you couldn't concentrate as good.

Lena: I could concentrate better because I felt kind of perkier.

While in the first break group interview there were individual opposite opinions on the effects on concentration, in the second interview the general opinion was that the breaks neither improved nor reduced concentration on math book work.

Cognitive engagement

Some pupils expressed negative perceptions about pausing their math book work for a break.

Emily (higher math, lower PA): Usually it was fun but sometimes, when you had a difficult calculation that you were just about to solve, it was kind of irritating when the teacher said we had to have a break.

Peter (higher math, higher PA): So it (the answer) goes out of your head.

When asked how the breaks affected learning, either positively or negatively, most pupils found it difficult to answer or did not see a connection between the concepts.

Emily (higher math, lower PA): Not in any way.

Vera (higher math, higher PA): Sometimes I just want to do the (book) work ‘cause it is one of my favourites.

Question: How did the breaks affect the end of the lesson?

Lena (lower math, lower PA): I felt perkier.

Answer (several): Not in any way.

Question*:* Why do you think adults planned these kinds of lessons?

Lena: So that the lessons wouldn’t be just completing written work (in the book), but we would move between them..

When asked to whom and what kind of pupils this kind of lesson was best suited, the pupils replied:

Lena (lower math, lower PA): The ones that have physical activity as a hobby.

Vera (higher math, higher PA): And the ones that don’t like math so much or can’t do math so well, so they get a chance to do something else.

Peter (higher math, higher PA): Nobody.

Theresa (higher math, lower PA): The lively ones who find it hard to concentrate.

Some high math performers seemed to perceive that PA breaks interrupted their cognitive efforts and, thus, experienced the breaks negatively. These pupils also expressed that math was one of their favourite subjects. It seemed that for most of the pupils, it was difficult to see the abstract idea of physical activity having some effect on their cognitive engagement.

Overall, the experiences and perceptions of the pupils in Group 2 were more mixed regarding all dimensions of engagement. For that reason, the results of all three types of engagement are

summarised in Figure 7. Both negative and positive perceptions were brought up, and thus the effect of the programme on pupils' engagement during math lessons seems neutral.

Discussion

The results of this study follow the earlier findings indicating that introducing more PA in classrooms can help provide physical (Resaland et al. 2011) and mental (Lubans et al. 2016) health benefits in children, and it can also offer a chance to improve pupils' engagement (Riley et al. 2017) and, thus, lead to higher academic achievement (Singh et al. 2018) and wellbeing. The overall results of this study indicate that the participants of the Moving Maths programme in the integrated PA group experienced increased positive emotional and cognitive engagement, while the pupils in the PA break group expressed mixed experiences, which were more difficult to summarise. Even though prior studies are sparse, these findings seem to be in line with the results of Riley and colleagues (2017) and Howie and colleagues (2014).

As supported by earlier findings, the role of emotional engagement seems to be emphasised in the pupils' experiences, and this might play a moderating role for the other dimensions of engagement; that is, increased enjoyment leads to improved behaviour (time-on task) and cognitive engagement (concentration and learning outcomes). This finding is particularly encouraging because many teachers may be sceptical about including PA in the academic classroom. Not surprisingly, the pupils experienced both negative and positive changes in the dimension of behavioural engagement. Traditionally, teachers expect children to work silently and complete written activities alone during math lessons. Already at the age of nine years some pupils, in both study groups, had perceptions suggesting that learning math is equal to 'completing a certain amount of work in the math book'. The change of this routine might have caused emotions of confusion and thus decreased the behavioural engagement of some children. The idea of what a math lesson should be like might take

more than nine weeks to change in both pupils' and teachers' minds. This can be seen as a hindrance by adults but can be solved by restructuring the school day; for example, by planning longer lessons but including more breaks. Ideally, integrating PA into classrooms should be started from the first school day.

The pupils in the integrated PA group expressed more often than the break group that the programme had helped their cognitive engagement. Improved concentration, new memorisation strategies and reduced anxiety were spontaneously mentioned by the pupils. The participants had few ideas about the mechanisms behind the effects of PA, which might indicate that nine-year-olds are most of the time still thinking on a very concrete level. Concentration was a concept already familiar to the pupils, and it seemed that some the pupils had spontaneously noticed improvement in their ability to focus on math book work after the PA activities, especially in the integrated PA group. In the PA break group, the experiences were more mixed with respect to changes in concentration. Concentration has been categorised as a part of behavioural engagement by Fredricks (2004) when it refers to time-on-task but, equally well, it could mean cognitive engagement when it is seen as the ability to work efficiently or to reach an experience of flow in learning.

A spontaneous theme, learning together, emerged as a novel factor in the integrated PA group, and it was experienced as an increase in emotional and cognitive engagement. This can be interpreted as the pupils' intuitive understanding of the social construction of learning. The findings also support recent suggestions implying that a social component needs to be added to the theoretical framework of engagement (Xerri, Radford and Shacklock 2018). It seems clear that, according to the pupils themselves, peer relations clearly play an important role in engaging students in learning tasks (Pietarinen, Soini and Pyhältö 2014).

Since the interview data were of a qualitative nature and the number of interviewees low, transferability of the pupil experiences based on the participants' background mathematics performance or PA levels is not warranted. However, some emerging issues based on the pupils' background characteristics can be discussed. Van der Berg and colleagues (2018) reported that almost all the pupils in their study were enthusiastic about additional PA in school, despite their different background PA levels. This is in line with the current study – the background PA levels of the participants did not seem to have a connection to their experiences of the Moving Maths programme. It may be possible that the role of PA as such was experienced as smaller in the integrated PA group, while the focus was more on learning mathematics in a novel and interesting way. Thus, the intervention raised fewer negative emotions in Group 1 pupils.

There was no clear pattern in the responses regarding the participants' math performance. Some higher math performers perceived the PA break lessons as emotionally negative, while others with similar performance levels reported positive experiences. On the other hand, several high math achievers in the PA break group stated that the feeling of working flow and concentration on learning was negatively interrupted by PA breaks and thus decreased cognitive engagement. It is noteworthy that the PA break group had more higher math performers (6) than the integrated math group (3), which might have played a role in the responses. The overall experiences towards the intervention seemed more negative in the PA break interviews, which might be explained by the participants' backgrounds rather than the intervention per se. Fredricks (2004) points out that individual differences, such as pupils' ability levels, moderate the relationship between task characteristics and engagement. In this study, the nine-year-olds did not seem to have prior negative emotional engagement towards mathematics as a subject. Developing math lessons towards more emotionally engaging learning situations might stop the harmful trend towards negative math attitudes (Attard 2013).

There are some limitations to this study. First, focus group interviews can create feelings of peer pressure when the children need to express their opinions. This was noticed especially in the PA break group interview. Second, it is possible that pupils and guardians posing prior positive attitudes towards PA, math or school in general were more likely to consent to the intervention and thus participated in the interview. Third, since the programme was specifically designed for a Finnish school, our findings might not be generalisable to other school systems and cultures. Finally, the results are based on a programme run by only two teachers.

On the other hand, this study has several strengths. To begin with, the use of semi-structured open-ended interview questions, instead of questionnaires, can be seen as a strength, as the young pupils are given a chance to express unique perceptions that might be unexpected of adults. At the age of nine, the pupils' reading and writing skills are still developing, which is why questionnaires might not yield as reliable data as interviews. The unedited expressions of young children are analysed through a widely used theoretical framework. Finally, the participants represented both girls and boys, high and low performers in math and children with different PA levels.

Conclusions

According to the participants, integrating PA into mathematics lessons is a feasible method from the perspective of student engagement, especially in the form of PA integrated into math curriculum goals. Integrating PA into math activities might benefit the cognitive engagement of children who have difficulties in learning math. There is a need for future research to provide further insight into developing and testing high-quality instructional materials that help teachers support pupils' behavioural engagement during physically active lessons. The results of this study encourage us to recommend practitioners to integrate PA into math lessons and policy makers to facilitate the introduction of this kind of novel teaching strategy.

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Declaration of interest statement

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APPENDICES

List of appendices

Appendix 1. Further details of the pilot study in the Moving Maths programme

Moving Maths programme

The Moving Maths pilot study was conducted in September–December 2018 as the pilot phase (registration ISRCTN75118772) of a larger scale Moving Maths intervention study to be conducted in 2019–2020 (registration ISRCTN71844310) involving about 400 participants in Finland. More detailed information is available for the pilot phase at http://www.isrctn.com/ISRCTN75118772 and for larger intervention study at http://www.isrctn.com/ISRCTN71844310.

The pilot phase of the Moving Maths study in 2018 involved 36 pupils (22 females, mean age 9.4 years) in a large (1300 pupils) suburban public school with pupils aged 7–16 in Northern Finland. Three volunteer third grade class teachers with master's degrees in education (two males and one female) were recruited. They and their classes were randomly assigned to Intervention Group 1, Intervention Group 2 and Control Group 3.

The study design aimed at comparing two kinds of physically active math lessons taught for a period of nine weeks. The aims of the Moving Maths pilot phase programme included gaining an understanding of pupils' engagement and mathematics performance during the Moving Maths programme. Ethics approval for the pilot study was sought and obtained from the University of Jyväskylä (28th September 2018).

Intervention Group 1 consisted of physically active math lessons in which physical activity (PA) was integrated into the mathematics curriculum goals. The programme was based on the principles and goals of the Finnish national Core Curriculum of Basic Education (Finnish National Agency for Education 2016), which instructs the use of concrete experiences and active learning methods in the teaching of mathematics in primary schools. Fluency of basic arithmetic as well as pupils' positive attitude towards mathematics and their positive self-image as learners are some core goals in the curriculum. Each of the 45-minute math lessons included 20 minutes of physically active learning tasks that primarily trained locomotor skills, balance and equipment handling skills, but also regularly increased heart rate and trained strength. The remaining 25 minutes of the lessons were planned by the class teacher, which ordinarily meant seated math book activities.

Intervention Group 2 implemented math lessons with PA breaks, including activities not related to mathematics curriculum goals. Each of the 45-minute math lessons included two five-minute PA breaks training the same skills as in Group 1. The remaining time of the lessons was planned by the class teacher, which normally meant seated math book activities.

The lessons took place four times a week for nine weeks. Groups 1 and 2 teachers received two hours of training and an instruction manual. The physically active tasks for both groups were developed by a team with experts in exercise physiology and physical education and primary school and special education teachers. The material was accessible online for teachers who participated in the study, and some instructions were also presented as short videos.

Control Group 3 continued with ordinary math lessons.

Appendix 2. Examples of interview questions.

Questions are translated from the Finnish language by first author SS. Possible prompts are in brackets. There was some variation in Group 1 and Group 2 interview questions.

Topic	**Example of questions**
Emotional engagement	- Tell about a Moving Math lesson/break that you especially liked. - In general, what kind of Moving Math activities did you like? (activities in the classroom, skipping, using equipment like balls and bean bags, activities in the corridor or elsewhere) - Tell about an activity that you did not like. - How did you feel when your teacher started the Moving Math activities? - How did you feel during the activities? - What do you think: How did the other pupils, the ones not taking part in the interview, feel about the lessons? - Did your feelings towards the lessons change during these nine weeks? - What kind of pupils do you think this kind of lesson suits best? (The ones who feel anxious about math, the ones who like it, the ones that find it easy or the ones that find it hard?) - Can this kind of math lesson affect pupils' attitudes towards math lessons?
Behavioural engagement	- How did the students in your class behave during the Moving Math lessons? (Did they follow the class rules and teacher's instructions?) Why was that? - Do you want to tell: How well or actively did you yourself participate in the MM activities? - How well did you understand the instructions and were able to follow them? - Personally, how do you think the activities affected your learning or concentration? - How did the activities affect 'peaceful work'? By this, we mean those parts of the lesson when pupils concentrate on their own math book exercises. - What can you say about pair and group work during the lessons?
Cognitive engagement	- Why do you think adults have designed this kind of lesson? - In what way do you think physical activity affected your learning? (Did it make it easier or harder?) - Group 1 only: Did you learn new ways to learn, study or revise mathematics? What were they? - Was there anything that disturbed or prevented you from learning in these lessons?

	In general, does physical activity affect thinking and learning? Why do you think that? (circulation, brain function, excitement, attitudes, working together, concentration)
General	- Group 1 only: What did you think about the videos? - What did you think about the equipment? - Should these lessons continue? - What else would you like to tell?

Figures

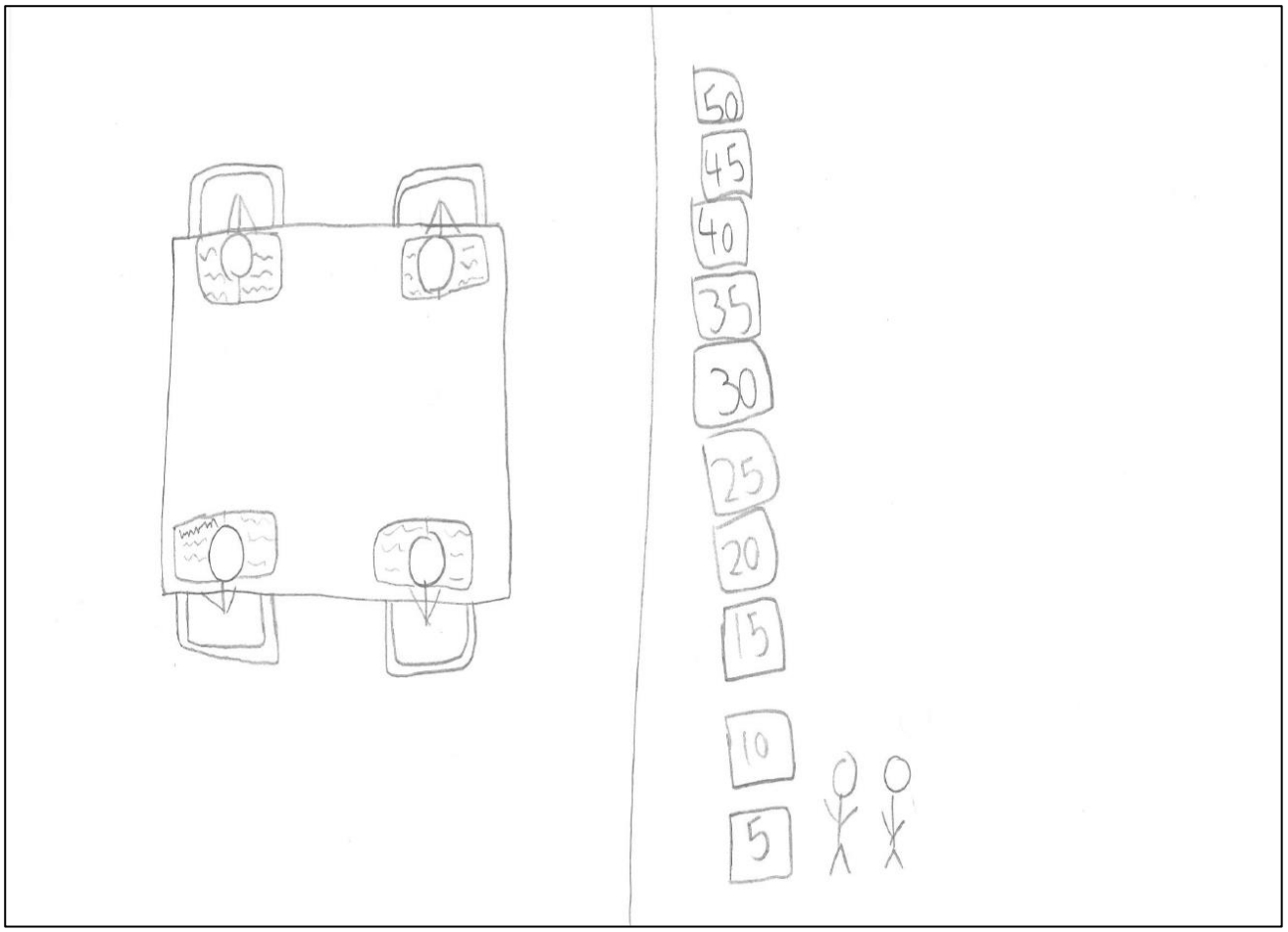
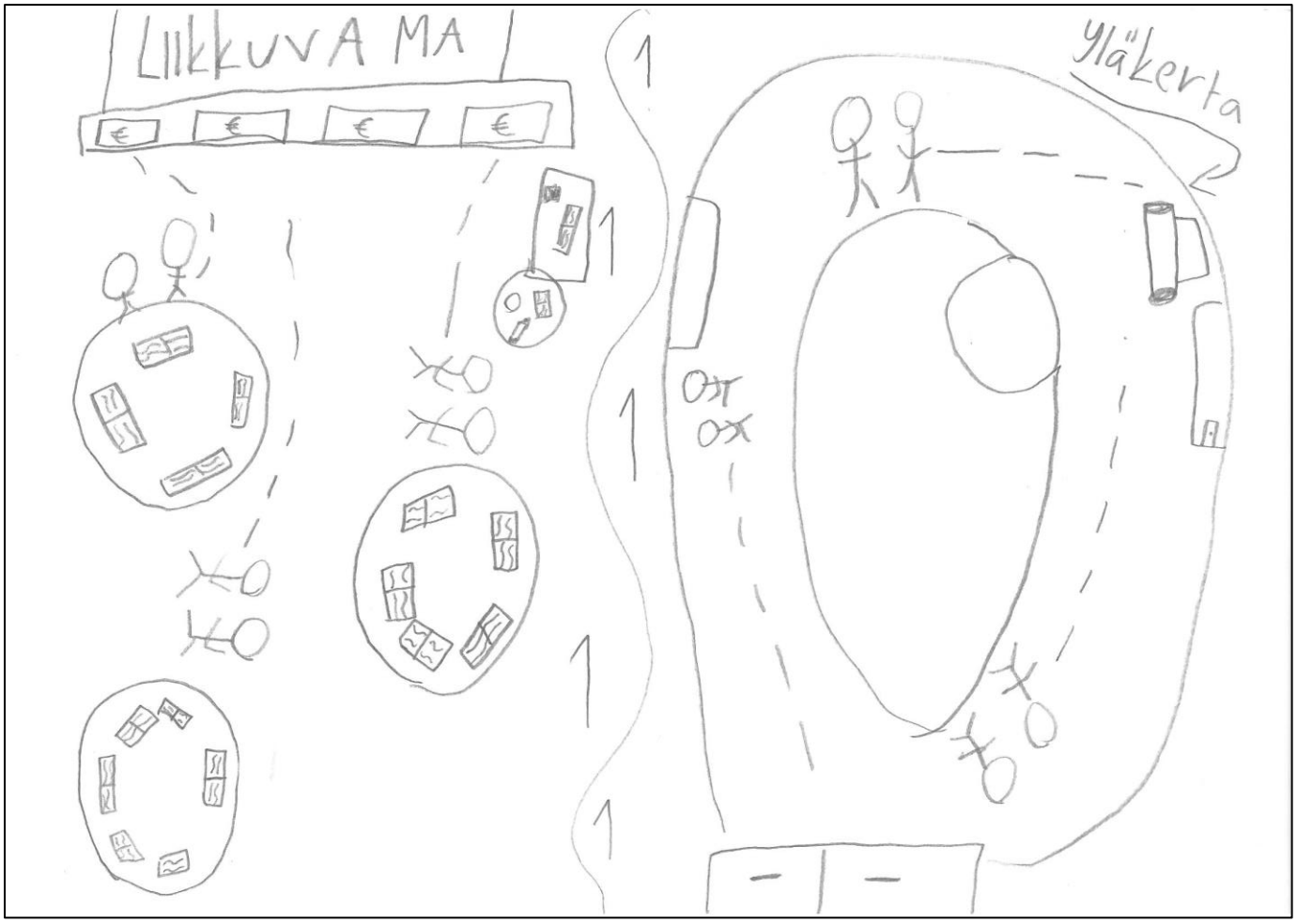


Figure 1.



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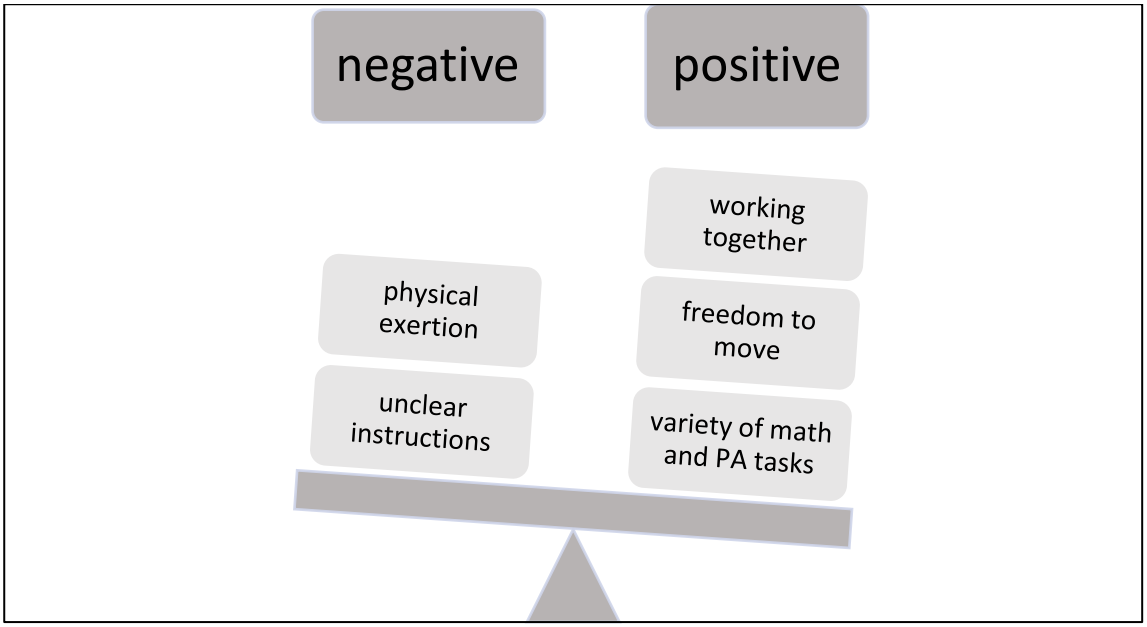

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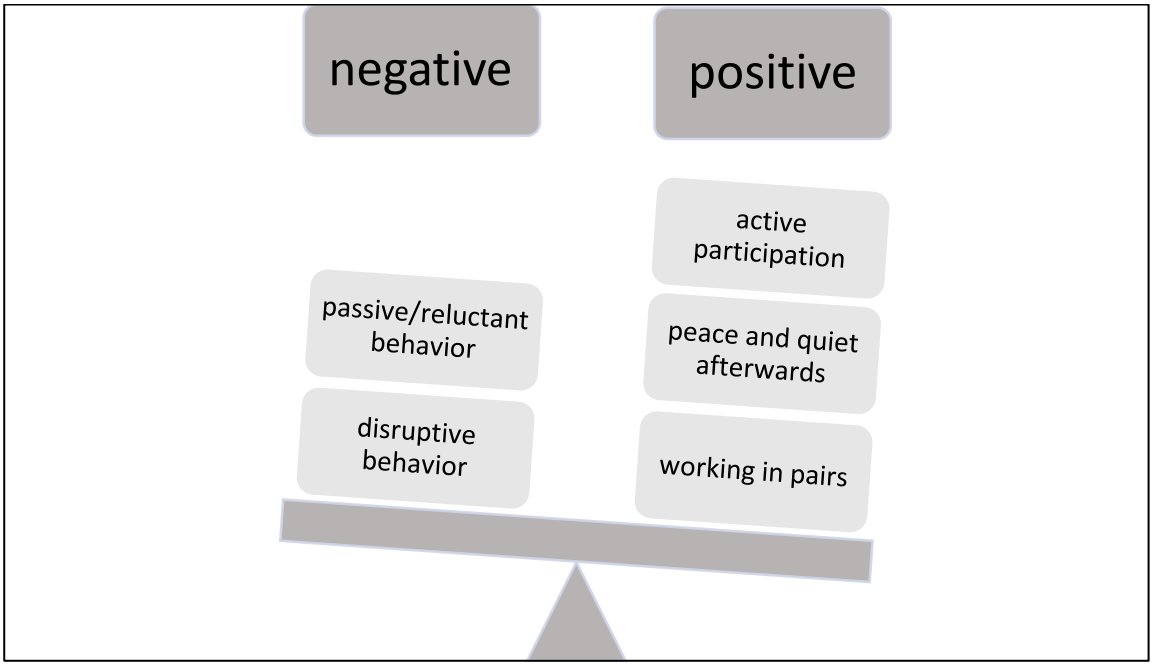

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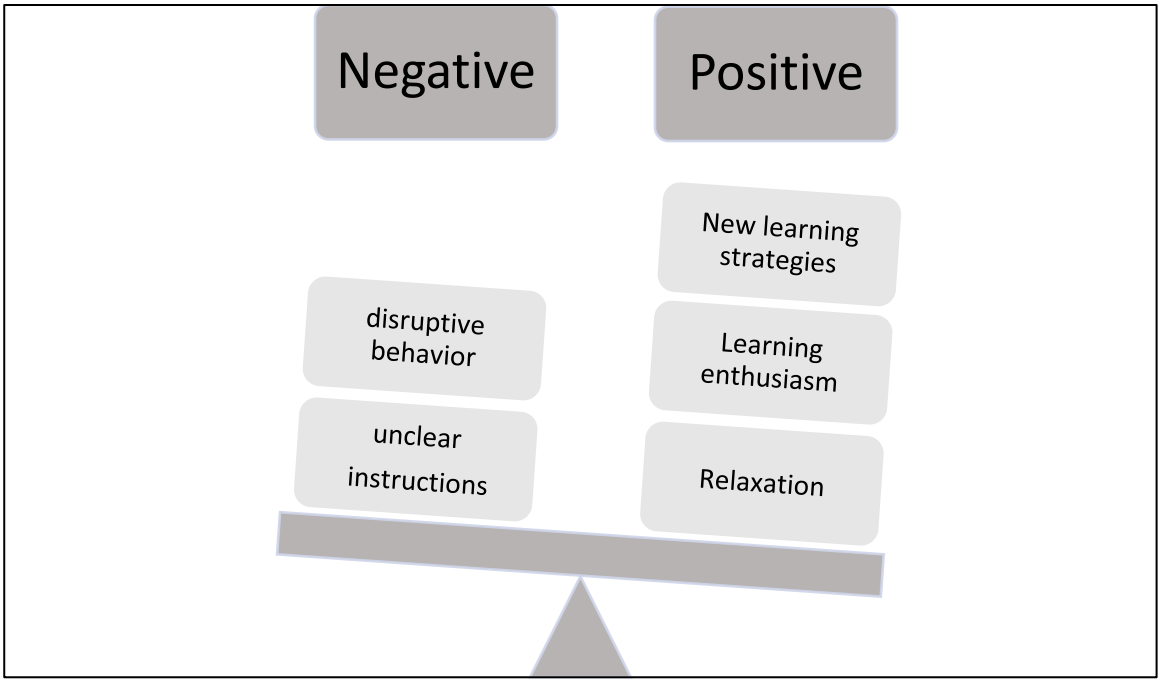

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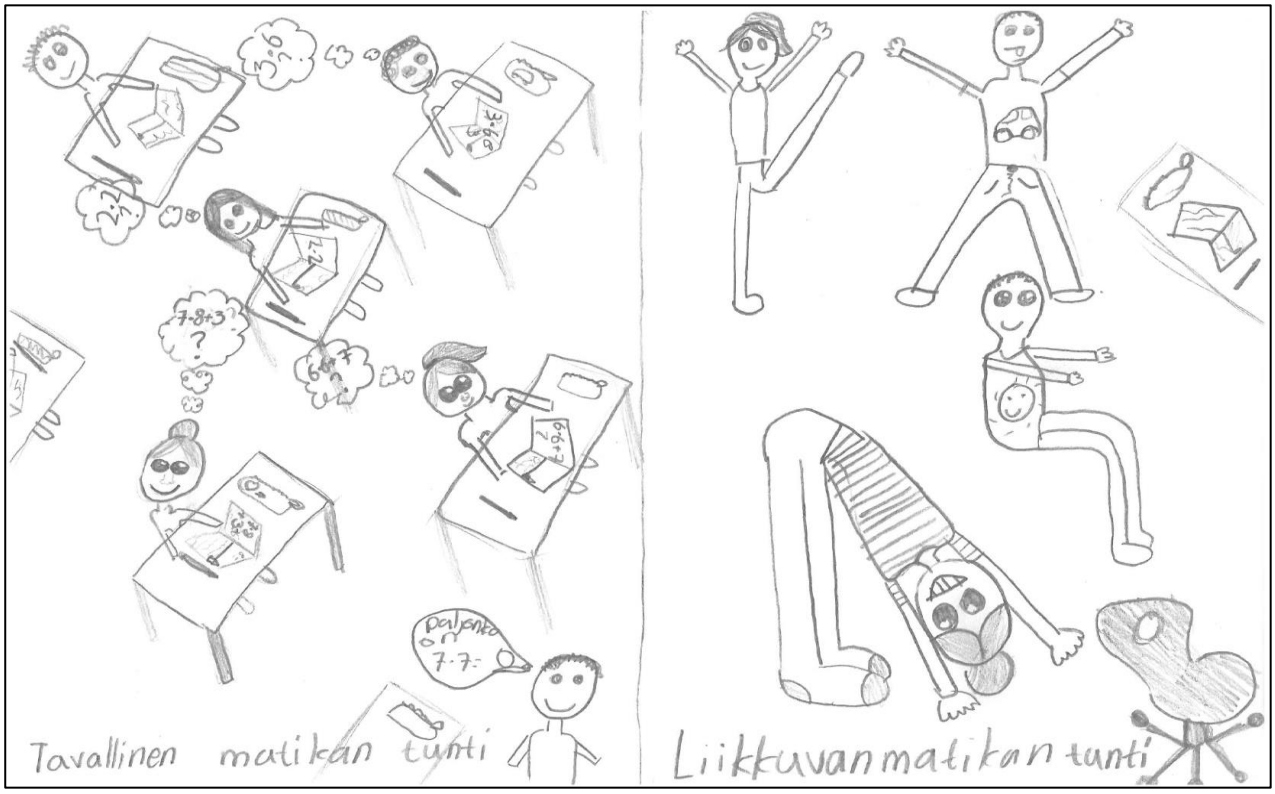

Figure 6.

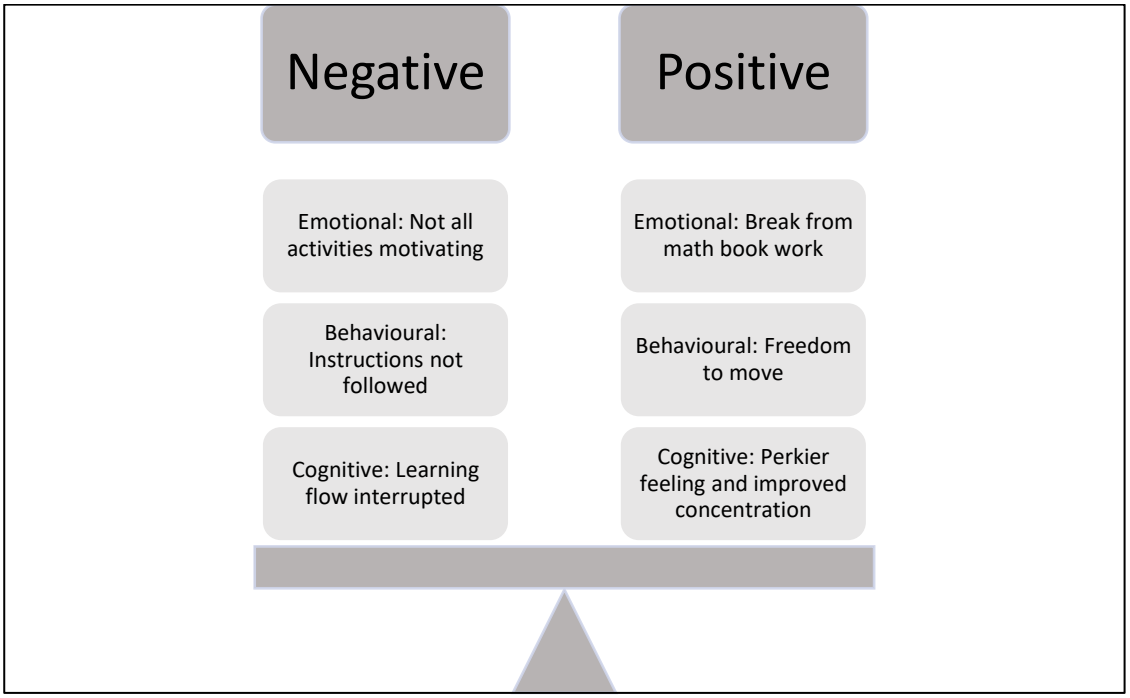
Negative
Positive
Emotional: Not all activities motivating
Emotional: Break from math book work
Behavioural: Instructions not followed
Behavioural: Freedom to move
Cognitive: Learning flow interrupted
Cognitive: Perkier feeling and improved concentration

Figure 7.

Figure captions

Figure 1. Example of a pupil's drawing describing an ordinary math lesson on the left and a Moving Maths lesson on the right (Lena; lower math and lower PA).

Figure 2. Example of a pupil's drawing describing two activities where physical activity was integrated into math (Anna; lower math, higher PA).

Figure 3. Summary of pupils' experiences of emotional engagement when physical activity (PA) was integrated into math curriculum goals.

Figure 4. Summary of pupils' experiences of behavioural engagement when physical activity was integrated into math curriculum goals.

Figure 5. Summary of pupils' perceptions of cognitive engagement when physical activity was integrated into math curriculum goals.

Figure 6. Example of a pupil's drawing describing an ordinary math lesson on the left and a Moving Maths break on the right (Nicole; higher math, higher PA).

Figure 7. Summary of all pupils' experiences and perceptions of engagement during math lessons with PA breaks.