

Moving Math

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“If we want deep-level learning, we cannot do without involvement.”

Dr. Ferre Leavers

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Abstract

According to Eric Jensen's book, *Teaching with the Brain in Mind*, movement can increase learning in all subject areas for students (Jensen, 2005). This information can benefit teachers as the growing workload for teachers has made it imperative that teachers integrate their subjects. As an elementary school teacher, I am always looking for opportunities to better my practice, create more opportunities for learning, and make my classroom a better space for creativity and play. In a perfect world, learning and play would amalgamate, with students learning through movement while also increasing academic scores. For this action research project, I worked with 19 grades one and two students to answer the following question: *Can embedding aerobic physical activity into grade 1/2 math lessons affect number sense comprehension and engagement?* The study utilized SNAP math assessments to test number sense pre-intervention and post-aerobic intervention. To test student involvement and engagement, Leuven scales were used. The data showed that there was a statistically significant difference in the students' SNAP assessments once the aerobic intervention was put in place. Upon initial intervention, SNAP scores showed the largest change, while further testing during intervention showed a slight regression. The Leuven scales showed that engagement was sustained after the intervention. The data was analyzed using pre-tests for baseline data, a one-way measured ANOVA was also used. A paired samples T-test was used to compare the SNAP scores. A one-way measured ANOVA was used to compare Leuven score data. The results from this statistical analysis parallels current theories such as Caine's Brain-based learning theory (Caine, 1994). This study can add to the body of research about the effects of movement on learning. Subsequent research should include a larger sample size to increase the generalizability of these findings.

Chapter One

Introduction

In this introductory chapter, I will discuss the purpose of my investigation into movement and learning and its' place in current literature. I will also discuss the research question, reasoning, and background for the question. Going into this action research I knew, from years of working with children, that adding movement and play to any activity created more space for engagement and appeared to add more enjoyment to that activity. Dr. Laevers (2015), discusses how most children find the highest level of engagement and involvement through play. What I wanted to know was did it in fact positively impact academic scores, specifically math scores. My hypothesis was that it would, which would align with current research such as Izabela Seger et.al.'s, experiment in a Swedish school in which they found a statistically significant difference in academic scores between a student group that received more aerobic movement compared to the control group (Seger et.al., 2022). This is similar to Dr. Richard A. Wittberg's (2012) research which showed increased academic scores for students when paired with increased aerobic movement. I also hypothesized that the movement would increase involvement/engagement and well-being.

In the Abbotsford school district, P.E. teachers are being removed and classroom teachers are now required to fill those roles in addition to regular classroom teaching. Due to this, teachers are integrating many of their subjects to help deal with time restraints. As a grade 1/2 teacher in a BC classroom, I have felt the heaviness that comes with fulfilling all curricular competencies while also trying to meet my students' daily physical activity requirements. To better meet these needs, teachers can integrate their curricular teaching with aerobic movement. Many programs have been created to integrate movement with academics; including Cairney's

Play program, which combines movement and literacy (Boettcher, 2016). Cairney and Bremer studied many experiments comparing movement, physical health, and a child's development (Bremer & Cairney, 2018). In Cairney's Canadian program, movement has been found to be beneficial for literacy and phonemic awareness. As we see more neuroscience research surrounding literacy and movement, one might wonder could aerobic movement be beneficial during mathematics learning.

Having a deep understanding of math can be beneficial for students' daily lives and futures. "The Organization for Economic Development (OECD) Survey of Adult Skills reveals that numeracy skills are used extensively in work settings worldwide. Across participating OECD countries, 38% of workers aged 16 to 65 report using fractions at work at least once a week, 29% simple algebra or formulas, and 4% advanced math" (Foley et al., 2017). For many students, math can be an overwhelming and stressful subject. Math anxiety or a fear of math can impact a student's ability to develop a deeper understanding of mathematical concepts. This anxiety can be passed down from parent to student and negatively impact math scores (Lital et al., 2021). Movement has been shown to decrease anxiety, therefore, utilizing movement during math may help alleviate some of that anxiety.

"Considering the benefits of physical activity on well-being (Penedo and Dahn, 2005), cardiovascular disease, and mortality (Penedo and Dahn, 2005), it is important that population-level interventions are developed in order to increase physical activity and take into account the high prevalence of anxiety globally" (Stubbs et al., 2017, pg.1).

Not only can math cause anxiety for others but, I have found it can be difficult to teach for many reasons: the first of which is that math, over the years, has been looked at in a new light and taught in new ways with the hopes of deepening children's numeracy. Considerations of the

mathematics curriculum has been adapted and reinvented to make sure that children are reaching a heightened understanding of numbers and to help children seamlessly transport their knowledge into real-world situations. This ‘new’ math may be difficult to understand for those people who were not taught this way. Therefore, teachers must dive deeply into the learning to, in turn, teach it. The second reason teaching math has been a challenge for me is that I, in fact, struggled with math in school. Due to this fact, it has been a goal of mine to make sure that my students are able to grasp a richer understanding of numbers and find joy in math. As my teaching has changed and improved over my professional years, I have tried to find ways to make math engaging and enticing for my students. I began to input movement into math activities. My students are not typically well suited to a lot of sit-down work as they are quite young. As I added more movement, I noticed that this appeared to help with engagement and excitement. This became an opportunity for action research into how movement and mathematics could be partnered to create a more engaging and inviting subject.

Research Question

This is why my research question is as follows:

Can embedding aerobic physical activity into grade 1/2 math lessons affect number sense comprehension and engagement? The aim of this study was to see if math scores would be positively impacted by aerobic movement; I hypothesized that math scores would increase along with engagement.

The following chapters will outline the current state of literature and the theoretical framework connected to this research, and the methodology used, after, the findings will be analyzed and discussed, followed by the conclusion of my research.

Chapter Two

Review of Literature & Theoretical Framework

This chapter explains the foundational and subsequent literature relating to the research question investigating the effects of aerobic exercise during math instruction and whether it has an impact on academic achievement, engagement, and well-being. It focuses on the importance of implementing an effective teaching approach, and the positive effects of physical activity related to quality of life, both in a wider context and within a context applicable to the student and teacher. This chapter also considers the effects of aerobic exercise on overall academic achievement, specifically related to math scores, engagement, and well-being. Lastly, this literature review examines the theoretical framework that underpins the relationship between physical movement and curricular achievement; supporting the use of brain-based learning theory, which plays a critical role in understanding the connection between a teacher's pedagogical approach and the merits of physical movement during instruction; related to overall achievement, engagement, and well-being.

There is substantial evidence that emphasizes the importance and efficaciousness of the pedagogical approach a teacher uses to connect with students; student success is inextricably linked to the quality of teaching the student receives. In fact, it is one of the strongest predictors of student academic success (Hattie 2009; Hargreaves & Fullan 2012). John Hattie's research is based on over 800 meta-analyses supported by over 50,000 empirical research studies that examined and measured 252 different variables contributing to student curricular success. These variables were categorized and delineated on a scale from low to high according to their effectiveness. The analysis found that the category of teacher's approach contributed to student success more than all other categories combined (Hattie, 2018; Hattie, 2009). Although

groundbreaking and respected, Hattie's findings have been criticized for their categorical simplicity, lack of an operationalized dependent variable (learning/achievement), and level of learning: surface, deep, or constructed. Considering this is a critique of a meta-analysis that encompasses thousands of studies there are undoubtedly many operationalizations, but there appears to be no relationship between the educational theory and empirical data used throughout (Rømer, 2019; Klaus & Klitmøller, 2021). Despite critiques of Hattie's findings, they are supported by longitudinal research from Sanders and Horn (1998) that looked at the relationship between school systems, schools, and teachers and student success over time. The result of this research suggests that teaching technique is a stronger predictor of overall student academic progress than race, socioeconomic status, class size, and classroom heterogeneity. Furthermore, "teacher effects on student achievement have been found to be both additive and cumulative with little evidence that subsequent effective teachers can offset the effects of ineffective ones" (Sanders, & Horn 1998, p. 247). Thus, highlighting the importance of effective teaching practices and approaches used to connect with students, especially at the elementary school level. While there is consensus in the literature that the teaching approach is paramount to a student's success no consensus has been made regarding the most effective teaching approach: if it is possible to accurately assess teacher quality (Goldhaber & Anthony, 2008), or if teachers' self-efficacy or belief in their ability matches the quality of their teaching (Thommen et al., 2022). This research examines the need to find a teaching approach that could universally appeal to students regardless of teaching style and individual student learning preferences; physical activity has shown promising results and may aid teachers in finding a ubiquitously effective teaching approach.

Aerobic exercise, according to the American College of Sports Medicine, is defined as exercise that uses the body's muscles in a way that is rhythmic and can be done continuously (Wahid et al., 2016). Aerobic exercise has been shown to enhance many of the indicators that contribute to building and maintaining a healthy quality of life such as improved sleep, mood (Reid et al., 2010), cognitive function (Ahn & Kim, 2023), mental and physical health (Shantakumar et al., 2022). The effect of aerobic exercise on quality-of-life indicators has been shown to be applicable cross-generationally (Sak et al., 2021) cross-culturally (Schmidt & Power 2006), and across a range of participants with physical and mental impairments such as autism (Rodriguez-de-Dios, 2023) and paraplegia (Cowell, Squires, and Raven, 1986). This is important because although teacher and administrator demographics in education are largely homogenous classrooms are often diverse (Simon & Azzarito, 2019). Being equipped with an effective teaching approach empowers educators to connect with their students regardless of their race, background, physical, mental, or socioeconomic status. Empirical evidence has been growing regarding the relationship between aerobic activity, academic achievement, and student engagement. This marriage of the two disciplines could be an approach that underpins the goals of executing effective teaching practices and creating lifelong learners. Both students and teachers can enjoy acquiring knowledge together as a community of learners (Deringöl, Ugurluel, & Eren, 2021).

Numerous studies have investigated the use of aerobic activity to bolster academic achievement. Research has shown that physical activity during learning is associated with improved grades (Coe et al., 2006; TopaŞ & Demirci, 2018), attendance, motivation (Juan He et al., 2023), and self-efficacy (TopaŞ & Demirci, 2018). The benefits of physical movement during academic learning have been shown to have even greater implications for building academic

resiliency. Specifically, having a positive effect on mental spontaneity, “academic passion, academic perseverance, and consistency of academic interest” (Gwon & Shin, 2023, p.1).

These benefits could change the trajectory of a student’s life and ignite the pursuit of one’s passion, benefiting both the student and humanity. Gwon and Shin’s research compliments Hattie’s findings which speaks to the impact that the teaching approach can have on a student’s immediate life. This also implies that positive multi-generational life changes are possible through blended learning, having the proper teaching approach, (Anthony, 2019), and amalgamating physical movement with academics. While there is a place for the traditional lecturer style of teaching, it should be combined with more dynamic teaching that involves movement (Harrington & Zakrajsek, 2017). It is particularly fascinating that the benefits of using aerobic exercise while learning are apparent even in preschool-age children (3-6 years of age) (Mellor, & Morini, 2023).

A seminal study conducted by Mellor and Morini (2023) looked at the impact that exercise, specifically aerobic exercise, would have on preschool-aged children’s ability to learn and recall vocabulary words. This study was done subsequent to a research study that showed that aerobic exercise immediately after vocabulary learning led to improved word recall while also controlling for previous vocabulary/language skills held by participants (Pruitt & Morini, 2021). Two groups of preschool-aged students (3-6 years of age), (N = 42) participated in a virtual word-learning task. The control group was taught the names of previously unknown items. They were then asked to sit and colour for 3 minutes before being tested on the acquisition and retention of the newly learned vocabulary words. The experimental group participated in 3 minutes of guided aerobic exercise before being tested. Both groups also completed a measure that tested their general learning skills. The researchers found that participants in the

experimental group who engaged in aerobic exercise scored significantly higher scores on their accuracy of word recognition measures compared to participants in the resting condition.

Moreover, the scores were unrelated to participants' existing language skills. This was one of the first studies to investigate the relationship between word learning and children as young as 3-6 years of age (Mellor & Morini, 2023). The results aligned with similar findings in older demographics but emphasize the universality of the potential benefits of implementing physical activity into learning. This research and most other research in this area looked at the effects of physical activity before learning on literacy; similar findings have been discovered in other curricular disciplines.

Mathematics has historically been considered an area of study that causes significant feelings of distress. It is linked to math anxiety, decreased math performance, and impaired emotional regulation (Cohen, Korem, & Rubinsten, 2021); the interplay of the three can be debilitating to adults, especially children lacking adequate modalities of coping. Fortunately, research continues to show that the coalescence of aerobic exercise and curricular activity is promising, even when applied to studying math (Gejl et al., 2018; Deringöl, Ugurluel, & Eren, 2021). A study involving twelve Danish schools, (N = 505 children with a mean age of 7.2), showed that participants in the intervention group who engaged in aerobic exercise showed improved math scores on a standardized math test when compared to students in the control group who did not engage in aerobic activity (Gejl et al., 2018). This study underscores the esteeming implications of aerobic activity on mitigating the effects of math anxiety, decreased math performance, and impaired emotional regulation. Similar to most research done in the area of aerobic activity and academic achievement, the intervention of aerobic exercise was

implemented before participants were tested, leaving questions about the efficacy and potential of aerobic activity implemented during instruction (Mavilidi et al., 2018).

Deringöl, Ugurluel, & Eren (2021) analyzed the effects of an activity-based mathematics teaching approach on the attitudes and beliefs of participants towards mathematics. A pre-test post-test design was used to measure the scores of 50 fourth-grade students (25 were in the control group and 25 were in the experimental group). Attitude and belief scales were administered to students after each activity-based mathematics lesson. Students were given an opportunity to give their subjective evaluations after each test. It was concluded that the experimental group who engaged in aerobic activity-based mathematics lessons “showed a significant difference between their pre-test and post-test average scores in favour of the final test” (Deringöl, Ugurluel, & Eren 2021, p 284). Their attitudes toward mathematics and beliefs about mathematics activities were far more positive than the students in the control condition (Deringöl, Ugurluel, & Eren 2021). These findings have implications for all academic subjects and speak to the importance of activity-based learning and teaching approaches. “It is suggested that teaching with activities in which students are active is used more often in classrooms because of the positive impact on students' attitudes to mathematics activities and their beliefs about mathematics” (Deringöl, Ugurluel, & Eren 2021, p. 284). Although the authors of this research express their beliefs in the efficacy of activity-based teaching to positively impact student learning, their research does not adequately show if both affect, and academics can be ameliorated. It does however draw attention to the emotionally curative and restorative capabilities of activity-based lessons and how they could affect student emotional well-being. School is about more than learning curriculum.

Incorporating aerobic activity with learning has many benefits for a student's mental health and overall well-being. Well-being is operationalized to include factors such as having positive relations towards things and others, self-acceptance, confidence, autonomy, purpose in life, and personal growth (Ryff, 1989). Most importantly, well-being is a human right that all children should have, especially in a school setting. A child that does not feel safe is incapable of learning (Laevers, & Declercq 2018). Research has shown aerobic exercise during learning is linked to decreased anxiety and depression, psychological well-being, improved concentration, mood, and motivation (Álvarez-Bueno, et al., 2017; Janssen & LeBlanc, 2010; Khan & Hillman, 2014). These incredible benefits also include enhancing working memory, a crucial core cognitive function that plays an important role in learning, reasoning, problem-solving, and intellectual activity (Chen, Zhu, Yan, & Yin, 2016). Researchers measured the brain activation patterns of preadolescence students using functional magnetic resonance imaging (fMRI). Astonishingly, these benefits to the working memory were found even after one session of aerobic activity. The imaging showed that there were increased brain activities of bilateral parietal cortices, left hippocampus, and bilateral cerebellum; all major components in cognitive function and working memory (Chen, Zhu, Yan, & Yin, 2016). These findings complement work done by Gwon & Shin (2023) around academic resiliency as a result of incorporating aerobic activity into learning. It makes sense that students would experience positive effects on their mental spontaneity, academic passion, academic perseverance, and academic interest considering novel information is more easily transferred to their working memory.

A study done by Lundy & Trawick-Smith (2021) examined the on-task behaviours of preschool students as a consequence of adult-directed physical activity. They found comparable findings to research investigating learning, "brain-related functions, and abilities in elementary

school children and adolescents” (Lundy & Trawick-Smith, p. 463, 2021). Their findings indicated that the on-task behaviour of children aged three, four, and five was greater after physical activity. Furthermore, there was an “even greater result in on-task behaviour for boys and children of low socioeconomic status” (Lundy & Trawick-Smith, p. 463, 2021). These findings highlight how paramount it is for educators to schedule aerobic activities around learning.

Although the research concerning teaching with movement is promising balancing the intensity of the activity is paramount. If extremely intense and rigorous physical activity is implemented during school time it can negatively affect academic performance. This is attributed to increased restlessness during instruction time (Golsteyn et al., 2020). This speaks to the importance of using aerobic exercise because it can be maintained for long durations of time without causing undue stress which might mitigate the numerous benefits of movement in learning. The research is clear, the marriage between aerobic exercise and learning has tremendous merits, both academically and psychologically. This approach to teaching has the potential to engender generational learners and in the present, make the learning process enjoyable and engaging. There are three ways physical activity is brought into the classroom: before, during, and after instruction is given. Despite extensive research on the three options for successfully implementing physical activity into instruction, a noticeable gap remains regarding using physical activity during instruction. It is currently the least used and studied approach (Myrto et al., 2018), especially when specifically looking at using this approach for elementary school mathematics. The earlier children can develop and reap the benefits of active learning the better for their long-term health. Research has shown that habits related to physical activity are both constructed and maintained if they are learned during early childhood (Lu & Montague,

2016). The demands on teachers are growing more and more with each passing year. Physical activity often takes a backseat to changes to the curriculum, standardized testing, and the overall politics of teaching (Thielmann et al., 2022). Applying this research-based approach to teaching might prove to be the most effective way to impact the quality of learning for children.

Theoretical Framework

One may ask if it is best practice to integrate two such diverse activities as mathematics and movement. According to Leslie Hart, the creator of brain-based theory, “Brain-based learning theory states that learning must take place using the information and advances in brain-based science” (Hart, 1978). If teachers are to utilize the best pedagogy, it will be necessary to be up to date on what research has found regarding brain development.

Hart argues that “teaching without an awareness of how the brain learns is like designing a glove with no sense of what a hand looks like—its shape, and how it moves”. Hart pushes this analogy even further to drive home his primary point, “if classrooms are to be places of learning, then the organ of learning, the brain, must be understood and accommodated” (Hart, 1978). It is important that educators have some familiarity with the interplay between the brain and learning:

“All around us are hand-compatible tools and machines and keyboards, designed to fit the hand. We are not apt to think of them in that light, because it does not occur to us that anyone would bring out some device to be used by human hands without being sure that the nature of hands was considered. A keyboard machine or musical instrument that called for eight fingers on each hand would draw instant ridicule. Yet we force millions of children into schools that have never seriously studied the nature and shape of the human

brain, and which not surprisingly prove actively brain antagonistic” (Chipongian, 2021, pg.1).

The question then must be what brain science tells us about learning, brain development and education, and more specifically what is being studied and written about regarding movement and learning. Current brain science tells us that movement creates synapses which enhance long-term memory. “Brain research appears to validate the concept of movement's contribution to learning. It has been found that the greater the movement and stimulation, the greater the number of synaptic nerve interconnections that gives the greater capacity to learn” (Stevens-Smith, 2004). There has been a substantial amount scientific research and discourse regarding brain-based learning with the primary focus on neuroplasticity. Thomas et al., have findings that infer that aerobic movement can impact changes in the brain that are different than the changes made through regular learning or other activities (Thomas et al., 2012).

Teachers can feel confident that if they are incorporating movement into their lessons their students could be gaining a deeper knowledge of the content. Hart’s brain-based learning theory aligns with the ideas of experiential learning which aim to enrich learning for students.

There have been many discussions over the years about play-based learning or experiential learning. Some teachers and researchers have delved into these theories by testing the value of incorporating movement into academics. John Cairney has spent time researching and creating programs incorporating phonics/reading and physical literacy (Cairney et al., 2019). Others have found ways to adapt movement into other subjects.

According to Lindt and Miller, “Students were significantly more excited by, engaged in, and focused on the lessons that integrated movement than those that did not” (Lindt, et al, 2017

p. 1). In a systematic review of the effects of physical activity on mathematics, researchers found that “of the 29 studies involving 11,264 participants, positive overall effects of PA intervention on mathematics performance were found in 13 studies (45%)” (Sneck, et al., 2019 p.1).

While there has been substantial research done in the area of movement before learning, what differentiates my proposed research from others is the implementation of physical activity during academic learning and assessment. Moreover, the effects of student engagement will be tested as a function of physical activity. This study aims to apply brain-based learning theory and research to test the impact of movement on the brain and to test its effect on learning and engagement/involvement (Caine, 1995). More specifically, examining how movement can impact the math scores of students in a grade one/two classroom to answer the research question: *can embedding aerobic physical activity into grade one/two math lessons affect number sense comprehension and engagement?*

Considering the relevant research on movement and its impact on the brain, it is conceivable that movement in cooperation with mathematical learning will affect number sense in a positive way-meaning student comprehension of number sense will be ameliorated. It is also perceivable that it will positively affect student engagement. Children may also be more involved and engaged due to the combination of learning with movement.

In summary, this literature review has identified key trends and findings related to the importance of teaching approach, and the benefits of aerobic activity during classroom instruction in relation to academic achievement and well-being. Conclusively, this comprehensive examination of the existing literature lays the foundation for research done to explore the examination of the effects of implementing aerobic exercise during instruction. The

next chapter will delineate the research design and methods used to address the research question.

Chapter Three

Methodology

This chapter outlines the research position, design, and methodology used to address the research question identified in the previous chapter: *Can embedding aerobic physical activity into grade 1/2 math lessons affect number sense comprehension and engagement?* Firstly, the chapter presents the ontological position for the study, the research design, and the methodology. Secondly, it identifies participants, and ethical considerations related to the participants and research design. Finally, it outlines the procedures for data analysis.

Research Paradigm

This research was undertaken from an ontological perspective in a post-positivist paradigm. I came to this research with the perspective that there can be multiple truths and understandings of reality and as such this study used mixed methods to ascertain the impact of the intervention on pupils' experiences (Saunders & Thornhill, 2019; Creswell, 2021). I recognize that a researcher brings with them their own set of ideas and biases which may impact the conclusions they come to. For this reason, I utilized scales and assessments which are highly used and recognized in the research and teaching field and are more difficult for a researcher to input bias or create errors. The first assessment was the SNAP assessment, which was used to explicitly show a student's mathematic understanding and number sense. SNAP stands for

“Student Numeracy Assessment and Practice”; the assessment contains four sections testing: communicating and representing, understanding and solving, connecting and reflecting, and real-life reasoning and analyzing. The second was the Leuven Scale for Well-Being and Involvement which assesses students’ emotional well-being and engagement/involvement through a five-point scale of observation (Leavers, 2008). The mixed methods approach to data collection gave me the opportunity to collect mathematics scores providing quantitative data and involvement/well-being scores providing qualitative data on how the students were interacting with the activities (Cohen et al., 2018). Both qualitative and quantitative data determined how math lessons were impacted by aerobic movement interventions. Data was collected by first creating a baseline mean for both SNAP scores and Leven Scores. Repeated measures analysis was done to see the effect of the aerobic movement intervention.

Research Methods & Tools

The research was a mixed methods approach of data collection through assessments and observation; quantitative data was collected through a math assessment and the Leuven scale for well-being and involvement. Qualitative data was generated through Leuven observations and field notes. As the classroom teacher, I was the sole researcher and as such provided the math lessons as well as administered all the assessments.

The focus of the math lessons and assessments was aimed at the curricular content of number sense from the British Columbia (Canada) Curriculum. (BC government, 2021).

“Big Idea:

Numbers to 100 represent quantities that can be decomposed into 10’s and 1’s

Number Concepts: curricular competency

- counting:
 - skip-counting by 2, 5, and 10:
 - using different starting points
 - increasing and decreasing (forward and backward)
- Quantities to 100 can be arranged and recognized:
 - comparing and ordering numbers to 100
 - benchmarks of 25, 50, and 100
 - place value:
 - understanding of 10s and 1s
 - understanding the relationship between digit places and their value, to 99 (e.g., the digit 4 in 49 has the value of 40)
 - decomposing two-digit numbers into 10s and 1s
- even and odd numbers”

SNAP Data

The SNAP assessments were used to assess number sense. This assessment was chosen because it is widely used in the Lower Mainland as a helpful and accurate way to show what children can do, know, and where they may need more support. The SNAP assessment assesses the three main areas of the BC curriculum:

- Communicating & Representing: through drawing, description, and expanded form
- Understanding & Solving: 3 equations
- Reasoning & Analyzing: Skip counting & number line

Each competency was scored out of three with a total possible score of nine.

There is one other assessment piece on the SNAP, mathematical connections to real life, but I did not utilize this piece for the research, assessment, or data, as I teach this in a different way, and it did not align with my research timeline.

Participants

The participants in this study were nineteen grade ones and twos. They were between the ages of five and seven years old, some were eight by the end of the study. Sixteen of the students were in grade one, and three were in grade two. Seven of the students were female and twelve were male. The students came from mixed socio-economic homes. Jackson Elementary is in an area that, over the past decade, has changed from somewhat of a rural farming area to an inner-city area. More and more students are coming to school without food or supplies and the school is providing families with more support than in previous years. All students were told that their participation was voluntary. Their parents signed consent forms to have their children involved in the experiment. I also attained Abbotsford School District permission to conduct this research. Students were coded by linking each participant to an alphanumeric ID for data analysis.

Intervention

The intervention was implemented through three game-based math activities. The first was ‘magic numbers’; in this game, the children danced while music was playing and when the music stopped, they raced back to their desks to find the ‘magic number’ on a hundreds chart. The magic number was called out by me. The second activity was skip-counting. For this, we went outside and jumped rope. Each successful jump counted as two. We were practicing our skip counting while practicing our gross motor movements jumping rope. Eventually the

students did this independently. They would skip and count, once they stopped or missed a jump, they would run to the other side of the school to write down their number with sidewalk chalk. They were continually trying to beat their own score. The final aerobic intervention was an ‘addition and subtraction run’. For this, the students would listen to an addition or subtraction equation and begin to run to find enough items outside to recreate that equation. A child might find four rocks and three sticks to recreate $4+3$. Each activity would last twenty to thirty minutes and were, as often as possible, done outside.

Data was collected through both qualitative and quantitative data using scales and mathematical assessments. Two assessments were used: a SNAP math assessment and the Leuven Scale for Well-Being and Involvement (Leavers 1998). The SNAP assessment is a number sense assessment that allows students to show their mathematical understanding and is done by students individually. “SNAP is a unique, student-friendly assessment and practice tool that enhances any balanced math program. The templates and rubrics are simple, straightforward and provide a clear snapshot of learning evidence.” (Chilliwack School District #33). The SNAP will provide clear numerical data. This assessment is used across multiple districts in the lower mainland as a standardized way of evaluating student numeracy. It was used pre and post-intervention. This assessment was not new to my practice; I have used it in previous years. I also took training with an Abbotsford District Math Helping Teacher to ensure a high level of expertise for my research data collection administering the SNAP assessment. For the first 3 SNAP assessments, 2 pre and one post, students were pulled from class one by one, given instructions, and observed as they completed the assessment. On the final SNAP assessment, as they were quite familiar with the format, students worked individually on the assessment in class. Please see the timeline later in the chapter.

To gather qualitative data, the Leuven scale was used. “The Leuven Scale is a form of assessment developed by Ferre Laevers and his team at Leuven University in Belgium (Laevers 1998). It is a five-point scale that allows childcare practitioners to measure children's 'emotional well-being' and 'involvement' – two vital components of learning, development, and progress in children.” (Cheqdin, 2021). The Leuven scale records low engagement which can include behaviours such as daydreaming or not participating, to high engagement which includes behaviours such as focus and engrossment in the activity. I recorded Leuven scores on each student on four occasions during both pre- and post-intervention math lessons; two pre and two post. The dates of those collections were November 18th, 2021, January 27th, 2022, April 1st, 2022, and May 27th, 2022. The Leuven Scale was done through teacher observations of students while they work. All the Leuven scales were done by me and on different days than the SNAP assessments. Each Leuven scale was done by observing the student during math activities to assess their well-being and involvement while they were learning rather than during a SNAP. The Leuven scale tests extremely low to extremely high involvement, with each category bearing a description to help the researcher. Someone who is extremely low may seem “absent” or “low energy”, as opposed to an extremely highly engaged student who may appear “involved” and “not easily distracted”. Students received a score from 1 through 5. Laevers suggested getting into a childlike mind space as a researcher and reporting on a two-minute snapshot of each child’s activities for scale assessment (Laevers, 2015). I followed Laevers instructions, and each Leuven scale was done by observing a two-minute window of each student’s activities. Please see a copy of the scale used in the appendices (Laevers, 2008).

A field journal was also used for additional qualitative data collection. This journal was used to note children's comments during lessons, as well as any discussions that came up regarding math lessons. Please see the timeline later in the chapter.

Timeline

For this quasi-experimental research, it was necessary to get a baseline of students' number sense. For this, students completed a SNAP assessment as well as a Leuven scale assessment at the beginning of November. It was not possible to have a control group, therefore a period of 'business as usual' was completed following the pre-test to act as a control. This consisted of regular mathematics lessons from November through to March. In December another SNAP assessment and Leuven Scale was completed. The intervention of aerobic movements commenced after Winter Break, from January to April. To assess the impact of the intervention two further SNAP and Leuven Scale assessments were completed during the intervention period, one at the end of March and another at the end of April. Below was the original timeline as presented in the original proposal for this research.

November	December	January	February
Baseline SNAP and Leuven Scale	Regular learning SNAP and Leuven Scale	*Intervention* SNAP and Leuven Scale	SNAP and Leuven Scale

Due to many unforeseen circumstances as well as the COVID-19 pandemic; the timeline listed above was adjusted slightly. All the circumstances and situations which affected the timeline are explained in detail in the Discussion chapter. Each assessment was completed later than previously planned. Please see the adjusted table below:

November	December	March	April
Baseline SNAP and Leuven Scale	Regular learning SNAP and Leuven Scale	*Intervention* SNAP and Leuven Scale	SNAP and Leuven Scale

Ethical Considerations & Bias

There are several ethical considerations for the research and data collection process. All students needed to receive equitable learning and movement time for the data to be reliable. Children with learning and/or physical exceptionalities needed to be included in all the learning activities. All assessments would be done by the same researcher to mitigate any potential bias or errors in assessment processes. The use of the SNAP and Leuven scale reduced the risk of researcher bias. Ethical approval for the research was gained from UWTSD (appendix 3). The researcher also completed the Canada Tri-Council Research Ethics Training and gained ethical approval from the district prior to the commencement of the study.

There was consideration of the risks of physical harm. It is possible that aerobic physical activity could have caused harm. All safety precautions were taken to make sure that all the environments used were free from any danger: classroom, playground, and outdoor spaces. Each child was shown how to safely practice each exercise.

All assessments were marked by me, the researcher, which could impact scoring. This could result in potential scoring biases. As well, due to the fluidity of the Leuven scale, it could be easily swayed by the researcher. Especially when the researcher has an interest in seeing positive results. Ethically, it is important that I did not skew the results. To mitigate this, I tried to remain as objective as possible by limiting any unnecessary interactions with students and observing from afar. The use of a researcher's field notes ensured I was able to be reflexive

about my role in the data collection and analysis and reduce the risk of bias through self-awareness.

I can also see that I bring my own bias to the experiment and there are an incredible number of outside forces that can impede the results. Data was generated through qualitative observational data and quantitative quasi-experiment to ascertain a cause-and-effect relationship from the intervention of movement.

Data Analysis

The data was analysed using SPSS. The SNAP assessments were analysed first by finding the mean baseline math scores using a frequency descriptive analysis. Those numbers were then run against the post-intervention SNAP assessments through a one-way repeated measures ANOVA. A paired samples T-test was used to evaluate the impact of the aerobic movement and compare pre and post-intervention tests. The qualitative data from the Leuven was also analysed using SPSS. A frequency descriptive analysis was used to a mean baseline of Leuven scale scores. Afterwards, a one-way repeated measures ANOVA was conducted to compare the Leuven scores. Lastly, a paired sample T-test was used to evaluate the level of well-being and engagement amongst the students.

In summary, this chapter outlines how over one school year, nineteen students participated in a mixed methods quasi-experimental design to assess the impact of aerobic movement on numeracy scores. The next chapter will present the results from the analysis of the data.

Chapter Four

Data Analysis, Findings, and Results

This chapter shares the findings and results of the research gathered during this research project. The analysis of this data suggests that a statistically significant number of participants experienced an ameliorated capacity to communicate, represent, understand, solve, reason, and analyze number sense post-intervention. Moreover, student well-being and engagement also increased after the intervention of movement during instruction was implemented. The results were analyzed using the Statistical Package for Social Sciences (SPSS). The quantitative evidence has been delineated in detail to give an accurate depiction of the results. In addition, qualitative evidence discovered throughout this research project is presented to complement and account for the improvements observed in engagement.

SNAP Pre-Test Control

A frequency descriptive analysis was performed to test the mean baseline pre-test scores of participants (Table 1). The majority of participants, 78.9%, scored 4 and 5 ($M = 4.37$, $SD = .831$) out of a possible score of 9 on their pre-test baseline scores in three categories: communicating and representing, understanding and solving, and reasoning and analyzing (Table 2). This suggests participants had an average familiarity with number sense before intervention. None of the participants scored above 6, suggesting they potentially lacked proficiency in the aforementioned areas. Successive SNAP tests were administered months apart “SNAP Pre-Test 1”, followed by several months of instruction without intervention, and “SNAP Pre-Test 2” to serve as a control for this experiment. A paired samples T-test (Table 3) was conducted to evaluate if there was any change in the initial participant SNAP scores before intervention. There was no statistically significant difference observed between the baseline pre-test ($M = 4.37$, $SD =$

.831) and the second pre-test ($M = 4.47$, $SD = .964$) scores, where our t of 18 = -1.455 and probability was greater than 0.05. This suggests that participant scores were generally unchanged as a result of learning traditionally, without movement.

Table 1 – Pre-Test (Baseline) Mean Scores

Statistics		
SNAP PRE-TEST 1 (BASELINE)		
N	Valid	19
	Missing	0
Mean		4.3684
Median		4.0000
Mode		5.00
Std. Deviation		.83070
Minimum		3.00
Maximum		6.00

Table 2 - SNAP Pre-test 1 (Baseline) Frequency

SNAP PRE-TEST 1 (BASELINE)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00	3	15.8	15.8	15.8
	4.00	7	36.8	36.8	52.6
	5.00	8	42.1	42.1	94.7
	6.00	1	5.3	5.3	100.0
	Total	19	100.0	100.0	

Table 3 - SNAP Pre-test 1 (Baseline) – Pre-test 2 Paired Differences

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SNAP PRE-TEST 1 (BASELINE)	4.3684	19	.83070	.19058
	SNAP PRE-TEST 2	4.4737	19	.96427	.22122

Paired Samples Test										
		Paired Differences					Significance			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	SNAP PRE-TEST 1 (BASELINE) - SNAP PRE-TEST 2	-.10526	.31530	.07234	-.25723	.04671	-1.455	18	.081	.163

SNAP

A one-way repeated measures ANOVA was conducted to compare the SNAP scores at pre-test 1 (baseline), pre-test 2 (pre-intervention), post-test 1 (post-intervention), and post-test 2 (retention). The means and standard deviations are listed in Table 4. There was a significant effect for time [Wilks' Lambda = 0.110, $F(3,16) = 43.071$, $P=0.000$, multivariate partial eta squared = 0.890]. This suggests that there was a change in test scores across the four different times (Table 5). To further determine where this difference occurred a dependent t-test was conducted between participant SNAP pre and post-test scores. All test scores were compared despite there being no statistically significant difference between the participant control scores (pre-test 1 and pre-test 2) as shown in Table 3.

Table 4 - SNAP Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
SNAP PRE-TEST 1 (BASELINE)	4.3684	.83070	19
SNAP PRE-TEST 2	4.4737	.96427	19
SNAP POST-TEST 1	6.3684	.83070	19
SNAP POST-TEST 2 (RETENTION)	5.2105	2.09706	19

Table 5 - SNAP Repeated Measures ANOVA

Multivariate Tests ^a						
Effect		Value	F	Hypothesis df	Error df	Partial Eta Squared
Time	Pillai's Trace	.890	43.071 ^b	3.000	16.000	<.001
	Wilks' Lambda	.110	43.071 ^b	3.000	16.000	<.001
	Hotelling's Trace	8.076	43.071 ^b	3.000	16.000	<.001
	Roy's Largest Root	8.076	43.071 ^b	3.000	16.000	<.001

a. Design: Intercept
Within Subjects Design: Time

b. Exact statistic

A paired samples T-test (Table 6) was conducted to evaluate the impact of physical movement during instruction on SNAP scores. Pre-test scores were compared to post-test scores. There was a statistically significant difference observed between pre-test 1 ($M = 4.37$, $SD = .831$) and post-test 1 ($M = 6.37$, $SD = .831$) scores, where our t of 18 = -10.677 and probability was less than 0.05. A statistically significant difference was also observed between pre-test 2 ($M = 4.47$, $SD = .964$) and post-test 1 ($M = 6.37$, $SD = .831$) scores, where our t of 18 = -8.818 and probability was less than 0.05. These results suggest that movement had a significant impact on SNAP scores. The other scores reflected no statistically significant differences, even when comparing both pre-tests to the retention scores of post-test 2. This will be examined in detail in the discussion section. These results are found in Tables 6 and 7.

Table 6- SNAP Pre-test – Post-test Mean Comparisons

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SNAP PRE-TEST 1 (BASELINE)	4.3684	19	.83070	.19058
	SNAP PRE-TEST 2	4.4737	19	.96427	.22122
Pair 2	SNAP PRE-TEST 1 (BASELINE)	4.3684	19	.83070	.19058
	SNAP POST-TEST 1	6.3684	19	.83070	.19058
Pair 3	SNAP PRE-TEST 1 (BASELINE)	4.3684	19	.83070	.19058
	SNAP POST-TEST 2 (RETENTION)	5.2105	19	2.09706	.48110
Pair 4	SNAP PRE-TEST 2	4.4737	19	.96427	.22122
	SNAP POST-TEST 1	6.3684	19	.83070	.19058
Pair 5	SNAP PRE-TEST 2	4.4737	19	.96427	.22122
	SNAP POST-TEST 2 (RETENTION)	5.2105	19	2.09706	.48110

Table 7- SNAP Pre-test – Post-test Paired Differences

		Paired Samples Test						Significance	
		Paired Differences				t	df	One-Sided p	Two-Sided p
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower Upper				
Pair 1	SNAP PRE-TEST 1 (BASELINE) - SNAP PRE-TEST 2	-.10526	.31530	.07234	-.25723 .04671	-1.455	18	.081	.163
Pair 2	SNAP PRE-TEST 1 (BASELINE) - SNAP POST-TEST 1	-2.00000	.81650	.18732	-2.39354 -1.60646	-10.677	18	<.001	<.001
Pair 3	SNAP PRE-TEST 1 (BASELINE) - SNAP POST-TEST 2 (RETENTION)	-.84211	1.67542	.38437	-1.64963 -.03458	-2.191	18	.021	.042
Pair 4	SNAP PRE-TEST 2 - SNAP POST-TEST 1	-1.89474	.93659	.21487	-2.34616 -1.44332	-8.818	18	<.001	<.001
Pair 5	SNAP PRE-TEST 2 - SNAP POST-TEST 2 (RETENTION)	-.73684	1.62761	.37340	-1.52133 .04764	-1.973	18	.032	.064

Leuven Scale

The descriptive statistics including mean, median, and standard deviation were performed to test participants' Leuven test scores for well-being and engagement while learning ($M = 3.52$, $SD = .964$) as shown in Table 8. A frequency descriptive analysis was also performed to test the mean baseline pre-test scores before the intervention took place (Table 9). The majority, 68.4%, of participants scored between 3 and 4 on a five-point scale: 1 = "Extremely Low", 2 = "Low", 3 = "Moderate", 4 = "High", and 5 = "Extremely High. Table 8 shows the frequency of scores for each participant. Most students were scored as moderately engaged while learning mathematics. No participant was observed being "extremely low" or "extremely high" in terms of engagement.

Table 8- *Leuven Pre-test Mean Scores*

Statistics		
LEUVEN PRE-TEST 1 (BASELINE)		
N	Valid	19
	Missing	0
Mean		3.5263
Median		4.0000
Mode		4.00
Std. Deviation		.96427
Minimum		2.00
Maximum		5.00

Table 9- *Leuven Pre-test 5-Point Scale Percentages*

LEUVEN PRE-TEST 1 (BASELINE)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	3	15.8	15.8	15.8
	3.00	6	31.6	31.6	47.4
	4.00	7	36.8	36.8	84.2
	5.00	3	15.8	15.8	100.0
	Total	19	100.0	100.0	

A one-way repeated measures ANOVA was conducted to compare the Leuven scores at pre-test 1 (baseline), pre-test 2 (pre-intervention), post-test 1 (post-intervention), and post-test 2 (retention). The means and standard deviations are listed in Table 10. There was a significant effect for time [Wilks' Lambda = 0.247, $F(2,17) = 25.879$, $P=0.000$, multivariate partial eta squared = 0.753]. This suggests that there was a change in test scores across the four different times (Table 10). To further determine where this difference occurred a dependent t-test was conducted between participant Leuven pre and post-test scores.

Table 10 - Leuven Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
LEUVEN PRE-TEST 1 (BASELINE)	3.5263	.96427	19
LEUVEN PRE-TEST 2	3.6842	1.00292	19
LEUVEN POST-TEST 1	4.7368	.56195	19
LEUVEN POST-TEST 2 (RETENTION)	4.7368	.56195	19

Table 11 - Leuven Repeated Measures ANOVA

Multivariate Tests ^a							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Time	Pillai's Trace	.753	25.879 ^b	2.000	17.000	<.001	.753
	Wilks' Lambda	.247	25.879 ^b	2.000	17.000	<.001	.753
	Hotelling's Trace	3.045	25.879 ^b	2.000	17.000	<.001	.753
	Roy's Largest Root	3.045	25.879 ^b	2.000	17.000	<.001	.753

a. Design: Intercept
Within Subjects Design: Time

b. Exact statistic

A paired-sample T-test was conducted to evaluate the level of perceived well-being and engagement pre and post-intervention. There was a statistically significant difference observed between all pre-test and post-test scores where the probability was less than 0.05:

- Pre-test 1 ($M = 3.53$, $SD = .964$) and post-test 1 ($M = 4.74$, $SD = .562$) scores, where our t of 18 = -7.398.
- Pre-test 1 ($M = 3.53$, $SD = .964$) and post-test 2 ($M = 4.74$, $SD = .562$) scores, where our t of 18 = -7.398.
- Pre-test 2 ($M = 3.68$, $SD = 1.002$) and post-test 1 ($M = 4.74$, $SD = .562$) scores, where our t of 18 = -6.508.
- Pre-test 2 ($M = 3.68$, $SD = 1.002$) and post-test 2 ($M = 4.74$, $SD = .562$) scores, where our t of 18 = -6.508.

This is reflected in Tables 12 and 13. Unlike the SNAP, Leuven scores remained the same post-intervention. Participant engagement scores after intervention were predominantly “Extremely High” with 78.9% of participants scoring in this category (Table 14). These results indicate that during observation the participant fully engaged and immersed themselves in the activity. They were highly motivated and strongly connected to the activity. They were also fully focused and paid attention to the task while being completely immersed in the lesson.

Table 12- *Leuven Pre-test and Post-Test Mean Comparisons*

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	LEUVEN PRE-TEST 1 (BASELINE)	3.5263	19	.96427	.22122
	LEUVEN PRE-TEST 2	3.6842	19	1.00292	.23009
Pair 2	LEUVEN PRE-TEST 1 (BASELINE)	3.5263	19	.96427	.22122
	LEUVEN POST-TEST 1	4.7368	19	.56195	.12892
Pair 3	LEUVEN PRE-TEST 1 (BASELINE)	3.5263	19	.96427	.22122
	LEUVEN POST-TEST 2 (RETENTION)	4.7368	19	.56195	.12892
Pair 4	LEUVEN PRE-TEST 2	3.6842	19	1.00292	.23009
	LEUVEN POST-TEST 1	4.7368	19	.56195	.12892
Pair 5	LEUVEN PRE-TEST 2	3.6842	19	1.00292	.23009
	LEUVEN POST-TEST 2 (RETENTION)	4.7368	19	.56195	.12892

Table 13- *SNAP Pre-test – Post-test Paired Differences*

		Paired Samples Test								
		Paired Differences						Significance		
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	LEUVEN PRE-TEST 1 (BASELINE) - LEUVEN PRE-TEST 2	-.15789	.37463	.08595	-.33846	.02267	-1.837	18	.041	.083
Pair 2	LEUVEN PRE-TEST 1 (BASELINE) - LEUVEN POST-TEST 1	-1.21053	.71328	.16364	-1.55432	-.86674	-7.398	18	<.001	<.001
Pair 3	LEUVEN PRE-TEST 1 (BASELINE) - LEUVEN POST-TEST 2 (RETENTION)	-1.21053	.71328	.16364	-1.55432	-.86674	-7.398	18	<.001	<.001
Pair 4	LEUVEN PRE-TEST 2 - LEUVEN POST-TEST 1	-1.05263	.70504	.16175	-1.39245	-.71282	-6.508	18	<.001	<.001
Pair 5	LEUVEN PRE-TEST 2 - LEUVEN POST-TEST 2 (RETENTION)	-1.05263	.70504	.16175	-1.39245	-.71282	-6.508	18	<.001	<.001

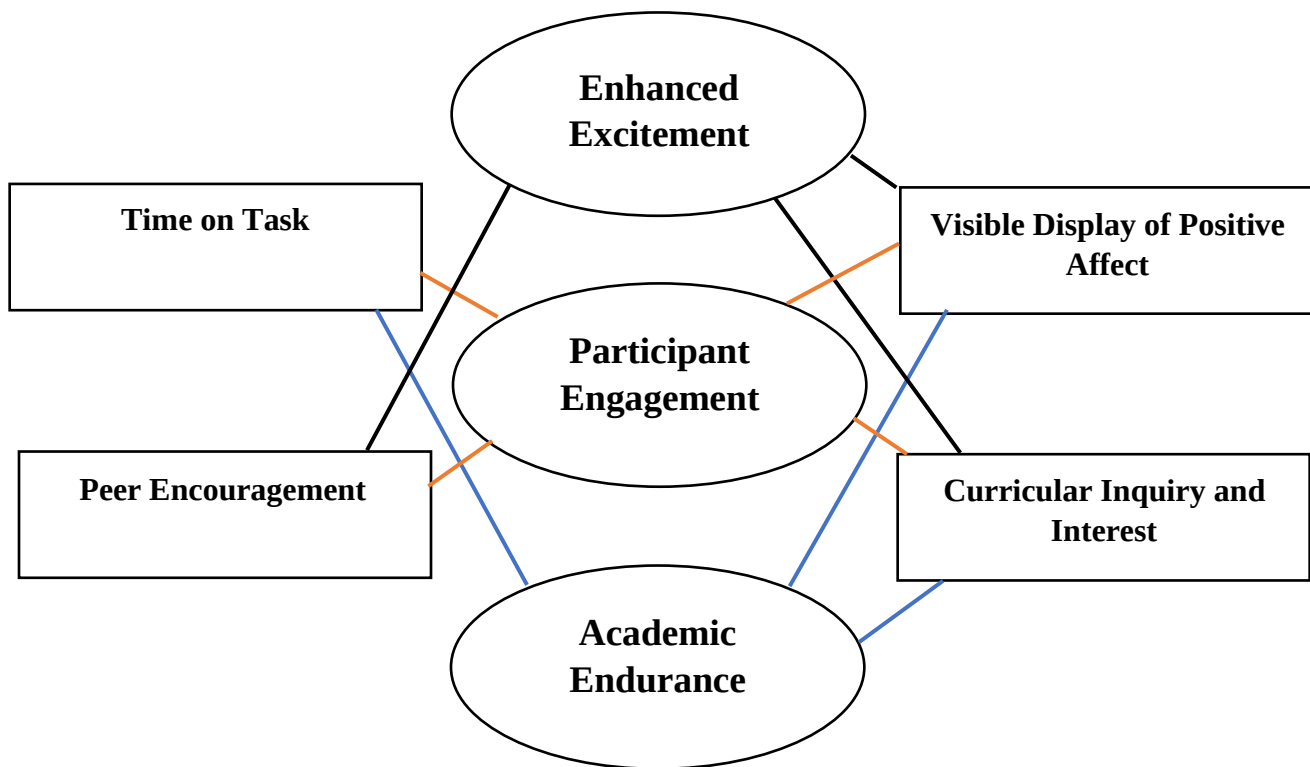
Table 14- *Leuven Post-Test Frequency*

LEUVEN POST-TEST 1					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00	1	5.3	5.3	5.3
	4.00	3	15.8	15.8	21.1
	5.00	15	78.9	78.9	100.0
	Total	19	100.0	100.0	

LEUVEN POST-TEST 2 (RETENTION)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00	1	5.3	5.3	5.3
	4.00	3	15.8	15.8	21.1
	5.00	15	78.9	78.9	100.0
	Total	19	100.0	100.0	

Qualitative Findings and Themes

Using Braun and Clarke's six-phase thematic analysis (Braun, V., & Clarke, V. 2006) three reoccurring themes emerged that aligned with my research question: *can embedding aerobic physical activity into grade one/two math lessons affect number sense, comprehension, and engagement?* The three emergent themes were: enhanced excitement, participant engagement, and academic endurance. Thematic evidence comes from an amalgam of resources including field notes, tests, personal reflections/ journal entries written, and conversations throughout my research journey all of which were meticulously coded and organized to provide a robust analysis of the data. *Figure 1* reflects a thematic map that relates to the research question.

Figure 1 - Thematic Map**Theme 1: Enhanced Excitement**

The intervention of movement during math lessons brought with it enhanced excitement for the participants involved. participants showed a greater proclivity towards learning mathematics when compared to other subjects. Participants regularly checked the classroom schedule for math and inquired when math was not listed on the schedule (participants B1, B3, P4). In addition to their inquisitiveness, participants often asked when they would have an opportunity to practice math (participants P3 and P5). Pre-intervention participants would only inquire about Physical Education and free time. Moreover, participants asked to do specific

activities and games: magic number and skip counting, both outdoor physical math activities. There was a noticeable difference in their attention given to transitions and the time between subjects. In the past, the participants did not ask about transitioning from one subject to another, but during the intervention, they asked about math specifically, “Where is math on the board?”, “When are we doing math?”, and “How much longer until math starts?” This anticipatory excitement was not only present before but also throughout the math lessons. It was noted that participants expressed more visible cues of happiness and excitement such as smiling and laughing during math lessons than pre-intervention; participants would cheer and celebrate when it was time for math. They exhibited positive affective behaviours such as giving each other a high five when I told them we would do skip counting (participants B5 and B12). Participant interactions with each other were significantly more positive during the math games, particularly magic numbers than during other subjects. They displayed an increased willingness to help each other in math. They seemed to have a palpable zest for learning math, and with joy, engagement followed.

Theme 2: Participant Engagement

Participant engagement changed once movement was introduced into the lessons. Participants asked more general math questions, even during other subjects and free time. Participants who typically showed reluctance to answer questions and who were previously hesitant to engage in math lessons wanted to participate. When asked about the noticeable change in their willingness to engage in math lessons participant P5 explained, “It was more of a game than school even though we are learning”. They wanted to be a part of the learning. Engagement and well-being were measured using the Leuven Scale (MacRae & Jones, 2020) during math lessons. Before the intervention participant Leuven scores were mostly “moderate”

= 3, but post-intervention they were in the “high” = 4 to “extremely high” = 5 range.

Remarkably, when retested for retention scores remained identical! From a purely observational perspective, the participants seemed to enjoy learning math even when they did not completely understand newer mathematical concepts. This will be expounded upon in the discussion section.

Theme 3: Academic Endurance

Participants gained an obvious measure of enhanced academic endurance post-intervention, meaning they were able to self-regulate and focus on one task for a longer duration of time. In the past participants could only last 10-15 minutes before learning was interrupted and needing a brain-break or time away from curricular activities. Participants preferred not to take a break and to continue the math with movement. From a researcher’s reflective perspective, the intervention embedded a brain-break into the lessons which might explain the participants’ ameliorated ability to stay focused longer; often 20-30 minutes of uninterrupted learning. I would perform a calm-down meditation after because participants were hyped up. Overall, participants were more well-behaved perhaps due to the amount of movement and having an outlet for their energy.

A further explanation of the findings will be delineated in the following discussion chapter. Here I will expound on what the data suggests and the potential implication for pedagogical approaches. There are meaningful implications for connecting with students and building an engaging learning experience while ameliorating their capacity to communicate, understand, solve, reason, and analyze curriculum. These have far-reaching implications for my personal development as a teacher and the profession as a whole.

Chapter Five

Discussion

This chapter discusses and expounds on the interpretation of the data collected and analyzed in the previous chapter, using the Statistical Package for Social Sciences (SPSS), to answer the research question concerning the impact that movement has on academic achievement, well-being, and engagement. This study aimed to provide evidence to support a pedagogical approach to teaching, coalescing movement with academic instruction, specifically mathematics, that will facilitate learning in a manner that is efficacious and engaging to both teachers and students. The analysis of the data suggests that a statistically significant number of participants experienced an ameliorated capacity to communicate, represent, understand, solve, reason, and analyze number sense post-intervention. Moreover, student well-being and engagement also increased after the intervention of movement during instruction was implemented; this influence on well-being and engagement proved to be long-lasting. Further explanations for these findings as well as how they relate to existing research literature, and their practical and theoretical implications, will be delineated throughout this chapter.

When I began this research, I had the belief that movement could increase students' ability to learn and their enjoyment of activities. This idea developed into a more concise action research question. The data results fall in line with my hypothesis that students' math scores could increase with movement as well as their involvement/engagement and well-being. There is a great library of research around movement's positive impacts on learning, including Lundy et al., who noted that students on-task behaviour was greater once movement was included in learning activities (Lundy & Trawick-Smith, 2021). There was an initial jump in scores from the intervention. What I did not expect was for the SNAP scores to taper off and not continue to

improve. Goldsteyn et al., studied the impact of increased movement on children and how that affected primary school performance. The negative impact of increased physical activity could cause restlessness in the students. This may be relevant to my research as children became engaged in more events such as sports, games, clubs, etc., towards the end of the school year when the weather became more accommodating to outdoor activities, possibly creating classroom restlessness and impaired focus on work (Goldsteyn et al., 2020). As for the Leuven scale scores, I was not surprised that involvement and well-being scores were high upon initial intervention and remained high afterwards. According to Jensen, movement added to any subject can create more interest and involvement (Jensen, 2005). This also speaks to Gwon and Shin's research that showed the effect of physical activity on fostering: academic grit, passion, perseverance, consistency, and interest. They also found that play positively impacted their relationships to each other and their attitudes towards school (Gwon & Shin, 2023). These findings advocate that teaching practice should be predicated on integrating movement with learning.

SNAP Student Numeracy Assessment and Practice

Since I was using my classroom for my research, which restricted my ability to teach the same lesson twice in different ways, I needed to create a baseline score as my control sample. The baseline SNAP math assessments were done using a teaching approach void of physical activity. Mathematics was taught in a conventional form, paper and pencil work sheets, dice games, math songs and, hundreds chart games, many of which were played/done at their desks, none involving aerobic activity. Two SNAPS were done to get data about mathematical abilities in the classroom before intervention. The data showed that SNAP scores stayed close to the same before intervention. Children came in with some basic number sense. Students were still

contending with the loss of education from COVID-19 lockdowns. In a study on grade one student's writing scores, after the pandemic school shutdowns, Skar et al. (2023), found that student scores were far lower than the previous year's grade one student writing scores. The math scores were not surprising and were also understandable as many students had never experienced the SNAP math assessment format before. The difference between the first and second SNAP assessments showed that number sense stayed relatively the same.

These four pieces of SNAP assessment data were crucial to creating a one-way repeated measures ANOVA to compare all four SNAP scores. Data from these results suggest that there was a statistically significant difference amongst the SNAP scores. A paired sample T-test was conducted to determine where the change in scores occurred. This test showed statistical significance upon the initial intervention. The data also showed that despite continued intervention, scores nearer the end of the year showed a regression towards pre-test scores. With that said, the scores were higher than both pre-tests but did not show significance compared to the first post SNAP test scores. This aligns with research which implies that aerobic movement has been shown to increase academic achievement (Ahn & Kim, 2023). Yet this does not explain why SNAP scores waned and lacked continued growth post-intervention. This could have occurred due to the elevated difficulty of the math being taught. As the year progressed, the expectation of what students could show mathematically and at what level they expressed mathematics changed. Students were working with much smaller numbers in the beginning of the year; they began with 12 as their SNAP number and progressed to 27 by the end of the year. While this explanation for decreased SNAP scores seems quite intuitive to me as their teacher, it is contrary to findings from Kesler, et. al. (2011), who conducted a study to investigate the efficacy of math training on students with neurodevelopmental limitations. They measured math-

related cognitive skills by examining fMRI imaging. Their findings suggest that training can improve cognitive skills even in individuals with altered brain development.

Another possibility for this change may have been the initial excitement of including aerobic movement in math lessons. The novelty of integrated movement during math lessons may have worn off as time went on. Although this does not coordinate with the Leuven data collected which showed high levels of engagement upon intervention and afterwards. Movement can increase students' attitudes and positive outlook, which may have impacted SNAP scores initially (Deringöl, Ugurluel, & Eren, 2021). Moreover, children may have had a heightened state of focus and with that came higher SNAP scores initially. Chen et al. (2016), found that on fMRI's students had greater working memory and cognitive function after aerobic activity. This then, may have levelled off scores due to dwindling novelty. Although, Leuven scores of involvement and well-being remained high. The enjoyment appears to have stayed but perhaps the focus on mathematics lessened.

Leuven Scale for Well-Being and Involvement Data

To enrich the research, I chose to utilize the Leuven scale. This scale measures student well-being and involvement/engagement. Well-being includes factors like: having positive relations towards things and others, self-acceptance, confidence, autonomy, purpose in life, and personal growth (Ryff, 1989). Involvement has links to a student's self-esteem which may impact how deeply they can learn (Laevers, 2008). The Leuven scales were implemented to measure the student's engagement and well-being during both pre and post intervention math learning. As previously discussed, the data from the SNAP assessments showed a statistical significance once the movement intervention began, but I wanted to also investigate engagement, comparing whether students found themselves more involved in math learning before or during

intervention. Similar to the SNAP data analysis, the Leuven scores were run through a frequency descriptive analysis to create a baseline of scores pre intervention. Data showed that the majority of students were moderately engaged during pre-intervention math lessons. Math in grade one and two tends to be engaging in unique ways as compared to higher grades, in that activities such as dice games, songs and hands on learning are used to deepen mathematical understandings. This could explain why most students were already somewhat engaged in math lessons pre-intervention.

A one-way repeated measure ANOVA was conducted next to compare all four Leuven scale data. This analysis suggested that there was a statistically significant change amongst the scores. A paired-sample T-test was conducted to evaluate the level of perceived well-being and engagement pre and post intervention. There was a statistically significant difference observed between all pre-test and post-test scores. Participant engagement scores after intervention were predominantly “Extremely High” with 78.9% of participants scoring in this category. This shows that despite the math difficulty increase, engagement and well-being remained high. The students were actively involved and participating. This also suggests that although, based on their SNAP scores, the work was challenging, they still enjoyed the learning experience. According to Gwon & Shin (2023), movement can increase academic resiliency which may be why students were engaged in difficult work, whilst being involved and persevering. Álvarez-Bueno (2017), echoes this knowledge reiterating that aerobic exercise is linked to decreased anxiety and depression and improved psychological well-being and concentration. Leuven scores remained high with most students being measured “extremely high”, as the aerobic movement continued. The qualitative data are aligned with the findings expressed through the Leuven scores.

Looking at the field notes and observations taken during the experiment, three themes emerged: enhanced excitement, participant engagement, and academic endurance. Field notes showed that students were looking forward to intervention-style math lessons by asking about them and checking the classroom shape of the day to see where math was scheduled for the day. Engagement in math was clear not only through the Leuven scales, but in watching students discuss how math felt like play or games more than learning. Finally, academic endurance seemed to be enhanced as lessons which pre-intervention would have lasted no more than fifteen minutes before students appeared distracted, post-intervention lessons could go on far longer, sometimes up to thirty minutes. Gwon and Shin (2023), found that movement increased academic resiliency and academic perseverance in children. This was evident in the improved stamina my students showed. This also relates to Hattie's (2018), research which considered a teacher's pedagogical approach to education, and how the quality of their work is linked to students' success. Since I was taking a holistic approach to teaching through whole body and mind activities, students appeared to show more involvement with the math curriculum (Hart, 1978). This could explain the deep connection and excitement they had for the subject.

Brain-based learning theory suggests that movement can affect academic scores and involvement. My pre and post-intervention scores suggest compatibility with the brain-based learning theory researched and discussed by Renate and Geoffrey Caine in the early '90s (Caine, 1994). Before the research by the Caines, Leslie Hart (1978) researched how to make the best environments for learning based on the current brain science of the time. The Caines, similarly, to Hart, chose to take a holistic approach to thinking and learning, addressing teaching in dynamic ways and utilizing all areas of the brain while also considering a child's developmental stages (Caine, 1995). As Eric Jensen states in *Teaching with the Brain in Mind*,

movement can strengthen learning, memory, and motivation/morale. He discusses the importance of implementing movement into all areas of the curriculum including math and science (Jensen, 2005). My research shows parallels to some of the current information in the field of brain-based learning and integrating movement into learning. The data from my research shows that movement can affect learning, which aligns with both Jensen's work as well as the Caines work. My study is comparable with Mellor and Morini's experiment involving preschool-aged children exploring vocabulary learning. Students who spent 3 minutes in aerobic movement scored higher on their vocabulary recall, than a group that spent 3 minutes colouring (Mellor & Morini, 2023). By understanding and applying brain-based learning theory, teachers can feel confident that they are applying an effective approach (Hattie 2009;2018) that bolsters student self-efficacy (TopaŞ & Demirci, 2018).

The findings of this research provide insight into the relationship between movement, academic achievement, and well-being. The data from this study suggests that adding aerobic movement to math lessons may affect math scores. It also suggests that adding movement to learning may improve students' involvement and well-being. The next chapter will discuss the strengths and limitations of this research while exploring considerations related to my own pedagogy and the implications for future research.

Chapter Six

Conclusion

This chapter highlights the conclusions and results of this study, followed by the strengths and limitations of the study as well as areas for further research. The results from this research imply that adding aerobic movement to math lessons positively impacts mathematics scores and can increase students' well-being and involvement. These results align with current research such as Shoval, who studied students using mindful movement during geometry class; the experimental group showed better academic scores using movement than the control group (Shoval 2012).

Limitations

There were unexpected obstacles which may have had an impact on the data collected during my study. In November, Abbotsford experienced a record-breaking flood which destroyed a great deal of farmland, killed thousands of animals, and left many farming families homeless. The community was greatly impacted and left in a state of emergency for over 6 weeks. Due to the flooding many communities were closed off from resources and the military came in for helicopter drop-offs of food, supplies, and fuel. The main highway was shut down. Many of the newly homeless Abbotsford residents were moved into homes with family; some of which were students at Jackson Elementary. One parent from my classroom noted that they had nine people living in their two-bedroom apartment. It was clear that a mental/emotional, and financial toll had been taken on our students/families during this time.

Another consideration for the year was staffing. I changed my schedule from full-time to part-time to focus on research and data collection. The students began the year with two part-

time teachers, which can be a challenge for some as they try to work within two differing sets of expectations. Fortunately, both myself and the Monday/Tuesday teacher, Mrs. Z., were well aligned in our pedagogical philosophies; we both embraced open and compassionate communication with our students. Unfortunately, in February Mrs. Z. needed to take a medical leave, and a new teacher was placed into that role. This move happened right before the implementation of our aerobic intervention. Their new teacher, Mrs. P. took to the classroom in a very different way and the students needed to adapt themselves once again to the changes. They also met daily challenges of Education Assistant (E.A.) changes. Over the course of that school year, the students met and worked with over twenty different E.A.'s. This was also the first year they met our new administrator who implemented many new changes throughout the school. Consideration should also be taken that all the mathematics interventions were only done on Wednesdays-Fridays.

Ideally math would be taught daily to students and in similar ways to create regularity and routine, giving students plenty of time for math practice. Due to my part-time status, math was only taught 3 days a week. It is plausible that more days of math practice could have influenced outcomes.

In education, teachers were recovering from the impacts of COVID-19, and children were learning how to interact safely once again. The impact of lost classroom time due to at-home learning was being felt by all. There were record absences as the district policies for what was considered illness were strict, and children were required to stay at home if they had any symptoms of COVID-19.

Another limitation is the sample size. It is beyond the scope of this study to address the question of interpreting this to a larger theory. This research was done on nineteen students. The

small sample size limited generalized ability to the greater population. Future research could include a larger and more diverse sample size. My sample size did not include any children with special needs or impairments. Research has shown that children with physical disabilities and autism have benefitted from active play (Ketcheson, 2018). More diversity amongst participants could influence the outcomes.

A further limitation could be the types of physical activities used. Although, they were aerobic in nature, meaning students should have been able to perform the tasks with relative ease, each child had their own physical fitness, and for some the aerobic exercises may have been challenging whereas for others, they may have been more manageable.

The last limitation is that some of the research, particularly the Leuven scales were conducted through my own observation as the researcher. Bias could have been a factor and to mitigate this it would have helped to have an unbiased researcher conduct some of the observations. Due to staffing shortages this was not possible. These limitations may have impacted my research. Despite these limitation and unanticipated obstacles, the results are nonetheless valid for answering my research question.

Areas for Further Study

The correlation or lack thereof, between the SNAP assessments and the Leuven scale statistics warrants further study. My experience showed that although some students did not improve their SNAP scores, they still scored high on the Leuven scale; seemingly the children could be actively engaged and enjoying themselves on work that was highly challenging for them. Further investigation should be conducted to see if results could be replicated within a larger sample size which would compliment the generalizability of this research. According to

Gwon and Shin's research, movement increases academic resiliency and interest which could explain some of the children's high Leuven scores despite SNAP scores remaining the same (Gwon & Shin 2023).

Taking into consideration the academic load teachers are bearing and how Physical Education is taking a backseat to most other learning, it is vital for teachers to find space for movement amongst their days. Perhaps embedding aerobic movement into lessons could be the resolution to the time constraint dilemma. The research implies that movement is necessary for learning; by weaving movement into learning, teachers may be able to not only increase involvement from their students but also see some possible academic progress (Jensen, 2005).

Strengths

One of the strengths of my study was consistency. I administered math lessons, aerobic interventions, and conducted all assessments. If there had been multiple teachers doing this work, there would have been differentiation amongst the lessons and assessments. Another strength is the study's ability to be easily reproduced by other researchers. The intervention and assessments are easily followed. This study also added to a somewhat wide gap in the research. Currently there is a great deal of research on the impacts of aerobic movement on learning, but often this movement is implemented before or after a lesson. There are far less studies that experiment with movement embedded into an academic lesson. This is important because it has practical implications for educators. Implementing movement into their curriculum could have positive impacts on students' well-being and involvement with curricular content as well as encouraging higher academic scores. Most teachers know the value in having students engaged in learning. As a teacher myself there is nothing more gratifying than seeing students involved in deep learning and looking forward to learning more. During math, a subject in which I have

seen students struggle with anxiety and apprehension towards learning, I find it encouraging that there could be a way of teaching that dispels those negative emotions. This will forever impact the way I teach as it should other educators who may have a chance to investigate this research. Another strength is the understanding that it can impact a student's willingness to be vulnerable and learn; furthermore, this way of teaching can affect how engaged they are. This may have lasting implications that can change the trajectory of a student's life.

In conclusion, the data from this study suggests that adding aerobic movement to math lessons can affect math scores. It also suggests that adding movement into learning may increase students' involvement and well-being (Leavers, 2009). For me, this changes the way I see my daily operations as a teacher and how I interact with the curriculum. I can see how embedding aerobic movement into aspects of my teaching may ease anxiety and increase involvement (Lital et al., 2021). This is a practice I will continue to use and encourage colleagues to implement.

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Appendices

1. SNAP Assessment



**Chilliwack
School District**

Operations Addition SNAP

Name:

Date:

Operation:

Guess:

Draw:

Calculate:

Create a Math Story

Beginning

Middle

End

Communicating & Representing

1 2 3 4

Entire assessment

Understanding & Solving

1 2 3 4

Draw and Calculate

Connecting & Reflecting

1 2 3 4

Math story

Reasoning & Analyzing

1 2 3 4

Guess

Grade 2

Student Numeracy Assessment and Practice (SNAP)
(Adapted from ANIE 2014)

SNAP
Number Sense (0 - 100)

 Chilliwack School District

Name: _____
Date: _____

Count forwards by _____ from the number.

↑

Draw to represent the value of the number:

Write the number in expanded form:

Create 3 equations that equal the number:

Write a real life example that shows the value of the number:

Count backwards by _____ from the number.

↓

Show where the number belongs on the number line.

0

100

Find grading rubrics for specific criteria at snap.sd33.bc.ca

Communicating & Representing: Drawing, description, expanded form 1 2 3	Understanding & Solving: 3 equations 1 2 3	Connecting & Reflecting: <i>Real-life</i> 1 2 3	Reasoning & Analyzing: Skip counting & number line 1 2 3
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Grade 2
Student Numeracy Assessment and Practice (SNAP)

2. Leuven Scale

Table 1: The Leuven Scale of wellbeing

Level	Wellbeing	Signals
1	Extremely Low	The child clearly shows signs of discomfort, such as crying or screaming. They may look dejected, sad, frightened or angry. The child does not respond to the environment, avoids contact and is withdrawn. The child may behave aggressively, hurting him/herself or others
2	Low	The posture, facial expression and actions indicate that the child does not feel at ease. However, the signals are less explicit than under level 1 or the sense of discomfort is not expressed the whole time
3	Moderate	The child has a neutral posture. Facial expression and posture show little or no emotion. There are no signs indicating sadness or pleasure, comfort or discomfort
4	High	The child shows obvious signs of satisfaction (as listed under level 5). However, these signals are not constantly present with the same intensity
5	Extremely High	The child looks happy and cheerful, smiles, cries out with pleasure. They may be lively and full of energy. Actions can be spontaneous and expressive. The child may talk to him/herself, play with sounds, hum, sing. The child appears relaxed and does not show any signs of stress or tension. He /she is open and accessible to the environment. The child expresses self-confidence and self assurance

3.

APPLICATION FOR ETHICAL APPROVAL

In order for research to result in benefit and minimise risk of harm, it must be conducted ethically. A researcher may not be covered by the University's insurance if ethical approval has not been obtained prior to commencement.

The University follows the OECD Frascati manual definition of **research activity**: “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications”. As such this covers activities undertaken by members of staff, postgraduate research students, and both taught postgraduate and undergraduate students working on dissertations/projects.

The individual undertaking the research activity is known as the “principal researcher”.

Ethical approval is not required for routine audits, performance reviews, quality assurance studies, testing within normal educational requirements, and literary or artistic criticism.

Please read the notes for guidance before completing ALL sections of the form.

This form must be completed and approved prior to undertaking any research activity.
Please see Checklist for details of process for different categories of application.

Delete the Guidance Notes at the end of the form BEFORE submitting your application

SECTION A: About You (Principal Researcher)

1	Full Name:	Meagan Smith			
2	Tick all boxes which apply:	Member of staff:	☐	Honorary research fellow:	☐
3	Undergraduate Student	☐	Taught Postgraduate Student	☒	Postgraduate Research Student
					☐

4	Institute/Academic Discipline/Centre:	Management and Health
5	Campus:	Carmarthen
6	E-mail address:	Meagan.smith@abbyschools.ca
7	Contact Telephone Number:	778 982 3757
For students:		
8	Student Number:	2007273
9	Programme of Study:	MAPESPL

10	Director of Studies/Supervisor:	Nalda Karen Sirna
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SECTION B: Approval for Research Activity

1	Has the research activity received approval in principle? (please check the Guidance Notes as to the appropriate approval process for different levels of research by different categories of individual)	YES	☒	NO	☐
				Date	
2	If Yes, please indicate source of approval (and date where known): Approval in principle must be obtained from the relevant source prior to seeking ethical approval	Research Degrees Committee	☐		
3		Institute Research Committee	☐		
4		Other (write in)	☒	Supervisor	

SECTION C: Internal and External Ethical Guidance Materials

	Please list the core ethical guidance documents that have been referred to during the completion of this form (including any discipline-specific codes of research ethics, and also any specific ethical guidance relating to the proposed methodology). Please tick to confirm that your research proposal adheres to these codes and guidelines.				
1	UWTSD Research Ethics & Integrity Code of Practice				☒
2	UWTSD Research Data Management Policy				☒
3	Tri-Canada ethics stuff				☒

SECTION D: External Collaborative Research Activity

1	Does the research activity involve collaborators outside of the University?	YES	☐	NO	☒
2	If Yes, please provide the name of the external organisation and name and contact details for the main contact person and confirmation this person has consented to their personal data being shared as part of this collaboration.				
3	Institution				
4	Contact person name				
5	Contact person e-mail address				

6	Has this individual consented to sharing their details on this form?	YES	☐	NO	☐	
7	Are you in receipt of a KESS scholarship?	YES	☐	NO	☐	
8	Is your research externally funded	YES	☐	NO	☐	
9	Are you specifically employed to undertake this research in either a paid or voluntary capacity?	Voluntary	YES	☐	NO	☐
10		Employed	YES	☐	NO	☐
11	Is the research being undertaken within an existing UWTSD Athrofa Professional Learning Partnership (APLP)	If YES then the permission question below does not need to be answered.	YES	☐	NO	☐
12	Permission to undertake the research has been provided by the partner organisation	(If YES attach copy) If NO the application cannot continue	YES	☐	NO	☐

Where research activity is carried out in collaboration with an external organisation

13	Does this organisation have its own ethics approval system?	YES	☐	NO	☐
14	If Yes, please attach a copy of any final approval (or interim approval) from the organisation				

SECTION E: Details of Research Activity

1	Indicative title:	Moving Math		
2	Proposed start date of your research (not your course start date):	November 2021	Proposed end date:	October 2023
3	Introduction to the Research Ensure that you write for a <u>Non-Specialist Audience</u> when outlining your response to the three points below: • <i>Purpose of Research Activity</i> • <i>Proposed Research Question</i> • <i>Aims of Research Activity</i> • <i>Objectives of Research Activity</i> Demonstrate, briefly, how <u>Existing Research</u> has informed the proposed activity and explain • <i>What the research activity will add to the body of knowledge</i> • <i>How it addresses an area of importance.</i>			
4	Purpose of Research Activity			

	To research the effects of movement on mathematics scores in a grade one and two classroom. The implications being possibly impacting the obesity crisis and mental health crisis currently impacting children.
5	Research Question Can embedding aerobic physical activity into a grade 1/2 math lessons effect number sense and engagement?
6	Aims of Research Activity This study aims to utilize brain-based learning theory and research on the impact of movement on the brain to test its' effect on learning and engagement/involvement. More specifically, how movement can impact math scores in a grade one/two classroom.
7	Objectives of Research Activity This can encourage students to use movement to facilitate self-regulation which aligns itself with social emotional learning. It also, moves students away from fixed mindsets and closer to growth mindsets as they experience the change that happens from incorporating movement into their studies, in this case math. Their conceptual understanding of the benefits of movement becomes authentic.
8	Proposed methods The research will take a mixed methods approach of data collection through assessments and observation; quantitative data will be done through assessments and qualitative data through observations. Two assessments will be used: a SNAP math assessment as well as the Leuven Scale. The SNAP assessment is a number sense assessment which allows students to show their mathematical understanding and is done by students individually. Each student will sit with a teacher to work through the SNAP. The Leuven Scale will be used; it is a five point scale to check student engagement and well-being. The Leuven Scale will be done through teacher observations of students at work. An observation journal will be used for additional qualitative data collection from the researcher.

9	
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10	Location of research activity Identify all locations where research activity will take place.
11	Jackson Elementary 33165 King Rd. Abbotsford, BC, Canada V2S 7Z9
12	Research activity outside of the UK Canada Tri-Council Ethics Completed District Ethical Approval is currently being reviewed Parent-consent forms will be sent home once all other ethical arrangements are complete
13	Canadian ethics training

14	Use of documentation not in the public domain: Are any documents <u>NOT</u> publicly available?	NO	☐
		YES	☒
15	Students personal files may be used. They are stored in schools and are confidential. Confidentiality contracts are signed by all those who have access to them.		

SECTION F: Scope of Research Activity

1	Will the research activity include:	YES	NO
2	Use of a questionnaire or similar research instrument?	☐	☒
3	Use of interviews?	☐	☒
4	Use of diaries?	☐	☒
5	Participant observation with their knowledge?	☒	☐
6	Participant observation without their knowledge?	☐	☒
7	Use of video or audio recording?	☐	☒
8	Access to personal or confidential information without the participants' specific consent?	☐	☒
9	Administration of any questions, test stimuli, presentation that may be experienced as physically, mentally or emotionally harmful / offensive?	☐	☒

10	Performance of any acts which may cause embarrassment or affect self-esteem?	☐	☒
11	Investigation of participants involved in illegal activities?	☐	☒
12	Use of procedures that involve deception?	☐	☒
13	Administration of any substance, agent or placebo?	☐	☒
14	Working with live vertebrate animals?	☐	☒
15	Other primary data collection methods, please explain in this box For example, 'focus groups'. Please indicate the type of data collection method(s) in this box and tick the accompany box.	☒	☐
16	Details of any other primary data collection method: SNAP math assessments, Leuven Scales and observational data collected		

If NO to every question, then the research activity is (ethically) low risk and **may** be exempt from **some** of the following sections (please refer to Guidance Notes).

If YES to any question, then no research activity should be undertaken until full ethical approval has been obtained.

SECTION G: Intended Participants

1	Who are the intended participants:	YES	NO
2	Students or staff at the University?	☐	☒
3	Adults (over the age of 18 and competent to give consent)?	☐	☒
4	Vulnerable adults?	☐	☒
5	Children and Young People under the age of 18? (Consent from Parent, Carer or Guardian will be required)	☒	☐
6	Prisoners?	☐	☒
7	Young offenders?	☐	☒
8	Those who could be considered to have a particularly dependent relationship with the investigator or a gatekeeper?	☐	☒
9	People engaged in illegal activities?	☐	☒
10	Others (please identify specifically any group who may be unable to give consent) please indicate here and tick the appropriate box.	☐	☒
11	Other – please indicate here:		

12	Participant numbers and source Provide an estimate of the expected number of participants. How will you identify participants and how will they be recruited?	
13	How many participants are expected?	1 grade 2 class of 22 students
14	Who will the participants be?	22 6- and 7-year-olds
15	How will you identify the participants?	The students in my class

16	Information for participants:	YES	NO	N/A
17	Will you describe the main research procedures to participants in advance, so that they are informed about what to expect?	☒	☐	☐
18	Will you tell participants that their participation is voluntary?	☒	☐	☐
19	Will you obtain written consent for participation?	☒	☐	☐
20	Will you explain to participants that refusal to participate in the research will not affect their treatment or education (if relevant)?	☒	☐	☐
21	If the research is observational, will you ask participants for their consent to being observed?	☒	☐	☐
22	Will you tell participants that they may withdraw from the research at any time and for any reason?	☒	☐	☐
23	With questionnaires, will you give participants the option of omitting questions they do not want to answer?	☐	☐	☒
24	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	☒	☐	☐
25	Will you debrief participants at the end of their participation, in a way appropriate to the type of research undertaken?	☒	☐	☐
26	If NO to any of above questions, please give an explanation			
27				

28	Information for participants:	YES	NO	N/A
29	Will participants be paid?	☐	☒	☐
30	Is specialist electrical or other equipment to be used with participants?	☐	☒	☐
31	Are there any financial or other interests to the investigator or University arising from this study?	☐	☒	☐

32	Will the research activity involve deliberately misleading participants in any way, or the partial or full concealment of the specific study aims?	☐	☒	☐
33	If YES to any question, please provide full details			
34				

SECTION H: Anticipated Risks

1	Outline any anticipated risks that may adversely affect any of the participants, the researchers and/or the University, and the steps that will be taken to address them. If you have completed a full risk assessment (for example as required by a laboratory, or external research collaborator) you may append that to this form.					
2	Full risk assessment completed and appended?	<table border="1"> <tr> <td>Yes</td> <td>☒</td> </tr> <tr> <td>No</td> <td>☐</td> </tr> </table>	Yes	☒	No	☐
Yes	☒					
No	☐					
3	Risks to participants For example: emotional distress, financial disclosure, physical harm, transfer of personal data, sensitive organisational information					
4	Risk to Participant: Possible injury	<i>How will you mitigate the Risk to Participant</i> All environments will be safe and all precautions taken. There will be two adult supervisors at all times.				
5	If research activity may include sensitive, embarrassing or upsetting topics (e.g. sexual activity, drug use) or issues likely to disclose information requiring further action (e.g. criminal activity), give details of the procedures to deal with these issues, including any support/advice (e.g. helpline numbers) to be offered to participants. Note that where applicable, consent procedures should make it clear that if something potentially or actually illegal is discovered in the course of a project, it may need to be disclosed to the proper authorities					
	Read below about risks to fill this in					
6	Risks to investigator For example: personal safety, physical harm, emotional distress, risk of accusation of harm/impropriety, conflict of interest					
	Risk to Investigator: Possible injuries from the physical activity	<i>How will you mitigate the Risk to Investigator:</i> All environments and work areas will be properly checked for danger.				

7	University/institutional risks For example: adverse publicity, financial loss, data protection	
	Risk to University: Researcher may conduct themselves in an inappropriate way.	<i>How will you mitigate the Risk to University:</i> Researcher will act in a highly professional manner at all times.

8	Disclosure and Barring Service			
9	If the research activity involves children or vulnerable adults, a Disclosure and Barring Service (DBS) certificate must be obtained before any contact with such participants.	YES	NO	N/A
10	Does your research require you to hold a current DBS Certificate?	☒	☐	☐

SECTION I: Feedback, Consent and Confidentiality

1	Feedback What de-briefing and feedback will be provided to participants, how will this be done and when?	
	class discussion after lessons to get feedback on how they are all feeling	
2	Informed consent Describe the arrangements to inform potential participants, before providing consent, of what is involved in participating. Describe the arrangements for participants to provide full consent before data collection begins. If gaining consent in this way is inappropriate, explain how consent will be obtained and recorded in accordance with prevailing data protection legislation.	
	Plain language statement with clear language, consent forms and children can give assent	
3	Confidentiality / Anonymity Set out how anonymity of participants and confidentiality will be ensured in any outputs. If anonymity is not being offered, explain why this is the case.	
	All data will be anonymized	

SECTION J: Data Protection and Storage

In completing this section refer to the University's Research Data Management Policy and the extensive resources on the University's Research Data Management web pages (<http://uwtsd.ac.uk/library/research-data-management/>).

1	Does the research activity involve personal data (as defined by the General Data Protection Regulation 2016 "GDPR" and the Data Protection Act 2018 "DPA")?	YES	NO
	<i>"Personal data" means any information relating to an identified or identifiable natural person ('data subject'). An identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.</i>	☐	☒
2	If YES, provide a description of the data and explain why this data needs to be collected:		
3	Does it involve special category data (as defined by the GDPR)?	YES	NO
	<i>"Special category data" means sensitive personal data consisting of information as to the data subjects' – (a) racial or ethnic origin, (b) political opinions, (c) religious beliefs or other beliefs of a similar nature, (d) membership of a trade union (within the meaning of the Trade Union and Labour Relations (Consolidation) Act 1992), (e) physical or mental health or condition, (f) sexual life, (g) genetics, (h) biometric data (as used for ID purposes),</i>	☐	☒
4	If YES, provide a description of the special category data and explain why this data needs to be collected:		

5	Will the research activity involve storing personal data and/or special category data on one of the following:	YES	NO
6	Manual files (i.e. in paper form)?	☒	☐
7	University computers?	☐	☒
8	Private company computers?	☒	☐
9	Home or other personal computers?	☐	☒
10	Laptop computers/ CDs/ Portable disk-drives/ memory sticks?	☒	☐
11	"Cloud" storage or websites?	☐	☒
12	Other – specify:	☐	☒

13	For all stored data, explain the measures in place to ensure the security of the data collected, data confidentiality, including details of password protection, encryption, anonymisation and pseudonymisation:		
	Laptop with me, locked drawer, no names on data		
14	All Data Storage		
15	Will the research activity involve any of the following activities:	YES	NO
16	Electronic transfer of data in any form?	☐	☒
17	Sharing of data with others at the University?	☒	☐
18	Sharing of data with other organisations?	☐	☒
19	Export of data outside the European Union or importing of data from outside the UK?	☐	☒
20	Use of personal addresses, postcodes, faxes, emails or telephone numbers?	☐	☒
21	Publication of data that might allow identification of individuals?	☐	☒
22	Use of data management system?	☐	☒
23	Data archiving?	☐	☒
24	If YES to any question, please provide full details, explaining how this will be conducted in accordance with the GDPR and DPA (and/or any international equivalent):		
	Information will be shared with professors for the master's program.		
25	List all who will have access to the data generated by the research activity:		
	Meagan Smith, Karen Syrna, and Nalda Wainwright		
26	List who will have control of, and act as custodian(s) for, data generated by the research activity:		
	Meagan Smith (researcher)		
27	Give details of data storage arrangements, including security measures in place to protect the data, where data will be stored, how long for, and in what form. Will data be archived – if so how and if not why not.		
	All stored on a password protected laptop and hard drive.		
28	Please indicate if your data will be stored in the UWTSD Research Data Repository (see https://researchdata.uwtsd.ac.uk/). If so please explain. (Most relevant to academic staff)		
	No		
29	Confirm that you have read the UWTSD guidance on data management (see	YES	☒

	https://www.uwtsd.ac.uk/library/research-data-management/	NO	☐
30	Confirm that you are aware that you need to keep all data until after your research has completed or the end of your funding	YES	☒
		NO	☐