Move and Improve Mathematics: Middle Years

Martin Ommundsen finds that incorporating movement activities into Mathematics can contribute to positive impacts on learning and class dynamics...

If asked 'What is good for the body, mind and spirit?' a typical Mathematics teacher might answer 'Maths!'

This author agrees and presents empirical research that targeted and regular inclusion of movement-based Mathematics pedagogy has beneficial learning outcomes for all students, including those who might typically be thought to be high achieving and coping well in more traditional, seated, classroom settings. The article sets out background research and context and goes on to detail findings for learning and social impacts, drawing on student voice and primary research, before presenting a series of examples for effective activities connected to the NSW syllabuses.

Background

The positive connection between physical activity and cognition has been understood since Sibley and Etnier's meta-study from 2003. They concluded that the academic level of achievement in a range of different subjects, including mathematics, does not decrease when students spend increased time on physical activities in these subjects (Sibley & Etnier, 2003).

Five years later, Tomporowski and colleagues, in a further meta-study, stated that positive changes in children's mental functions caused by physical education lessons are primarily seen in the executive functions. In other words, increased movement in physical education will be followed by increased self-control, short-term memory and cognitive flexibility (Tomporowski et al., 2008).

However, movement during school time can be many other things than those in dedicated subjects, such as NSW's sport or Personal Development, Health and Physical Education (PDHPE). In my home country of Denmark, since 2014, it has been a requirement that students should do some kind of movement averaging 45 minutes per day. The aim of the new law was to bring a lot of movement activities or games into subjects like Mathematics, Danish, English and so on, building on an understanding that physical activity contributes positively to the learning output of students.

The findings below come from empirical research, including my own, which included students interviews with my Class 9 (aged around 15 years old), who frequently received Mathematics instruction involving planned moving games and activities. Their answers are used to understand how these 'games' are experienced from a student's perspective, and in this article, their responses will be referred to as "Year 9 Student".

Impact on learning

There is evidence that physical activity improves student learning. Danish studies report that in Mathematics, students in the youngest school classes can increase their mathematical skills by 35 per cent compared to students who do not have physical activities incorporated into their Mathematics lessons. An Australian study of NSW students at the older end of the age scale advocated that implementation of

activities like high intensity interval training programs increased students' fitness and improved their well-being with potential subsequent benefits to academic performance. (Lubens et al., 2019). However, according to brain researcher Jesper Lundbye-Jensen (Sederberg et al., 2017), for targeted impact on learning outcomes, it is necessary that the physical activities are connected to the subject itself and that they are not "just" a run around. In Mathematics, several cognitive dimensions can be improved, for example, problem solving, logical thinking, spatial perception, short-term memory and awareness.

Student experience and brain function

So, what about the Year 9 class? How did they experience these movement games and did they find the strategies helpful in their lessons? One of the students gives the following description:

You are really using your brain a lot while sitting and working, and you can get quite tired. It's nice with a break halfway through, but you still stay in Mathematics. While moving you refresh what you've learned about prime numbers, square numbers or similar, and after that you are ready to work again.

Another student explains it like this:

It makes things more interesting. You get some oxygen to your brain. You don't feel so tired. Some things you remember better this way, instead of writing them down.

There are several interesting key points to draw out from this. Firstly, the use of Mathematics when moving instead of sitting seem to freshen up the students. It is also important to remember that students are usually sitting down in all other subjects except for physical education, so moving activities can really bring a welcome change. Secondly, it apparently helped the students with the learning afterwards as well. Last but not least, it appears that certain concepts can be easier to remember, perhaps as the body embraces the knowledge in more than one way while moving. This last insight is also supported by other empirical research arguing that the brain develops when practising motor skills (Sederberg et al., 2017). Furthermore, the role of novelty is important here, as in an educational world where most learning is expected to occur whilst sitting at similar looking tables, in similar looking classrooms, the body and brain will more quickly remember the exact learning that happened when it was connected to distinct or novel movement activities in a different setting in the school yard or likewise.

Not only for the disengaged

Some might think that movement activities are only or mainly for those students who struggle to sit in their seats doing usual work at tables. However, one of the Year 9 students explained how that was not correct.

Even though I would categorise myself as a student who is fully capable of sitting down for one hour and listening, I also find it good and welcome to do something where the academic work and physical activities are blended together.

From my own master thesis research, it was evident that movement activities are absolutely not only for students who are struggling with the normal classroom setting, but indeed for anyone in the classroom,

regardless of academic level and gender. Interestingly, these findings have been very similar across very different countries, such as Denmark, Tanzania and Nepal (Ommundsen 2016). My own interpretation is that there could be a universal appreciation for such an incorporated model.

Careful selection is required

At this point, though, it is important to clarify that not all parts of the Mathematics syllabus can be met through such activities. In the first instance, it would obviously be too monotone and not very interesting. The Year 9 students identify certain areas where they find the physical activities fruitful. As example,

Repetition, very clearly! It could be something with questions and answers that are matching. For instance, equations, geometry or mental arithmetic tasks.

Repetition. Like calculation rules, prime numbers or square roots.

This suggests that it is important not to implement new, difficult, or complex Mathematics topics in the movement activity itself. Rather, aim to repeat some previously introduced concepts or areas and then allow the students to practice on that through the movement strategies. As a Mathematics teacher, that is a welcome opportunity to review some of those things you might not otherwise find the time for. Also, it can become easier to relate future discussions to something concrete, as for instance, when using prime numbers again, you can refer back to the physical experiences and say "remember, those were the ones we practiced when we did that activity outside…".

Impact on social life

In addition to the positive impacts on learning outlined above, there can also be advantages for the social life and dynamics of the class as a group. Year 9 student responses on this specific matter illustrate a range of different, important points:

That's a really important part (the social life) and one of the most important reasons to do it. When you're together in groups, everybody is moving, and everyone is passionate. That creates a better teamwork. You build much more on your teamwork when there is some movement in the teaching.

You are talking and communicating more with people. You easily come around to each other. Maybe you come to chat to someone you usually aren't talking to.

Maybe you get some fun memories with each other, you get a little closer with each other, because you have something you can look back on.

Other students interviewed over the years have expressed similar views; that movement activities provide a special mood in the classroom (or outdoor space) when these activities are going on. It would seem unnecessary here to argue further about why a good mood in the classroom is a positive factor.

Whereas in the normal classroom setting students are not usually meant to talk to very many other people, besides maybe their table partner and the teacher, the students in the movement activities pass a lot of

other students simply because they are moving around to lots of different places. In my master's thesis, I found that the students actually did not get disturbed by their classmates in these activities, something that I noticed tended to happen more frequently in the quiet (supposedly) classroom settings. The most likely reason why is that they are so engaged themselves by the activity (Ommundsen, 2016).

There are obviously different ways of creating fun memories together, but the theory of science of body phenomenology argues that the body plays a distinctly important role. Merleau-Ponty (1994) argues that bodies have a will for some kind of freedom. Steen Nepper Larsen further explains how the motorical system operates prior to consciousness so that *We can, before we know*[i]. It has been my experience that movement activities in and of themselves often help create those important fun memories that build the class up together.

Movement activities linked to NSW syllabuses

Thus, having argued that there are several benefits, some specific examples of activities to try are included below. All of the following are activities I have had good success with and each is connected to some relevant syllabus outcomes. The suggestions below are designed to give an indication of starting points and it is anticipated that Mathematics teachers could find many ways to modify and extend these to suit their students.

Tall, broad, thin, low

Method

- Most likely to be done inside the classroom.
- The teacher writes the following on the board:
    - 76-100: tall
    - 51-75: broad
    - 26-50: thin
    - 1-25: low
- The students are given (the teacher can write on the board) different questions like: 3 x 8 - 2. Students can use lots of different combined calculation methods and indicate their answer by manipulating their body to reflect the category for the range the answer falls into. In this example, the result is 22, and so all students should make themselves as low to the ground as possible.
- Divide the students into two or three groups and let them compete against each other, or make a class challenge to notice how fast the whole class can do ten questions.
- Raise the difficulty by using percentage. For example, "How much is 25% of 240?" In this case, using the same range above, the answer is 60, and so students make themselves as broad as possible.

NSW syllabus outcomes

- MA3-6NA: selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation
- MA4-5NA: operates with fractions, decimals and percentages

True or false

Method

- Most likely to be done outside or in a big hall.
- The students are divided into two teams. On each team the members stand in a line next to each other, all facing the opponent team. There should be approximately two steps between the two lines, each student facing a student from the opposite team.
- A "goal line" is marked about 10 m behind each line of the students.
- One of teams is the true team, the other is the false team.
- If the teacher says something which is true, the true team turns around and runs back to their own goal line for safety while the false team tries to catch them. If they teacher says something which is false, the false team has to turn around and run back to their own goal line for safety, and the true team has to try to catch them. So, if the teacher says, "A triangle consists of 190 degrees", the false team runs back to their goal line and the true team tries to catch them.
- If someone is caught before the goal line, this student will go on the other team when the students are lining up to the next question. When doing this activity the first time, it can appear a bit confusing, but the students will soon learn it.
- For making it easier, the teacher can make a break before saying the last part of a sentence, for example "5 x 5 x 2 equals... [pause]... 50". Then students are given a better chance to calculate.
- Play for a set period of time, until one side has caught 10 players from the other team, or until one team is fully captured.

NSW syllabus outcomes

- MA3-6NA: describes and compares length and distances using everyday language
- MA3-7NA: compares, orders and calculate with fractions, decimals and percentages
- MA4-6N4: solves financial problems involving purchasing goods

One in the middle

Method

- Most likely to be done outside or in a big hall.
- The whole class stand in a big circle, each student standing at a spot (marked by a cone/textbook/chair), with one student in the centre of the circle.
- Every participant is given one of four different numbers (for example 6, 7, 8, 9).
- The teacher calls out a larger number which is a product of one or more of the four selected numbers (for example 21, 24, 72). The students who have the relevant number(s) run from their place to another vacated place around the circle (several will always be free at the same time as there are only four numbers allocated).

- Importantly, the student in the centre also has to find a free spot each time, and so every time there will be one student who does not find a spot, and this person will be the new person in the middle for the next round.
- Change the numbers after 5-10 minutes and remember, even though it is a very fun game it is supposed to be a 'brain break' and so not consume the whole lesson.
- Note. This game works well for other subjects such as English or languages, with four words allocated and teachers calling out categories, so please consider sharing with your colleagues.

NSW syllabus outcomes

- MA2-6NA: uses mental and informal written strategies for multiplications and division
- MA3-6NA: selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation

Over to you!

The benefits of physical activity are well understood in health fields, and finding ways to incorporate this knowledge into the school experience is a challenge which, if achieved, could have significant advantages. The strategies outlined in this article suggest that thoughtful integration of subject-specific movement activities into teaching programs can bring improvement in mathematical understanding as well as potential gains in student wellbeing and class cohesion for the full range of students in the middle years.

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[i] This observation was made by Professor Steen Nepper Larsen during a lecture at Aarhus University, Denmark, in 2015.