An Experimental Evaluation on the Effect of Dynamic Chairs on the Behaviour, Movement, and Academic Achievement of Students

A thesis

submitted in fulfilment

of the requirements for the degree

of

Doctor of Philosophy in Psychology

at

The University of Waikato

by

ISAAC MARTIN

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2025

Abstract

Traditional classroom chairs are often rigid and inflexible, resulting in uncomfortable static sitting. Conversely, Dynamic chairs are designed to promote healthy movement and comfort, which is hypothesised to improve student engagement, reduce disruptive behaviour, and, in turn, improve academic achievement. Currently, there is a lack of research into the effects of dynamic chairs on student learning compared to regular classroom chairs. This thesis comprises a series of studies that investigate the effect that BodyfurnFlex chairs, a new type of dynamic chair, had on the behaviour, movement, achievement, and perceptions of students in comparison to traditional classroom chairs.

In Study 1, we used a multiple baseline ABAB reversal design to investigate the effect that BodyfurnFlex chairs had on students' behaviour and movement in comparison to regular classroom chairs. Additionally, a survey was used to assess students' perceptions of the chairs, while classroom environmental conditions were monitored as potential confounding variables. The results showed that BodyfurnFlex chairs significantly increased students' on-task behaviour and reduced disruptive behaviours, including chair tipping and out-of-seat behaviour. Meanwhile, both in-chair movement and overall movement in the classroom increased when students were seated in BodyfurnFlex chairs. The majority of participants preferred BodyfurnFlex chairs, finding them more comfortable and believing they made it easier to complete their schoolwork. The environmental conditions in the classroom remained within the recommended levels throughout data collection, indicating they were not confounding variables in this study.

In Study 2, we conducted a detailed analysis of the movement and environmental data collected in Study 1. This included analysing different aspects of the in-chair movement data, including displacement, acceleration, and rotation. Additionally, we examined whether BodyfurnFlex chairs could influence noise levels in classrooms and explored possible connections between movement, environmental, noise, and behavioural variables. The results showed that both in-chair displacement and acceleration significantly increased when students sat in BodyfurnFlex chairs. However, displacement was not associated with students' behaviour; acceleration was, suggesting

that student behaviour is not related to how much students move but rather how consistently they move. Noise levels in the classroom had a significant negative correlation with on-task behaviour and decreased when students sat in BodyfurnFlex chairs. All environmental variables (CO_2, temperature, and humidity) showed small, non-significant correlations with all other variables, indicating that they were not confounding factors.

In Study 3, we investigated the effect of BodyfurnFlex chairs on students' academic achievement across multiple mathematics assessments using a pre-post intervention between-groups design. Additionally, focus group discussions were conducted to gain greater insight into teachers' and students' perceptions of the chairs. The results showed no significant difference in test grades between students who used the BodyfurnFlex chairs and those who used regular chairs. However, several limitations around the results, including the testing/grading system and design, are discussed. Students reported far greater satisfaction with BodyfurnFlex chairs compared to the regular chairs, stating that they were more comfortable, functional, aided their ability to do their schoolwork, and felt they had a positive effect on their test results.

Acknowledgements

Firstly, I would like to thank my wonderful supervisors, Professor Angelika Anderson and Professor Nicola Starkey, for your guidance, expertise, and patience. I am truly grateful for the time and effort you have dedicated to guiding me through this journey. I would also like to give a heartfelt thank you to all the schools, teachers, and students who participated in this research. Thank you for welcoming me into your classrooms. This thesis would not have been possible without your cooperation. A special thanks to Callaghan Innovation and the team at Resero for providing this incredible opportunity to work with these exciting new tools. Thank you, Matt, for your support over these past few years. I would like to acknowledge my friends and family, would have encouraged me throughout this journey. Especially my parents, I am deeply thankful for your continuous love, support, and encouragement. I would not have been able to complete this without you. Lastly, I thank God for your many blessings and for being my strength throughout this journey.

Preface

This thesis is presented as a PhD with a publication, written from a behaviour analytic perspective. It begins with a brief Introduction chapter that outlines the main concepts and provides justification for the research. This is followed by a Literature Review that offers an in-depth explanation of these concepts, situating them within the broader body of research. The main body of the thesis consists of three studies, each presented as an independent, stand-alone paper, some of which have been submitted for publication. The thesis concludes with a General Discussion chapter that synthesises the key findings from the studies, interpreting them within the existing literature. Due to its structure, there is some repetition of content across sections.

Table of Contents

Chapter 1: Introduction

Academic achievement is often regarded as a key indicator of students' success in their educational journey. However, its significance extends beyond the classroom, as it also plays a crucial role in shaping an individual's future quality of life (Edgerton et al., 2012; Starr et al., 2024). However, according to a recent OECD report, academic achievement in New Zealand has been steadily declining over the past two decades (OECD, 2024). Between 2009 and 2022, New Zealand's average score in the OECD Program for International Student Assessment (PISA) test declined by the equivalent of two years of education in mathematics, 18 months in science, and one year in reading (OECD, 2024).

A key factor that appears to be a significant contributor towards poor achievement in New Zealand is the environmental conditions in the classrooms. When outside of the recommended levels, carbon dioxide (CO2), temperature, and humidity can all have a significant negative impact on student achievement (Haverinen-Shaughnessy & Shaughnessy, 2015; Liu et al., 2021). Despite the Ministry of Education having strict guidelines around the environmental conditions in learning spaces, many New Zealand classrooms fail to meet these standards (Building Research Association of New Zealand, 2019a, 2019b), indicating that the achievement of these students is likely to suffer.

Another factor that can significantly influence academic achievement is student behaviour (Blank & Shavit, 2016; Flores-Mendoza et al., 2013; Wong et al., 2024). According to the Education Review Office, poor student behaviour, including disruptive behaviour and lack of student engagement, is a major factor contributing to low achievement in New Zealand schools (Education Review Office, 2024). The report revealed that over the last 20 years, New Zealand classrooms have consistently had worse behaviour compared to most other OECD nations, including the worst among all countries in maths classes. To tackle the issue of poor behaviour, the Education Review Office emphasised the importance of schools adopting interventions/strategies that address the underlying causes of poor behaviour, rather than just addressing the behaviour itself (Education Review Office, 2024).

One potential solution to improving student behaviour is through classroom seating. Regular/standard classroom chairs are typically monobloc (single-piece) plastic chairs that are rigid and inflexible, resulting in static sitting (i.e., sitting in the same position without moving). Prolonged static sitting can cause pain/discomfort (Caromano et al., 2015; Waongenngarm et al., 2015), which can lead to decreased engagement (Aga, 2024; Hanaysha et al., 2023; Scott-Webber et al., 2018), and students engaging in disruptive behaviours like fidgeting, out-of-seat behaviour and chair tipping, in an effort to relieve discomfort (Knight & Noyes, 1999; Morishima et al., 2016). The current literature suggests that, in addition to having a negative effect on student engagement, static sitting may be a motivating operation, an environmental factor that increases the likelihood of a specific behaviour occurring (Cooper, Heron, & Heward, 2020), for engaging in disruptive behaviours such as chair tipping and out-of-seat behaviour.

Unlike regular classroom chairs, dynamic chairs are designed to be flexible and promote movement through active sitting (i.e., consistent movement through postural changes). Dynamic chairs have been shown to significantly increase the movement of occupants compared to regular (non-dynamic) chairs (Grooten et al., 2017; Nüesch et al., 2018; Tanoue et al., 2016) and reduce pain/discomfort (Cardenas et al., 2024; Frey et al., 2021; Garcia et al., 2016). These findings suggest that dynamic chairs could be an effective intervention for improving student engagement by reducing uncomfortable static sitting, thereby removing the motivating operation for students to engage in disruptive behaviours such as chair tipping and out-of-seat behaviour.

Although the current literature suggests that dynamic chairs can enhance student behaviour and, in turn, achievement, this is not yet supported by empirical evidence, as there is a lack of research examining the impact of dynamic chairs on students' behaviour and outcomes (Rollo et al., 2019). Despite the lack of evidence, many schools are transitioning from traditional classroom chairs and investing in more expensive dynamic chairs and other flexible seating options under the belief that they can enhance students' learning (Anderson & Hartley, 2018; Attai et al., 2021; Cole et al., 2021; Putman et al., 2024). To address this gap in the literature, robust evidence is needed to demonstrate that dynamic chairs are an effective intervention for improving student behaviour and achievement, and that they are a worthwhile investment for schools.

Chapter 2: Literature Review

Academic Achievement

Academic achievement, also known as academic performance, refers to outcomes that indicate the extent to which a person has accomplished academic goals/success, and is typically measured either by educational attainment (i.e., completion of a degree or qualification) or by test scores/grades (Nyström et al., 2019; Steinmayr et al., 2014; Wong et al., 2024). Academic achievement can have a significant positive effect on an individual's future quality of life, including with better mental and physical health (Kosik et al., 2018; Lê-Scherban et al., 2014; Raghupathi & Raghupathi, 2020), increased life satisfaction (Lettau, 2021; Ng et al., 2015), improved well-being (Nordlander & Stensöta, 2014), higher income (Hahn & Chattopadhyay, 2019; Lallukka et al., 2019), greater self-esteem (Metsäpelto et al., 2020), and increased life expectancy (Kaplan et al., 2014; Raghupathi & Raghupathi, 2020). Better academic achievement also has several important societal benefits, including improved economic growth (Heller-Sahlgren & Jordahl, 2024; Woesserman, 2016), greater civic engagement (An et al., 2024; Belete, 2024), and lower crime rates (Lankester et al., 2025; Machin et al., 2011; Martins et al., 2022).

Academic achievement is influenced by a wide range of factors, both individual/personal and external/environmental (Costa et al., 2024; Nunes et al., 2023). Some of the most important personal variables include intelligence (Lozano-Blasco et al., 2022; Roth et al., 2015), personality type (Mammaddov, 2022; Meyer et al., 2023), attitude (Mao et al., 2022; Solpuk, 2017), motivation (Amrai et al., 2011; Kriegbaum et al., 2021), self-efficacy (Hwang et al., 2016; Motalgh et al., 2011), and study habits (Elango & Manimozhi, 2021; Walck-Shannon et al., 2021). While these individual variables are crucial in determining a student’s academic success, they can be difficult to change. However, there are many external variables that share a significant association with academic achievement and can be influenced, including teachers (Lopez-Martin et al., 2022), parental involvement (Castro et al., 2015; Otani et al., 2020), the school and classroom climate (Dulay & Karadağ, 2017; Erdem & Kaya, 2024), socio-economic status (SES) (Liu et al., 2022; Selvitopu &

Kaya,2023), and the physical learning environment (Barrett et al., 2015; Cheryan et al., 2014; Opio et al., 2024). There are a number of aspects within the physical learning environment that have been shown to have a significant impact on the achievement of students, including the classroom design (Imms & Byers, 2017; Byers et al., 2018), lighting (Heschong et al., 2002; Mogas-Recalde & Palau, 2021), noise (Brill & Wang, 2021; Shield & Dockrell, 2008), and the environmental conditions including CO_2, temperature, and humidity (Haverinen-Shaughnessy & Shaughnessy, 2015; Liu et al., 2021).

Environmental Variables in the Classroom

CO_2 is a colourless, odourless gas found in our atmosphere. When we exhale, we release CO_2 into the surrounding air. As a result, indoor spaces with large numbers of people, such as classrooms, often exhibit elevated levels of CO_2 (Lopez et al., 2023). CO_2 can significantly affect the learning environment and has been shown to decrease students' attention and cognitive function (Coley et al., 2007; Fan et al., 2023; Sidorn, 2015; Tu et al., 2021; Woo et al., 2022). According to Coley et al. (2007), in classrooms with high CO_2 levels, students are likely to be less attentive and struggle to focus on the teacher, with this decline in concentration comparable to the effect of skipping breakfast (Coley et al., 2007). Unsurprisingly, CO_2 has a significant negative association with students' academic performance (Haverinen-Shaughnessy & Shaughnessy, 2015; Haverinen-Shaughnessy et al., 2011; Wargocki et al., 2020). Additionally, CO_2 is linked to various negative health and social issues, including headaches, fatigue, agitation, feelings of depression, and lower attendance (Bogdanovica et al., 2020; Carrer et al., 2015; Gaihre et al., 2014; Setimo et al., 2024; Tu et al., 2021).

Classroom temperature also affects students' learning, with temperatures outside the range of 18-25 ˚C shown to significantly impair cognitive performance (Lan et al., 2022; Yeganeh et al., 2018), attention (Aydin & Goktas, 2023; Yeganeh et al., 2018), and academic outcomes (Cho, 2017; Haverinen-Shaughnessy & Shaughnessy, 2015; Wargocki et al., 2019). Additionally, low indoor temperatures significantly increase the risk of catching viruses and developing respiratory infections

(Jaakkola et al., 2014; Mäkinen et al., 2009), while higher temperatures are linked to fatigue, dizziness, headaches, nausea, and sleepiness (Bidassey-Manilal et al., 2025; Lala & Hagishima, 2023; Tu et al., 2021).

Humidity is the measure of moisture (water vapour) present in the air. The amount of water vapour that can be held in the air without condensation (i.e., turning to water) is dependent on the air temperature. As the temperature rises, the amount of moisture that can be in the air increases. Humidity is typically expressed as relative humidity, which refers to the percentage of water vapour in the air compared to the maximum amount of vapour that could exist at the current temperature. Both low and high humidity have been shown to significantly increase the risk of illness, including respiratory infections, asthma symptoms, and allergies (Angelon-Gaetz et al., 2016; Jaakkola et al., 2014; Mäkinen et al., 2009; Toyran et al., 2020). Humidity has also been shown to affect memory, cognitive performance, fatigue, attention, and academic performance (Liu et al., 2021; Qiu et al., 2021; Sarbu & Pacurar, 2015; Tian et al., 2021).

The Ministry of Education has strict guidelines regarding the environmental conditions in New Zealand classrooms to guarantee they are suitable for students' learning and health (Ministry of Education, 2022). The recommended daily average CO_2 concentration in learning spaces is greater than 800 ppm (parts per million); however, it is compulsory that the daily average does not exceed 1,250 ppm. Furthermore, CO_2 concentration must never surpass 2000 ppm at any time during the day. Classroom temperature should be maintained between 18-25 ˚C, while the relative humidity must always be within 35-70% (Ministry of Education, 2022).

Despite strict guidelines, research shows many New Zealand classrooms do not meet the required standards for learning environments (Building Research Association of New Zealand, 2019a, 2019b). The Building Research Association of New Zealand (BRANZ) carried out a study on indoor air quality in classrooms across New Zealand, including Auckland, Wellington, Christchurch, Dunedin, and the Hawke's Bay region. Findings indicated that CO_2 levels in numerous classrooms significantly exceeded acceptable limits, with one Christchurch classroom recording average CO_2 levels of 2000–

3000 ppm over an entire week. Another classroom experienced levels above 2000 ppm for most of the year, reaching up to 3,800 ppm, more than three times the daily average limit. In Hawke's Bay and Dunedin, students faced temperatures below 16°C for extended periods, whereas a Christchurch classroom frequently recorded temperatures above 28°C (Building Research Association of New Zealand, 2019a, 2019b). The study also found that the weekly average humidity in one Christchurch classroom was 81%. Additionally, some Hawke's Bay classrooms had humidity levels often exceeding 70%, with one reaching 86%.

The findings of the Building Research Association of New Zealand (2019a, 2019b) indicate that many students in New Zealand are not receiving the quality of learning spaces that the Ministry of Education requires. As a result, the learning and health of many students in New Zealand are likely to suffer. It appears there is a need for tools/equipment that can accurately measure environmental variables and assess the quality of learning spaces, to identify which spaces require interventions (e.g., ventilation, air conditioning). Furthermore, despite extensive research into the effects of CO_2, temperature, and humidity on students' attention, cognitive performance, and academic achievement, there is limited research on how these variables influence students' on-task behaviour, disruptive behaviour, and movement, highlighting a need to examine these relationships.

Noise in the Classroom

Another key factor that can significantly impact academic achievement is classroom noise (Buchari & Matondang, 2017; Caviola et al., 2021; Fernandes et al., 2019; Shield & Dockrell, 2008). In addition to negatively affecting their achievement, noisy classroom environments can harm the well-being of students (Astolfi et al., 2023; Mealings & Bucholz, 2025) and teachers (Kristiansen et al., 2011; Mealings et al., 2024). One study found that students reported classroom noise made it difficult to hear the teacher, ask questions, and focus, and caused them to feel stressed, uncomfortable, angry, dizzy, and less enthusiastic about attending class (Buchari & Matondang, 2017). Noise in the classroom can originate from a wide range of sources, including both environmental (e.g., traffic, air conditioning, electrical noise or humming, weather) and behavioural (e.g., students talking) factors (Alqahtani et al., 2023; Rantala et al., 2015). Behavioural noise in the classroom is often seen as a sign of disruptive behaviour (Douglas et al., 2016; Olota, 2022) and lack of student engagement (Chapman et al., 2023; Ludyga et al., 2021).

Student Perceptions

While objective measurement is important, students' perceptions and opinions can also impact their achievement. Higher satisfaction and better perceptions of the physical learning environment have been shown to have a significant positive effect on students' academic performance (Edgerton & McKechnie, 2023; Hopland & Nyhus, 2015; Opio et al., 2024; Salar et al., 2024). Student perceptions are not only important for determining whether educational practices/interventions are effective, but are also crucial for determining their acceptability and whether participants find them meaningful (Ferguson & Cihon, 2021; Huntington et al., 2023). This is important because even if learning interventions are effective, they are only useful if students are willing to use/implement them. Another significant implication of students' perceptions is their impact on student engagement, with improved perceptions of the physical learning environment shown to have a significant positive correlation with student engagement (Edgerton & McKechnie, 2023; Scott-Webber et al., 2018).

Student Engagement

Student engagement is a broad concept that has been defined in various ways; however, in simple terms, it refers to students being actively involved in their learning tasks and activities (Lei et al., 2018). Student engagement is multidimensional and includes three key aspects: cognitive engagement, emotional engagement, and behavioural engagement (Lei et al., 2018; Wong et al., 2024). Cognitive engagement refers to the mental effort or investment put into learning, involving focusing one's attention and concentration on the activity or task (Halverson & Graham, 2019; Reeve et al., 2025). Emotional (or affective) engagement refers to a student's emotional investment and feelings towards learning, including enthusiasm, motivation, interest, and attitude (Liu et al., 2024;

Reeve et al., 2025). Meanwhile, behavioural engagement is the observable actions of students participating in learning activities and tasks (Cappella et al., 2013; Reeve et al., 2020).

Student engagement has been shown to have a significant positive correlation with academic achievement (Lei et al., 2018; Tao et al., 2022; Wong et al., 2024). Wong et al. (2024) conducted a comprehensive systematic review and meta-analysis, including 137 studies and 158,510 participants, on student engagement and its association with academic achievement. The results revealed a significant positive relationship between student engagement and academic achievement (r = .33, p < .001). However, when analysed in its three dimensions, behavioural engagement showed the strongest correlation with academic achievement (r = .39, p < .001), surpassing both cognitive (r = .31, p < .001) and emotional engagement (r = .26, p < .001). Another meta-analysis, involving 69 studies and 196,473 participants, yielded similar results (Lei et al., 2018). Academic achievement had a noticeably larger correlation with behavioural engagement (r = .35, p < .001) compared to cognitive (r = .25, p < .001), emotional (r = .22, p < .001), and overall student engagement (r = .269, p < .001). These findings suggest that behavioural engagement is the best indicator of academic achievement, even more so than all the dimensions of student engagement combined (i.e., overall engagement). Furthermore, since behavioural engagement involves students' observable actions, it can be measured through direct observation. Conversely, cognitive and emotional engagement are internal and subjective, which makes them harder to measure and quantify.

Although the correlation between behavioural engagement and academic achievement is moderate in size, it remains one of the most influential factors when compared to other significant determinants of academic success. This includes intelligence (r = .37) (Lozano- Blasco et al., 2021), motivation (r = .27) (Kreigbaum et al., 2018), SES (r = .22) (Liu et al., 2022), teacher competence (r = .40) (Lopez- Martin et al., 2023), and school (r = .28) and classroom climate (r = .20) (Erdem & Kaya, 2024).

Behavioural engagement, often referred to as on-task behaviour (Caldrella et al., 2021; Philip & Duschesne, 2017; Schmidt et al., 2025), has important implications beyond academic achievement, including positive reciprocal relationships with students' subjective well-being (Wong et al., 2024; Zhu et al., 2019), self-esteem (Karababa, 2020; Eryılmaz & Kara, 2025), and teacher-student relationships (Engels et al., 2016). Low behavioural engagement is also a significant predictor of students dropping out of school (Archambault et al., 2022; Lamonte et al., 2013; Szabó et al., 2024; Wang & Fredricks, 2014). Another important implication of on-task behaviour is its significant negative association with disruptive behaviour (Becherer et al., 2021; Bru, 2006; Caldarella et al., 2021).

Disruptive Behaviour

Disruptive behaviour is often functionally defined in classroom settings as behaviour on the part of the learner that interferes with the teacher's ability to teach or another student's ability to learn (Dobmeier & Moran, 2008; Meany-Walen et al., 2014). Common examples include speaking out of turn (i.e., talking when it's not appropriate or interrupting), disrupting or interfering with other students, fighting, or engaging in verbal or physical abuse or threats (Collins et al., 2016; Ødegård & Solberg, 2024). Disruptive behaviours can disturb other students, causing them to become off-task and negatively impacting the learning environment of the entire classroom (Alkhadim et al., 2024; Okeke et al., 2023).

Disruptive behaviour also has a significant negative effect on the academic achievement of not only the students who exhibit disruptive behaviours (Alatupa et al., 2011; Bierman et al., 2013; Finn et al., 1995; Flores-Mendoza et al., 2013; Kremer et al., 2016) but also the entire classroom (Bäckström, 2021; Blank & Shavit, 2016; Goulas et al., 2024; Kristoffersen et al., 2015; Zhao & Zhao, 2021). Flores-Mendoza et al. (2013) conducted a study examining how the disruptive behaviour of students (N = 160), alongside factors like SES, crystallised and fluid intelligence, and various personality traits (including psychoticism, extroversion, and neuroticism), impacted academic achievement. The findings indicated that student's disruptive behaviour had a significant negative correlation with their academic achievement (*r* = -.34, *p* < .01) and emerged as the second strongest predictor of achievement (*β* = −.28, *SE* = .08, p < .001), following crystallized intelligence (*β* = .40, *SE* = .08, *p* < .01). A separate study found that the disruptive behaviour of students (*N* = 1,013) had a significant (*p* < .01) negative effect on test scores in mathematics (*r* = -.29), language (*r* = -.28), reading (*r* = -.21), and social studies (*r* = -.20), and science (*r* = -.18) (Finn et al., 1995). Blank and Shavit (2016) investigated the effect of disruptive behaviour on the test scores of 2,422 students, finding that disruptive behaviour in the classroom was negatively correlated with the mean achievement of the entire classroom (*r* = -.29, *p* < .01).

Students' disruptive behaviour can also have a significant negative effect on teachers' well-being and is associated with teacher burnout, exhaustion, and job dissatisfaction (Ghanizadeh & Jahedizadeh, 2015; Kollerova et al., 2023; Otero-Lopez et al., 2009; van den Brink et al., 2024; Vidić et al., 2021). According to Kollerova et al. (2023), the current literature indicates that student disruptive behaviours are considered the primary social stressor that increases teaching demands and contributes to teacher exhaustion. Recent studies have found that many teachers are considering leaving the profession, with student behaviour being one of the leading causes (Doan et al., 2024; Reinke et al., 2025).

Two of the most common and problematic types of classroom disruptive behaviours are out-of-seat behaviour (Axup & Gersch, 2008; Infantino & Little, 2005; Patterson, 2009) and chair tipping (Cogswell et al., 2020; Ozdemir, 2008; Zuniga & Cividini-Motta, 2022).

Out-of-Seat Behaviour

Out-of-seat behaviour refers to a student leaving their seat without permission from the teacher and walking around the room while class is in session (Conklin et al., 2017; Flower et al., 2014; Patterson, 2009). Out-of-seat behaviour is generally defined as anytime a student's backside/buttocks lose contact with the seat of the chair (Matin Sadr et al., 2017; Sarver et al., 2015; Schilling & Schwartz, 2004).

Out-of-seat behaviour is consistently recognised as one of the most common and problematic disruptive behaviours by teachers (Alter et al., 2013; Atici & Merry, 2001; Axup & Gersch, 2008) and students (Infantino & Little, 2005; Patterson, 2009; Sun & Shek, 2012). Axup and Gersch (2008) asked teachers to identify three student behaviours that they found the most difficult to cope with. Out-of-seat behaviour was the third most prevalent response, following talking and general work avoidance, with 33% of all teachers surveyed identifying out-of-seat behaviour as one of the top three most difficult student behaviours to deal with. Infantino and Little (2005) surveyed 350 secondary school students and asked them to identify which behaviour they considered to be the most troublesome in the classroom. Out-of-seat behaviour was the third most common response, after talking out of turn and using inappropriate language.

Out-of-seat behaviour is also frequently identified as one of the most prevalent types of off-task behaviour in the classroom (Austin & Soeda, 2008; Goodwin et al., 2016; Jaffal, 2019; Swinson & Knight, 2007). Swinson and Knight (2007) observed the type of behaviour exhibited by students (N = 303) when they were off-task (e.g., talking to other students, general inattention) and found that out-of-seat behaviour was the fourth most common type of off-task behaviour. Although out-of-seat behaviour is not always indicative of a student being off-task, unsurprisingly, several studies have demonstrated that when out-of-seat behaviour increases, time on-task decreases (Conklin et al., 2017; Fedewa & Erwin, 2011; Schilling & Schwartz, 2004).

Chair Tipping

Chair tipping, often referred to as students swinging or rocking on their chairs, is defined as the act of using a foot, leg, or any other body part to tilt the chair backwards, causing one or more legs to lift off the ground (Zuniga & Cividini-Motta, 2022). It is frequently listed as a common disruptive behaviour in classrooms (Cogswell et al., 2020; Miller, 2019; Ofsted, 2014; Ozdemir, 2008; Scattone et al., 2002; Zuniga & Cividini-Motta, 2022). A survey by the Office for Standards in Education, Children's Services and Skills (Ofsted), which involved 1,048 teachers, identified chair tipping as one of the top 10 causes of classroom disruption (Ofsted, 2014). Besides being disruptive, chair tipping can also be dangerous, with chairs tipping over being a leading cause of injuries in classrooms (Goss, 1992; Salminen et al., 2014; van Dyne, 2010).

Interventions

A number of different interventions/strategies, including positive reinforcement (Crewdson et al., 2023; Kirkpatrick et al., 2019), self-management strategies (Bulla & Frieder, 2018; Smith et al., 2022), and social stories (Ozdemir, 2008; Scattone et al., 2002), are used to reduce disruptive behaviours such as chair tipping and out-of-seat behaviour. However, although effective at reducing disruptive behaviours, these are consequence-based interventions and do not necessarily address the underlying cause of the behaviour. As previously mentioned in the Education Review Office report, there is a need for interventions/strategies that address the underlying causes of disruptive behaviours, rather than just addressing the behaviour itself (Education Review Office, 2024). Behaviours such as chair tipping and out-of-seat behaviour are often attributed to attention-seeking or work avoidance (Mellor, 2005; Turtura et al., 2014). However, there is evidence to suggest that one reason students engage in these behaviours may be due to pain/discomfort caused by static sitting (Antle et al., 2018; Knight & Noyes, 1999; Okino et al., 2022; Taylor et al., 2022; Udo et al., 1999).

Pain and Discomfort

Musculoskeletal pain/discomfort (related to the muscles, bones, ligaments, tendons, and nerves of the body) is a prevalent issue among students (Chambers et al., 2024; Gogoi et al., 2024; Kandasamy et al., 2024; Minghelli, 2020; Ogunlala et al., 2021). A meta-analysis conducted by Chambers et al. (2024) on the prevalence of chronic pain in children and adolescents, which included 119 studies and over a million children (age ≤ 19 years) from 70 different countries showed that 1 in 4 children (25.7%, 95% CI [17.3-35.1]) suffer from chronic (persistent/recurring) musculoskeletal pain. Furthermore, musculoskeletal pain was found to be the most common type of chronic pain in children, alongside headaches, which also had a prevalence of 25.7% (95% CI [22.2-29.3]) (Chambers et al., 2024).

A significant factor contributing to the high prevalence of musculoskeletal pain in students is static sitting (Caromano et al., 2015; Harithasan et al., 2022; Ogunlana et al., 2021; Waongenngarm et al., 2015; Zemp et al., 2016). Prolonged static sitting has been shown to significantly decrease circulation in the lower limbs, resulting in discomfort (Antle et al., 2018; Okino et al., 2022; Taylor et al., 2022). It is hypothesised that to relieve discomfort caused by static sitting, students will engage in fidgeting, which has been shown to significantly increase blood flow in the lower limbs (Morishima et al., 2016; Pettit-Mee et al., 2021; Tamiya et al., 2024). Fidgeting, which differs from active sitting, involves non-goal-oriented, repetitive movements (Carriere et al., 2013; Perrykkad & Hohwy, 2020) such as foot tapping, leg bouncing, pen clicking, or finger tapping (Carriere et al., 2013; Perrykkad & Hohwy, 2020), and is also a common disruptive behaviour in the classroom (Cogswell et al., 2020; See, 2012).

Similarly, tipping/rocking on a chair has been shown to increase blood flow in the lower limbs (Frey et al., 2021; Stranden, 2000; Udo et al., 1999), as has standing up or walking (Antle et al., 2018; Francisco et al., 2022). Knight and Noyes (1999) investigated the effect that school chairs on the behaviour of a classroom of primary school students (*N* = 21). In response to questions about what they did when they felt uncomfortable, 67% of participants reported that they would rock or tip on their chairs. Furthermore, 48% of the participants reported that at some point they had left their seat (i.e., out-of-seat behaviour) in response to discomfort (Knight & Noyes, 1999). Another study found that chair tipping significantly reduced neck, shoulder, and back pain, but increased hip pain (Udo et al., 1999). Although these two studies (Knight & Noves, 1999; Udo et al., 1999) suggest a connection between static sitting and behaviours like chair tipping or out-of-seat behaviour, the existing research on these behaviours and their link to pain/discomfort remains limited, highlighting the need for additional studies in this area.

Pain has also been shown to have a disrupting effect on attention (Attridge et a., 2017; Dick & Rashiq, 2007; Moore et al., 2012; Moore et al., 2019; Ooosterman et al., 2012) and can have a significant negative impact on academic achievement (Grimby-Ekman et al., 2019; Kosola et al., 2017; Ragnarsson et al., 2022; Voerman et al., 2017). Conversely, physical comfort has been shown to improve student engagement (Aga, 2024; Hanaysha et al., 2023; Scott-Webber et al., 2018) and performance (Bell et al., 2009; Hoque & Weil, 2016). Additionally, pain is also associated with aggression and behavioural problems (Just et al., 2003; Lindley, 2012), reduced school attendance (Groeneweld et al., 2019; Owiredua et al., 2023) and poor social functioning and peer relationships (Forgeron et al., 2010; Serbic et al., 2021).

Movement Interventions

One-way schools have sought to reduce static sitting and improve student behaviour and achievement is by integrating movement into the classroom. Most commonly, this has been implemented using movement/physical activity breaks (a short break in the lesson that involves physical activity) (Gilmore et al., 2024; Turner & Chaloupka, 2016). Gilmore et al. (2024) found that over 70% of teachers (*N* = 220) incorporate movement breaks into their classrooms, while another study reported that movement breaks are used in 76.5% of primary schools (*N* = 640) (Turner & Chaloupka, 2016).

Movement breaks have been shown to significantly increase the on-task behaviour of students (Broad et al., 2023; Fenesi et al., 2019; Howie et al., 2014; Ma et al., 2014; Mavilidi et al., 2021; Watson et al., 2017; Webster et al., 2015). Watson et al (2017) conducted a meta-analysis of 39 studies on the effects of physical activity breaks on student behaviour and achievement. Physical activity breaks had a moderate positive effect on improving on-task and reducing off-task behaviour (d = 0.60, 95% CI: [0.20, 1.00]). Broad et al (2023) found that movement breaks significantly (p < .01) increased the on-task behaviour of students regardless of whether the break was implemented during the morning (Δ 10.4%), afternoon (Δ 10.5%), or both (Δ 14%). Movement breaks have also been shown to decrease disruptive behaviours (Broad et al., 2023; Chesnias et al., 2022; McGowan et al., 2021; Moon et al., 2020), including out-of-seat behaviour (Camahalan & Ipock, 2015; Wells, 2012). One study, which included 229 students from 12 different classrooms, found that movement breaks had a significant negative correlation with disruptive behaviour (r = -.26, p < .05) (Moore et al., 2020).

Movement breaks can also have a positive impact on students' academic achievement (Donnelly & Lambourne, 2011; Fenesi et al., 2019; Mavilidi et al., 2019; Mullender-Wijnsma et al., 2015; Petrigna et al., 2022; Shoval et al., 2018; Watson et al., 2017). The meta-analysis by Watson et al. (2017) revealed that physical activity breaks had a large positive effect on academic achievement (d = 1.03, 95% CI: [0.22, 1.84]) when progress monitoring tools were used. However, when standardised testing was used, there was generally no improvement in academic achievement (d = −0.13, 95% CI [-0.72, 0.46]). However, despite having a positive influence on students' behaviour and achievement, movement breaks interrupt lessons (cutting into valuable learning time) and require teachers to be trained on how and when to introduce them (Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011).

Dynamic Seating

Another way that schools have looked to integrate movement into the classroom is through dynamic seating. Dynamic seating refers to alternative options designed to promote movement and encourage active sitting (Hyeon et al., 2014). Active (or dynamic) sitting involves maintaining consistent movement while seated through postural adjustments (Akkarakittichoke et al., 2023; Arippa et al., 2022; Hyeong et al., 2014). Dynamic seating is a broad term that covers a variety of options, including stability balls (also known as swiss, therapy, or exercise balls), cycle chairs (chairs equipped with pedals so students can cycle while seated), wobble stools, air cushions (inflatable cushions placed on regular chairs to encourage active sitting) (Rollo et al., 2019).

One type of dynamic seating that has been studied quite extensively is stability balls. Numerous studies have shown that, compared to regular classroom chairs, stability balls can significantly improve students' on-task behaviour and reduce some disruptive behaviours, including out-of-seat behaviour (Brennan & Crosland, 2021; Fedewa & Erwin, 2011; Krombach & Miltenberger, 2020; Matin Sadr et al., 2017; Schilling, 2003; Schilling & Schwartz, 2004). However, all these studies only involved participants with either Autism Spectrum Disorder (ASD) or Attention Deficit Hyperactivity Disorder (ADHD). When used in mainstream classrooms, stability balls had either no effect on students’ on-task behaviour and, in some cases, decreased it (Erwin et al., 2016; Fedewa et al., 2015; Hulac et al., 2020; Metz et al., 2020).

Research on the effects of other types of dynamic seating on student behaviour is limited, particularly in mainstream classrooms (Rollo et al., 2019). Outside of stability balls, the only other dynamic seating option that has been tested in mainstream classroom settings is the cycle chair, which was shown to have a significant negative effect on students’ on-task behaviour (Fedewa et al., 2024). Furthermore, neither stability balls nor cycle chairs have been shown to have a positive effect on students' academic achievement (Fedewa et al., 2015; Joubert et al., 2017; Mead et al., 2016; Torbeyns et al., 2017). The inability of stability balls and cycle chairs to have a positive effect on students’ behaviour or achievement in mainstream classroom settings may be due to their failure to reduce static sitting. Erwin et al. (2016) found that stability balls actually reduce the movement of students in comparison to regular classroom chairs. Meanwhile, although cycle chairs have been shown to increase energy expenditure and heart rate (Fedewa et al., 2017; Torbeyns et al., 2017), there is no evidence that they can reduce static sitting (i.e., sitting in the same posture).

Rollo et al. (2019) conducted a systematic review on the effects of dynamic seating on students' behaviour and achievement. They concluded that dynamic seating could positively influence the behaviour of students with ASD and ADHD. However, there was no clear evidence that it could improve the behaviour or academic achievement of general-education students. Furthermore, it was emphasised that more rigorous and in-depth research is needed into the effects of dynamic seating, outside of stability balls and cycle chairs (Rollo et al., 2019).

Dynamic Chairs

Although dynamic chairs are a type of dynamic seating, they are not directly comparable to other dynamic seating options, such as stability balls. A dynamic chair is a chair (a specific type of seat that includes a flat or slightly angled seat, one or more legs, and a backrest) that incorporates dynamic features (i.e., features that allow movement). According to Hyeon et al. (2014), a dynamic chair features flexible/dynamic backrest and seat panels that move with the user, enabling changes in posture (i.e., active sitting). There is reason to believe that, unlike other dynamic seating options, dynamic chairs could significantly improve the behaviour and achievement of mainstream students by increasing their movement and enhancing their comfort.

In contrast to stability balls and cycle chairs, a number of studies show that dynamic chairs can significantly increase the movement of occupants in comparison to static (non-dynamic) chairs (Garcia et al., 2015; Grooten et al., 2017; Nüesch et al., 2018; Stanić et al., 2022; Synnott et al., 2017; Tanoue et al., 2016). However, it should be noted that there are some limitations around the generalisability of the findings of these studies. Firstly, several of the cited studies only included adult participants and were conducted in isolated office or laboratory settings, and not in classrooms (Grooten et al., 2017; Nüesch et al., 2018; Synnott et al., 2017; Tanoue et al., 2016). Garcia et al. (2016), on the other hand, examined how dynamic and static chairs affected the movement of 12 school-aged children (average age 8.3 years). Accelerometers were used to measure participants' movement, and a movement index (activity count, AC) was calculated to compare their relative activity levels. Two test sessions were conducted, each consisting of a 20-minute lecture. A within-subjects design was implemented, with half of the participants ($n = 6$) assigned to the dynamic chair condition and the other half ($n = 6$) to the static chair condition. After the first session concluded, they switched conditions for the second session. The results showed that participants moved significantly more when seated in the dynamic chairs compared to the static chairs (40.82 AC/min vs. 9.81 AC/min, $p < .01$). However, this study had several limitations, including taking place in an exercise physiology laboratory (not directly comparable to a regular classroom setting), there was limited information about the chairs used in the study, no details were provided on how the movement index was calculated, and all data was collected over a very short period within a single day (two 20-minute sessions with a 5-minute break in between) (Garcia et al., 2015).

Stanić et al. (2022) also used accelerometers to compare the effects of three types of seating (traditional school chair, stability balls, and a dynamic chair) on children's movement (*N* = 23, aged 8-11 years). The results showed that participants moved significantly more when seated in the dynamic chair compared to the stability ball, $F(1, 21) = 5.06$, $p < .05$, η2p = .19, and the traditional school chair, $F(1, 21) = 15.49$, $p < .01$, η2p = .43. This study also had some limitations, such as assessing participants one by one in a counselling room instead of a classroom group setting. But most importantly, they did not specify the amount of time participants spent in each seat (Stanić et al., 2022).

Dynamic chairs have also been shown to reduce pain/discomfort of users in comparison to static (non-dynamic chairs) (Cardenas et al., 2024; Cardoso et al., 2021; Frey et al., 2021; Garcia et al., 2016; O'Keeffe et al., 2013; Tanoue et al., 2016). However, just like with movement, most of these studies were conducted in office settings with adult participants (Cardenas et al., 2024; Cardoso et al., 2021; Frey et al., 2021; O'Keeffe et al., 2013; Tanoue et al., 2016). Garcia et al. (2016), who, as previously discussed, compared the effect of dynamic and static chairs on children's movement, also asked participants their opinions on the chairs. The participants reported that the dynamic chairs were more comfortable than static chairs. However, it is unclear how many participants reported that the dynamic chairs were more comfortable (Garcia et al., 2016).

The current literature also suggests that, compared to static chairs, students have better perceptions of dynamic chairs (Garcia et al., 2016; Stanić et al., 2022). Garcia et al. (2016) found that 75% of participants (*N* = 12) reported that they would prefer sitting on the dynamic chairs over the static chairs at school, stating that they were 'more fun' and comfortable. One participant reported feeling more alert and attentive while sitting in the dynamic chair (Garcia et al., 2016). Similarly, Stanić et al. (2022) found that 75% of participants (*N* = 24) preferred the dynamic chair over the stability ball (16.7%) and the regular chair (8.3%).

In summary, the reviewed literature suggests that by increasing student movement and improving their comfort and perceptions, which are all associated with improved behavioural and academic outcomes (Aga, 2025; Broad et al., 2023; Edgerton & McKechnie, 2023; Grimby-Ekman et al., 2019; Mavilidi et al., 2021; Salar et al., 2024; Watson et al., 2017), dynamic chairs could improve students' behaviour and achievement. However, there is a need for more robust research on the effect of dynamic chairs on students' movement, comfort, and perceptions, specifically in a classroom setting where students have the opportunity to experience the chairs over an extended period.

Despite the current literature suggesting that dynamic chairs could improve the behaviour and achievement of students compared to regular classroom chairs, there is a distinct lack of research specifically examining their impact on these outcomes. However, in 2021, a master's research project attempted to address some of this gap in the literature by evaluating the effect that a dynamic chair, called the Bodyfurn chair, had on the on-task and disruptive behaviour of students compared to regular classroom chairs (Martin, 2021). The study included three separate groups of five primary school students and implemented a multiple baseline design. All three groups used the regular classroom chairs during the baseline phase, and Bodyfurn chairs were introduced in a staggered fashion once stable baselines were established. The results showed that the introduction of Bodyfurn chairs resulted in immediate and noticeable increases in on-task behaviour for two of the three groups, with a ceiling effect preventing any noticeable experimental effect from occurring in the third group. The results also showed marked decreases in disruptive behaviour across all three groups when Bodyfurn chairs were used, compared to the regular classroom chairs. When asked for their opinions on the chairs, 13 of the 15 participants reported that they preferred the Bodyfurn chairs over the regular chairs, stating that they were more comfortable, reduced back pain, and allowed them to adjust their position easily (Martin, 2021). The findings of this study suggest that, compared to regular classroom chairs, Bodyfurn chairs can improve students' on-task behaviour and comfort while reducing pain and disruptive behaviours, and in turn may improve their academic achievement (Martin, 2021). However, the study had several limitations that impacted the validity and generalisability of the results. These included ceiling and floor effects, a small sample size, a relatively short duration, the inclusion of only one age group and type of regular chair, and conducting the study in small breakout rooms with just five students (which is not comparable to a typical classroom environment).

Overview of Studies

The aim of this thesis was to build upon the findings of Martin (2021) and investigate the effect that BodyfurnFlex chairs, the updated version of the Bodyfurn chair, had on the behaviour and achievement of students. As part of this research, we also utilised a new research tool, the Smart Classroom System, to evaluate various aspects of movement, noise, and environmental conditions within the classroom and investigate relationships to student behaviour. This thesis comprises a series of studies, with each study building upon the findings of the former.

In Study 1, we investigated whether BodyfurnFlex chairs affected the on-task, disruptive, out-of-seat, and chair tipping behaviours of students compared to regular classroom chairs. A survey was conducted to investigate students' perceptions of the chairs, including their preferences, whether they felt the chairs made it easier to complete their work, and the reasons behind their responses. The study also investigated whether BodyfurnFlex chairs affected student movement, measuring both in-chair and overall movement levels in the classroom. Additionally, environmental data (CO_2, temperature, and humidity) were measured as potential confounding variables.

In Study 2, we conducted an in-depth analysis of the movement and environmental data from Study 1. It provides a detailed overview of the Smart Classroom System, including data collection methods, and evaluates different aspects of the in-chair movement data (acceleration, rotation, and displacement). Additionally, Study 2 investigated whether BodyfurnFlex chairs could affect classroom noise levels and examined potential correlations between movement, environmental factors, noise, and behavioural variables.

Finally, in Study 3, we compared the impact of BodyfurnFlex and regular classroom chairs on students' academic achievement by tracking progress across several mathematics assessments.

Additionally, focus group discussions were held with students and teachers to gain deeper insights into their perceptions of the chairs and how they affected their comfort and learning.

Chapter 3: Study 1

The Effect of BodyfurnFlex Chairs on the Movement and Behaviour of Students

Study 1: The Effect of BodyfurnFlex Chairs on the Movement and Behaviour of Students is a manuscript submitted for publication in Learning Environments Research and formatted according to the journal's requirements.

The Effect of BodyfurnFlex Chairs on the Movement and Behaviour of Students

Isaac Martin, Angelika Anderson, Nicola Starkey

School of Psychological and Social Sciences, The University of Waikato, Hamilton, New Zealand

Author Note

Isaac Martin https://orcid.org/0009-0009-6183-3384

Angelika Anderson https://orcid.org/0000-0003-1156-4066

Nicola Starkey https://orcid.org/0000-0002-4370-8186

Correspondence concerning this article should be addressed to Isaac Martin. Email: im47@waikato.students.ac.nz

Statements and Declarations

Funding

This study received funding from Callaghan Innovation (contract number: FURNW2102) and research support from Resero in the form of supplying research equipment (including the Smart Classroom System and BodyfurnFlex chairs).

Competing Interests

The authors declare that they have no competing interests.

Ethics Approval

The study received ethical approval from the University of Waikato Human Ethics Research Committee (Ref: FS2022-61).

Consent

Informed consent was obtained from participating students and their parents/guardians.

Note

Callaghan Innovation (https://www.callaghaninnovation.govt.nz/).

Resero (https://www.reserogroup.com/). Resero is the parent company of Furnware (https://www.furnware.com/en-nz) who are the developers of BodyfurnFlex chairs.

Abstract

The physical environment can have a significant impact on the learning and behaviour of students. One particularly important part of the physical learning environment is the classroom chairs. Traditional classroom chairs are often rigid and inflexible, resulting in uncomfortable static sitting. This study was conducted to determine whether dynamic chairs can promote healthy movement while also increasing engagement and reducing disruptions in the classroom. A multiple baseline with ABAB reversal design was used to compare the effect that BodyfurnFlex chairs, a new type of dynamic chair, had on on-task, disruptive, out-of-seat and chair tipping behaviour of students in comparison to traditional classroom chairs. We also investigated whether BodyfurnFlex chairs affected the movement of students around the classroom and their perceptions of the chairs. The environmental conditions in the classroom were also measured as potential confounding variables. The results revealed that when students sat in BodyfurnFlex chairs, there was a significant increase in time spent on-task, a decrease in out-of-seat behaviour, and a significant reduction of disruptive behaviour and chair tipping. Both in-chair movement and overall movement in the classroom increased when students were seated in BodyfurnFlex chairs. The majority of participants reported that they preferred sitting in BodyfurnFlex chairs and felt they made it easier to complete their schoolwork. These findings suggest that BodyfurnFlex chairs can improve student engagement while also promoting healthy movement and reducing unproductive and disruptive movement.

Keywords: student engagement, dynamic chairs, active sitting, physical learning environment, classroom behaviour, flexible furniture

Introduction

Good academic outcomes are associated with improved life satisfaction, self-esteem, physical and psychological well-being, income, life expectancy, employment opportunities, social skills, standard of living, and personal relationships (Edgerton et al., 2012; Hahn & Chattopadhyay, 2019; Lettau, 2021; López-López et al., 2021; Metsäpelto et al., 2020; Raghupathi & Raghupathi, 2020). Academic achievement can also have significant societal effects, leading to less crime, reduced unemployment, and improved economic growth (Machin et al., 2011; Woessmann, 2016).

Academic achievement is influenced by many factors, including socioeconomic status (Liu et al., 2022), teachers (López-Martín et al., 2023), personality (Mammadov, 2022), intelligence (Lozano-Blasco et al., 2022), and behaviour (Becherer et al., 2021; Kremer et al., 2016). Several learning associated behaviours have been shown to have significant correlations with academic outcomes including on-task behaviour or behavioural engagement, which has a significant positive correlation with academic achievement (Lei et al., 2018; Wong et al., 2024). Conversely, disruptive behaviour has a significant negative correlation with academic achievement (Finn et al., 1995; Blank & Shavit, 2016). Two common types of disruptive behaviours are chair tipping (Cogswell et al., 2020; Zuniga & Cividini-Motta, 2022) and out-of-seat behaviour (Axup & Gersch, 2008; Infantino & Little, 2005), which is also considered an indicator of off-task behaviour (Austin & Soeda, 2008; Godwin et al., 2016).

The physical learning environment can have a significant impact on students' learning and behaviour, including the classroom design/layout (Imms & Byers, 2017; Wannarka & Ruhl, 2008), lighting (Pulay & Williamson, 2019), furniture (Castellucci et al., 2016; Morris & Imms, 2024), and the environmental conditions such as carbon dioxide (CO_2) concentration, temperature, and humidity (Brink et al., 2021; Carton et al., 2023; Coley et al., 2007). Chairs are a particularly important part of the physical learning environment, with students spending 97% of class time seated (Cardon et al., 2004). Traditional classroom chairs are designed to be durable, cost-effective, and efficient (i.e., easy to store/stack and move). These chairs are often rigid and inflexible, resulting in static sitting (i.e., sitting in the same posture/position without moving). Prolonged static sitting is associated with pain and discomfort (Caromano et al., 2015; Waongenngarm et al., 2015; Zemp et al., 2016), which has been shown to negatively impact students' engagement (Aga, 2024; Groenewald et al., 2020; Randall et al., 2019). Pain/discomfort also appears to be a key reason for out-of-seat behaviour and chair tipping (Knight & Noyes, 1999; Udo et al., 1999) found that chair tipping resulted in reduced back pain while another study found that 67% of students stated that they would rock/tip on their chairs as a response to feeling uncomfortable (Knight & Noves, 1999). Knight and Noyes (1999) also found that 48% of the participants reported that they would engage in out-of-seat behaviour at some point due to discomfort (Knight & Noyes, 1999).

Recently, schools have looked to incorporate ergonomically designed dynamic chairs in their classrooms to improve student comfort and behaviour. In contrast to traditional classroom chairs, dynamic chairs are designed to be flexible, allowing them to move with the user and promote active sitting. Active or dynamic sitting refers to consistent movement through postural changes (Akkarakittichoke et al., 2023; Arippa et al., 2022). Dynamic chairs have been shown to reduce pain/discomfort (Cardenas et al., 2024; Frey et al., 2021) compared to traditional chairs, indicating that they may improve students' engagement and reduce disruptive/unproductive movements, such as chair tipping and out-of-seat behaviour. Dynamic chairs have also been shown to increase the in-chair movement of students in comparison to non-dynamic chairs (Garcia et al., 2016; Stanić et al., 2022). Integrating movement into classrooms has been shown to increase on-task behaviour and decrease disruptive behaviours (Broad et al., 2023; McGowan et al., 2021; Webster et al., 2015), including out-of-seat behaviour (Camahalan & Ipock, 2015; Wells, 2012). These findings suggest that dynamic chairs may increase students' on-task behaviour and decrease disruptive behaviours.

Currently, there is a lack of research directly comparing the effect of dynamic and regular chairs on student behaviour in the classroom. Several studies have compared the effect of other dynamic seating options, including stability balls, to regular classroom chairs, with most finding that they improved on-task behaviour and decreased some disruptive behaviours, including out-of-seat behaviour (Fedewa & Erwin, 2011; Matin Sadr et al., 2017; Schilling, 2003; Schilling & Schwartz, 2004). However, the generalizability of these findings is limited as stability balls are not comparable to dynamic chairs, and the studies only included participants with Attention Deficit Hyperactivity Disorder [ADHD] or Autism Spectrum Disorder [ASD]. When stability balls were introduced in a mainstream classroom, they resulted in a decrease in on-task behaviour compared to regular classroom chairs (Fedewa et al., 2015; Hulac et al., 2020). Rollo et al. (2019) conducted a review on the effects of dynamic seating interventions and found that there was no clear evidence to suggest that dynamic seating can positively affect students' on-task and disruptive behaviour in general education settings. It was concluded that more rigorous and in-depth research is needed into the effects of dynamic seating on children's behaviour in the classroom, particularly options beyond stability balls. Imms et al. (2020) suggested the use of longitudinal, withdrawal, single-case experimental designs to analyse the effect of furniture on students' behaviour.

The aim of the current study was to investigate the effect that BodyfurnFlex chairs (Furnware, n.d.), a new type of dynamic school chair, had on the on-task, disruptive, out-of-seat, and chair tipping behaviour of students in comparison to regular (traditional) classroom chairs. The study also investigated whether BodyfurnFlex chairs affected student movement, measuring both in-chair and overall movement levels in the classroom. Environmental data, including classroom temperature, humidity, and CO_2, were also measured as potential confounding variables. Additionally, social validity data was collected in the form of a participant survey to measure students' preferences/opinions on the chairs and whether they felt they made it easier to complete their work. Social validity data is crucial to ensuring that an intervention is acceptable, important, meaningful, and worthwhile for those experiencing it (Huntington et al., 2023).

Methods

Ethical approval for this study was gained from the XXXXX Human Ethics Research Committee.

Participants

Data was collected from two separate classrooms that included a total of 60 students. The first classroom (Class A) was an intermediate school maths class of 31 students, aged between 11 and 13 years. The second classroom (Class B) was a secondary school English class of 29 students, aged 13 to 14 years. Overall movement and social validity data were collected for the entire classroom, while in-chair movement and behavioural data were collected for 10 students in each classroom (Groups A and B). The 10 students were selected using purposive sampling, with the selection criteria being good attendance and average/middling performance in the target behaviours relative to the class population. Good attendance was included to minimize participant absences, while participants with middling/average performance in the target behaviours were selected to be a representative sample of the classroom and to try and avoid ceiling or floor effects. The teachers of the classrooms selected the 10 students that best fit the selection criteria based on their own experience and knowledge of the students. Groups A and B both included 5 female and 5 male participants.

Materials

Chairs

Two types of chairs were used in the study: the regular classroom chairs and BodyfurnFlex chairs.

The **BodyfurnFlex chair** is a dynamic chair with an independently moving polypropylene seat and backrest connected to a high tensile steel frame with a sled base (Furnware, n.d.). The size of the chairs used for each classroom was determined by the age group of the students. The BodyfurnFlex chairs for Class A had a seat height of 410mm and an overall height of 777mm, while Class B's chairs had a seat height of 460mm and an overall chair height of 872mm. The BodyfurnFlex chair is displayed below in figure 1.

Figure 1

BodyfurnFlex Chair

The **regular classroom chairs** were solid (single piece) non-dynamic, polypropylene chairs. Both groups used chairs with similar designs but different brands. The regular chairs used for Class A had a seat height of 430mm and an overall chair height of 799mm, while Class B's regular chairs had a seat height of 460mm and an overall chair height of 805mm. The regular chairs used for Groups A and B are displayed below in figures 2 and 3, respectively.

Figure 2

Class A Regular Classroom Chair

Figure 3

Class B Regular Classroom Chair

Smart Classroom System

The Smart Classroom System is a network of sensors that was developed by the project stakeholders for this study to assess the quality of learning environments. The system includes two different types of sensors: Nordic Thingy:52 sensors (Nordic Semiconductor, 2024), which contain movement and environmental sensors (including CO_2, temperature, and humidity); and Raspberry Pi cameras (Raspberry Pi, 2024) utilised as motion sensors. These sensors wirelessly connect to a laptop that has software that organises and graphs the data.

Video Camera

Behavioural data was collected by recording sessions with a video camera.

Participant Survey

The researchers created a survey to gather social validity data from participants. The survey asked students which chair they preferred sitting in and to explain why, if they felt that either chair made it easier for them to complete their schoolwork and why, along with any additional feedback about the chairs or study.

Procedure

Design

This study implemented a multiple baseline design across participants with an integrated ABAB reversal design, alternating between baseline (Regular chairs - A) and intervention (BodyfurnFlex chairs - B) conditions. Phase changes were implemented only after several sessions of stable on-task behaviour had been established.

Dependent Variables

This study included six dependent variables: on-task behaviour, disruptive behaviour, out-of-seat behaviour, chair tipping, in-chair movement, and overall movement in the classroom.

On-task behaviour was defined as being actively engaged in learning activities. For a student to be scored as on-task, they had to attend to or be engaged in the assigned task either visually (e.g., looking at the teacher, speaker, or task material), verbally (e.g., asking/answering questions or discussing the task), or physically (e.g., writing, gluing, or cutting). Additionally, following the teacher's instructions (e.g., "when you finish your work, sit and wait quietly" or "can you go and close that window, please") was also scored as on-task.

Disruptive behaviour was functionally defined as any behaviour that caused another student to stop their on-task behaviour (i.e., become off-task) or caused the teacher to stop teaching. Task-related behaviours such as asking questions or engaging in task-related discussion were not deemed as disruptive behaviours.

Out-of-seat behaviour was defined as any time a student's backside lost contact with the seat of the chair without permission from the teacher (e.g., permission to go to the bathroom) or when it was not directly related to the task (e.g., standing up to fetch a pair of scissors).

Chair tipping was defined as any time a student was seated and part of a chair leg or base lost contact with the floor.

In-chair movement was recorded by Thingy:52 sensors that were attached to the chairs. These sensors detect the size and amount of movement (i.e., displacement). This data was converted into a movement index that represents the amount of movement from each sensor.

Overall movement in the classroom was recorded by the Raspberry Pi motion sensor cameras. These cameras recorded black-and-white video footage and detected motion by comparing changes in pixels from frame to frame (i.e., as an image changes, the pixels of the image change). The amount of movement (i.e., changes in the image) was converted into a turbidity index that indicates the size/amount of motion.

Additionally, the Thingy:52 sensors measured several environmental factors, including CO_2 concentration, temperature, and humidity.

Participant Recruitment

Participant information sheets and assent/consent forms were provided to all students and their parents/guardians. Signed assent/consent was collected from the 10 selected students and their parents/guardians before data collection began.

Setting

Classrooms were arranged in a traditional layout, with the teacher positioned at the front and students seated around tables. Two Thingy:52 sensors were attached to the 10 chairs of the selected participants (Groups A and B) in each classroom using Velcro patches (Velcro, n.d.). One sensor was placed under the seat and the other on the back of the backrest in the same place on each chair. The chairs were positioned around two adjacent tables (5 chairs around each table). The layout of the classroom and position of the chairs remained constant throughout data collection. The two motion sensor cameras were positioned in opposite corners of the classroom to avoid blind spots. The video camera was positioned at the side of the room against a wall and was only focused on the 10 students who consented to behaviour data collection.

Data Collection

Data was collected during regular class periods, with all equipment being set up prior to class beginning and removed after class. Behavioural data was coded from the video footage of the lesson, which allowed for the behaviour of multiple students to be observed simultaneously (i.e., could watch back the video multiple times). Behavioural observations took place during the first 25 minutes of the lesson once all the participants were seated. There were two data collection sessions per week for each classroom, with data collection for Class B beginning two weeks after Class A. There was a total of 25 and 24 sessions for Classes A and B, respectively.

Data Coding

On-task behaviour was measured using momentary time sampling at 20-second intervals, with each participant being marked as either on-task or not on-task at the 20-second mark of each interval. If a student was not present at the 20-second mark of an interval (e.g., they went to the bathroom) and provided they had permission to leave or there was evidence that they left for a task-related reason (e.g., they returned with a pair of scissors), they were marked as absent for that interval. However, if a student did not have permission to leave (e.g., just got up and walked off) or did not show evidence that they left for a task-related reason, they were marked as not on-task. On-task behaviour was converted to a percentage for each student (i.e., the percentage of intervals where students displayed on-task behaviour), with absent intervals excluded.

Disruptive behaviour was recorded using event recording, with each instance/occurrence of disruptive behaviour being tallied. Students were marked as absent only if they were off camera for the entire interval. The scores were converted to the mean number of disruptive behaviour occurrences per hour for each student.

Out-of-seat behaviour and chair tipping were measured using partial interval recording at 20-second intervals. If a participant exhibited out-of-seat behaviour or chair tipping at any point during the 20-second interval, the behaviour was marked as present. Both behaviours were converted to percentages (i.e., the percentage of intervals the behaviour was displayed) for each student.

Movement and environmental data collected during the 25-minute observation period were downloaded for data analysis. Due to technical and connection issues, several sessions had incomplete and/or corrupted data and were excluded from the results, with four sessions removed for both groups/classes.

Furthermore, any sessions that involved pedagogical outliers (e.g., sessions that deviated from typical classroom lessons, such as test-taking classes or those with a substitute teacher) were excluded from the results.

Following the completion of the final data collection session, students completed the participant survey.

Data Analysis

Each dependent variable was graphed over the course of data collection, with each data point representing the group mean for a session. Visual analysis involved comparing differences in the trend, level, and variability of data between baseline and intervention phases. In addition to visual analysis, Tau-U was used to calculate the size and significance of the effect.

The reliability of the behavioural data coding was assessed through interobserver agreement (IOA) for 25% of the data collection sessions. On-task behaviour was assessed using total agreement IOA, while out-of-seat, chair tipping, and disruptive behaviour were assessed using scored interval IOA. On-task behaviour had a mean total agreement IOA of 95.8% and 94.3% for Groups A and B respectively. Groups A and B had a mean scored interval IOA of 85.7% and 88.4% for disruptive behaviour, 94.4% and 90.3% for out-of-seat behaviour, and 91.0% and 93.1% for chair tipping.

Results

On-Task Behaviour

Mean on-task percentages for Groups A and B are displayed in figure 4 and summarised in table 1.

Figure 4 shows that Group A baseline levels of on-task behaviour (A1) remained relatively stable (*M* = 76.3%), except for session 3. The introduction of the intervention (B1) coincided with a noticeable increase in on-task behaviour which remained stable throughout the phase and consistently above baseline levels (*M* = 85.5%). A return to baseline conditions (A2) resulted in a visible decrease in on-task behaviour and return to baseline levels (*M* = 75.8%). The reintroduction of the intervention (A2) was associated with an immediate increase in on-task behaviour that remained stable throughout the phase (*M* = 82.2%).

The Group B baseline levels of on-task behaviour remained relatively stable (*M* = 72.1%). The introduction of the intervention resulted in an immediate increase in on-task behaviour that consistently remained above baseline levels (*M* = 80.1%). The second baseline phase coincided with a noticeable decrease in on-task behaviour which remained relatively stable with a slight decreasing trend (*M* = 67.9%). The reintroduction of the intervention again resulted in an immediate increase in on-task behaviour which remained relatively stable (*M* = 76.2%), with all but one session remaining above A2 levels.

In every case, changes in the independent variable (chair type) were associated with immediate changes in the dependent variable (on-task behaviour), demonstrating a clear functional relationship.

Table 1 shows that on-task behaviour increased during the intervention condition for both groups, with large significant effect sizes (Tau-U) for both Group A (.95, $p < .01$) and Group B (.92, $p < .01$), indicating that the intervention had a large positive effect on the on-task behaviour of students.

Figure 4

Mean Percentage of On-Task Behaviour across Sessions for Groups A and B

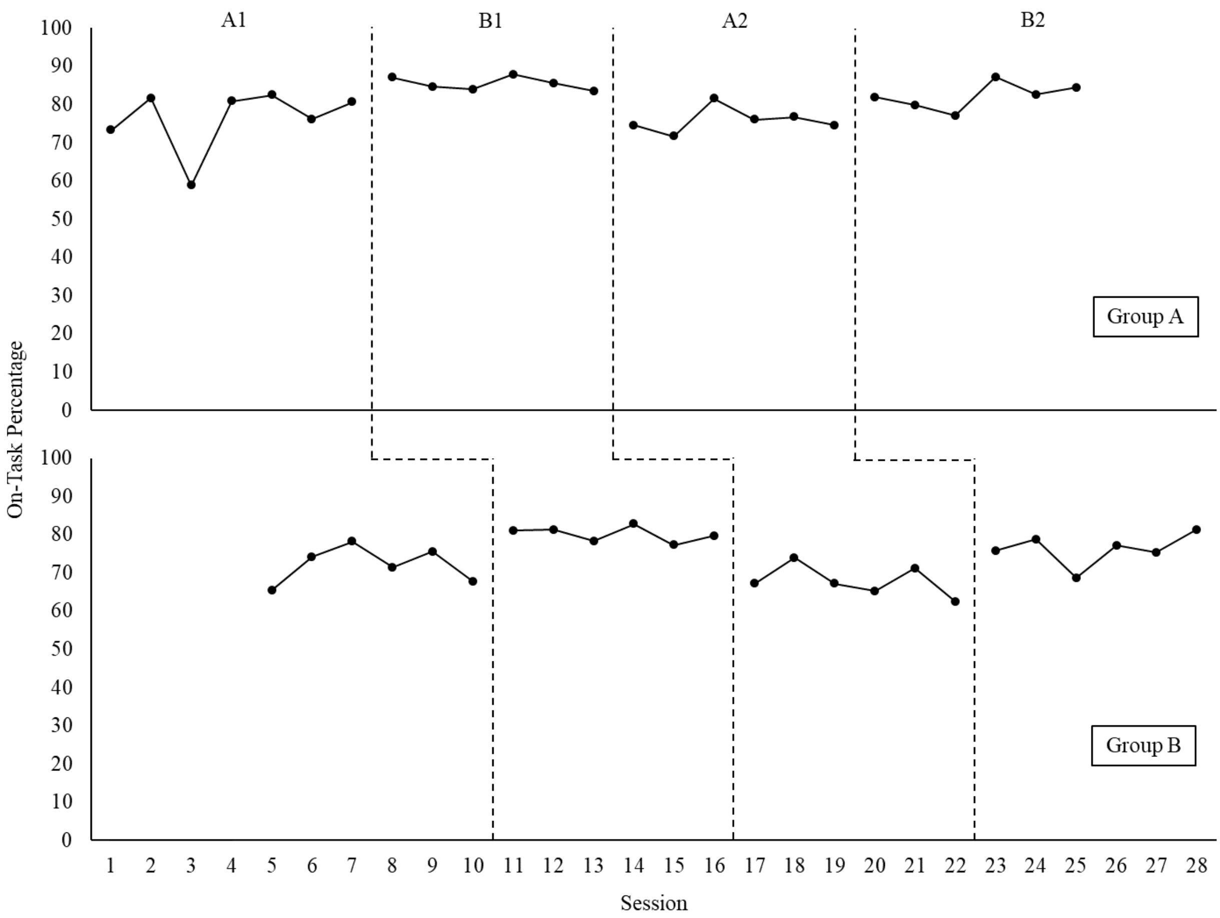


Table 1

Mean Percentage of On-Task Behaviour across Conditions and Effect Sizes for Groups A and B

	Group A			Group B		
	Baseline (n = 13)	Intervention (n = 12)	Tau-U	Baseline (n = 12)	Intervention (n = 12)	Tau-U
On-Task Percentage	76.1%	83.9%	.95**	70.0%	78.1%	.92**

Note: *p < .05, **p < .01

Disruptive Behaviour

The mean number of disruptive behaviour occurrences per hour are presented in figure 5 and table 2.

Figure 5 shows that Group A baseline levels of disruptive behaviour displayed a high level of variability (M = 10.1). During the first intervention phase the levels of disruption stabilised with a slight increasing trend and a decrease in mean from the baseline (M = 8.7). The return to baseline conditions was associated with an initial decrease in disruptive behaviour and increased variability with a mean of 9.7 disruptive behaviour occurrences per hour. The reintroduction of the intervention resulted in an immediate decrease in disruptive behaviour (M = 7.3).

The Group B baseline levels of disruptive behaviour were also highly variable (M = 14.5). The introduction of the intervention did not reduce the variability but was associated with a sizeable reduction in disruptive behaviour (M = 10.2). Levels of disruption were more stable in the second baseline phase and returned to the initial baseline mean (M = 14.8). The reintroduction of the intervention resulted in an immediate decrease in disruptive behaviour with all but one session remaining below phase A2 levels (M = 9.8).

Table 2 shows that the mean frequency of disruptive behaviours decreased during the intervention condition for both groups. However, the intervention only resulted in a small non-significant decrease in disruptive behaviour in Group A (-.35, p = .15) but a significant moderate decrease in Group B (-.75, p < .01).

Figure 5

Mean Disruptive Behaviour Occurrences per Hour across Sessions for Groups A and B

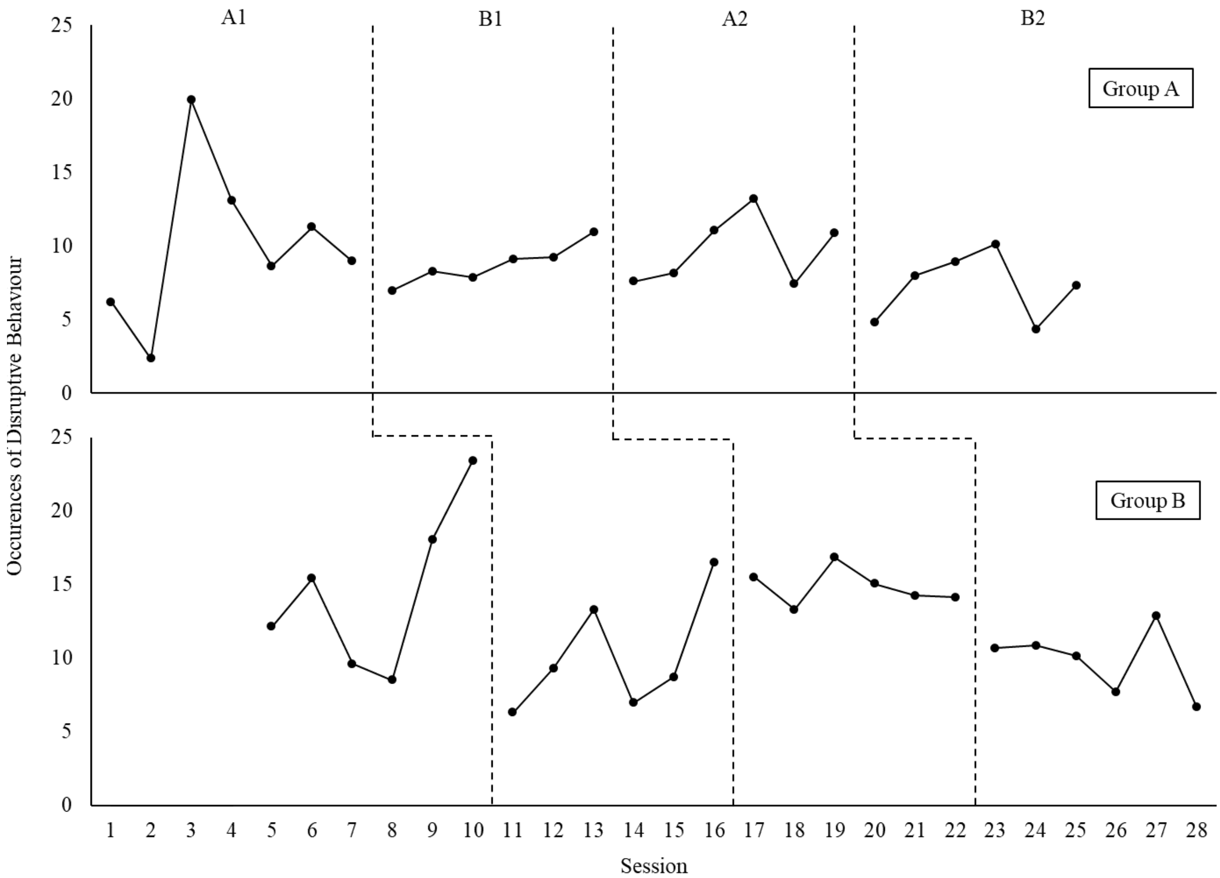


Table 2

Mean Disruptive Behaviour Occurrences per Hour across Conditions and Effect Sizes for Groups A and B

	Group A			Group B		
	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U
Disruptive Behaviours	9.9	8.0	-.35	14.7	10.0	-.75**

Out-of-Seat Behaviour

The mean percentage of intervals where students displayed out-of-seat behaviour are displayed in figure 6 and table 3.

Figure 6 shows that the Group A baseline levels of out-of-seat behaviour showed an increasing trend, except for session 6 (*M* = 3.24%). The first intervention phase showed moderate variability in out-of-seat behaviour and a noticeable decrease in levels of that behaviour from baseline (*M* = 1.40%). The return to baseline conditions was associated with an immediate increase in the level and variability of out-of-seat behaviour (*M* = 2.93%). The second intervention phase, with the exception of session 20, remained stable and well below baseline levels (*M* = 1.11%).

The Group B baseline levels of out-of-seat behaviour were reasonably stable with a slight increasing trend (*M* = 1.27%). The introduction of the intervention was associated with increased variability in out-of-seat behaviour but no clear change in mean from the baseline (*M* = 1.33%). The second baseline phase resulted in an immediate increase in out-of-seat behaviour and high variability across sessions (*M* = 1.82%). The reintroduction of the intervention was associated with moderate variability and a decrease in mean out-of-seat behaviour from A2 (*M* = 1.05%).

Table 3 shows that out-of-seat behaviour decreased during the intervention condition for both groups. The intervention resulted in a large significant decrease in out-of-seat behaviour in Group A (-.87, $p < .01$) and a small non-significant decrease in Group B (-.35, $p = .16$).

Figure 6

Mean Percentage of Intervals during which Students Displayed Out-of-Seat Behaviour across Sessions for Groups A and B

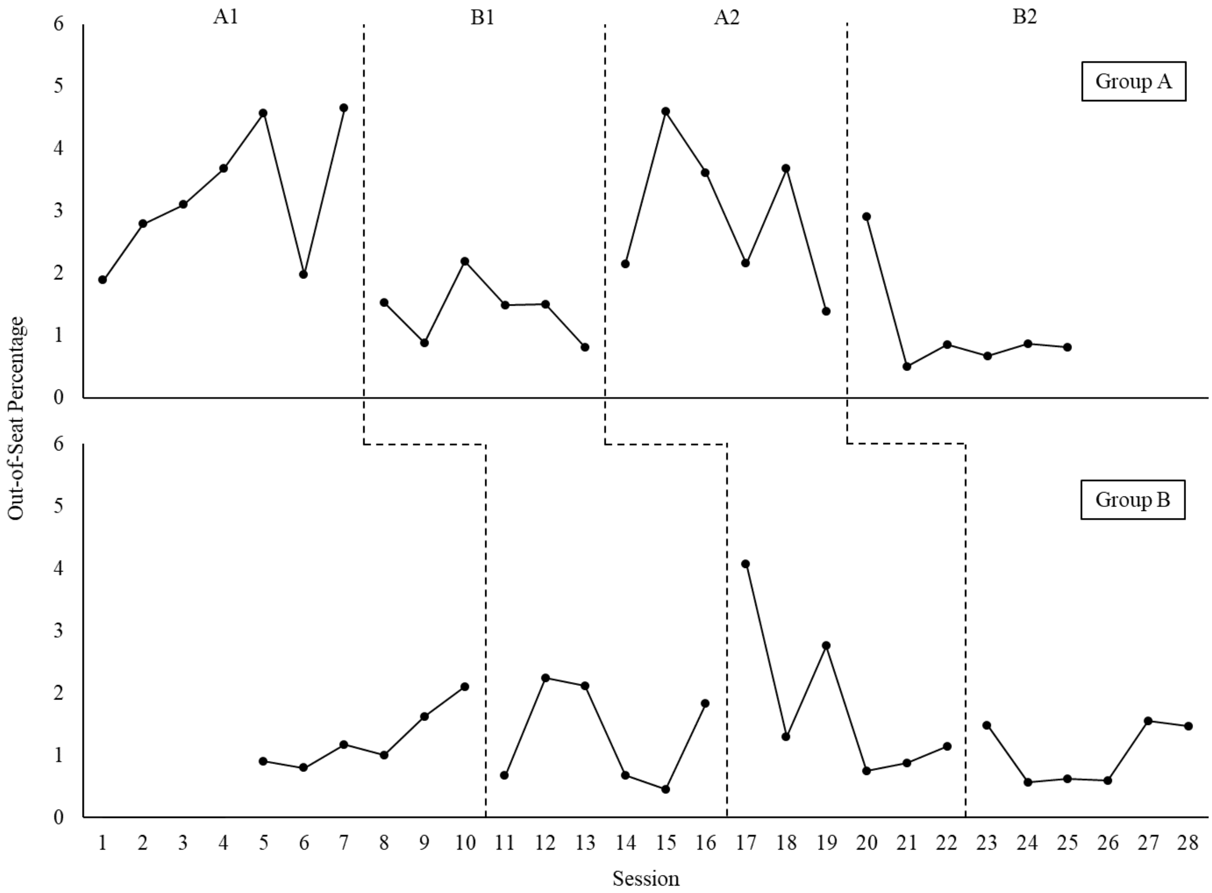


Table 3

Mean Percentage of Intervals during which Students Displayed Out-of-Seat Behaviour across Conditions and Effect Sizes for Groups A and B

	Group A			Group B		
	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U
Out-of-Seat Percentage	3.10%	1.26%	-.87**	1.54%	1.19%	-.35

Chair Tipping

The mean percentage of intervals during which chair tipping occurred for Groups A and B is presented in figure 7 and table 4.

Figure 7 shows that Group A baseline levels of chair tipping were highly variable (*M* = 2.53%). During the first intervention phase the behaviour stabilised with low levels of chair tipping and a decrease in mean from the baseline (*M* = 0.26%). The reinstatement of the baseline conditions was associated with an increase in variability and mean chair tipping levels (*M* = 1.17%). The second intervention phase was associated with moderate variability but a decrease in mean levels in chair tipping from A2 (*M* = 0.35%).

The Group B baseline levels of chair tipping displayed a slight increasing trend, apart from session 10 (*M* = 0.56%). The first intervention phase was associated with stable and low levels of chair tipping and a noticeable decrease in mean from the baseline (*M* = 0.15%). On returning to baseline conditions the variability and mean chair tipping levels increased (*M* = 1.02%). The reintroduction of the intervention resulted in an immediate drop in chair tipping which remained stable and at very low levels throughout the phase (*M* = 0.06%).

Table 4 shows that chair tipping decreased during the intervention condition for both groups. The intervention resulted in a moderate significant decrease in chair tipping for Group A (-.76, $p < .01$) and Group B (-.79, $p < .01$).

Figure 7

Mean Percentage of Intervals during which Students displayed Chair Tipping across Sessions for Groups A and B

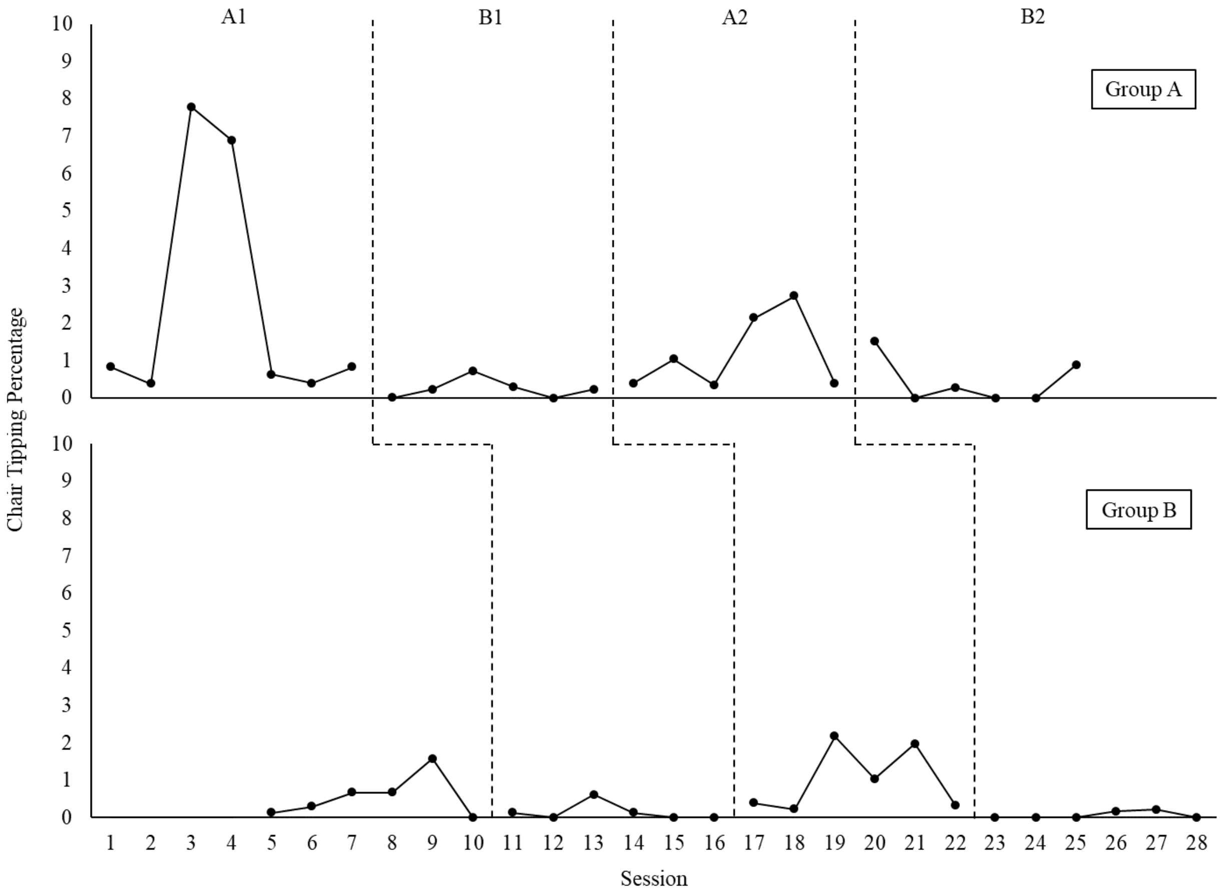


Table 4

Mean Percentage of Intervals during which Students displayed Chair Tipping across Conditions and Effect Sizes for Groups A and B

	Group A			Group B		
	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U	Baseline (*n* = 13)	Intervention (*n* = 12)	Tau-U
Chair Tipping Percentage	1.90%	0.35%	-.76**	0.79%	0.10%	-.79**

In-Chair Movement

Mean in-chair movement levels across conditions are presented in table 5. In-chair movement data was unavailable for sessions 4, 10, 17, and 22 for Group A, and sessions 7, 11, 22, and 23 for Group B, due to technological issues.

Table 5 shows that the mean in-chair movement levels increased during the intervention conditions for both groups with a small non-significant increase for Group A (.23, $p = .39$) and a significant moderate increase for Group B (.64, $p < .05$).

Table 5

Mean In-Chair Movement Levels across Conditions and Effect Sizes for Groups A and B

	Group A			Group B		
	Baseline (n = 11)	Intervention (n = 10)	Tau-U	Baseline (n = 10)	Intervention (n = 10)	Tau-U
Movement Index	337.1	347.6	.23	365.1	405.4	.64*

Overall Movement

Mean overall movement levels for Classes A and B are presented in Table 6. Overall movement data was unavailable for the first half of data collection with only data for phases A2 and B2 included.

Table 5 shows that the mean overall movement levels increased during the intervention conditions for both groups with a small non-significant increase for Class A (.20, $p = .30$) and a significant moderate increase for Class B (.84, $p < .05$).

Table 6

Mean Overall Movement Levels in the Classroom across Conditions and Effect Sizes for Classes A and B

	Class A			Class B		
	Baseline (n = 5)	Intervention (n = 5)	Tau-U	Baseline (n = 5)	Intervention (n = 5)	Tau-U
Turbidity Index	.045	.048	.20	.061	.075	.84*

Environmental Variables

Mean levels of environmental variables across conditions for Classes A and B are presented in table 8. Environmental data was unavailable for sessions 4, 10, 17, and 22 for Class A, and sessions 7, 11, 22, and 23 for Class B.

Table 8 shows that there were no significant differences between baseline and intervention levels for each of the environmental variables for both groups, indicating that they were not significant confounding variables in this study.

Table 8

Mean Classroom CO_2, Temperature, and Humidity Levels across Conditions and Effect Sizes for Classes A and B

	Class A			Class B		
	Baseline (n = 11)	Intervention (n = 10)	Tau-U	Baseline (n = 10)	Intervention (n=10)	Tau-U
CO_2	242 ppm	280 ppm	.26	281 ppm	263 ppm	-.32
Temperature	22.1 °C	21.1 °C	-.32	21.9 °C	22.0 °C	.08
Humidity	59.3%	56.0%	-.02	55.5%	56.3%	-.16

Social Validity Data

A total of 28 students completed the survey for Class A and 26 for Class B. Participant responses are presented in table 7.

Table 7 shows that 71.4% and 80.7% of students preferred the BodyfurnFlex chairs, for Classes A and B respectively, compared to 17.9% and 7.7% who preferred the regular chairs. For the students that preferred the BodyfurnFlex chairs, the most common reasons given were improved comfort and better flexibility in comparison to the regular chairs. Additional reasons included; they felt softer, reduced pain in comparison to the regular chairs, they were easier to stack, and nicer to look at. Students who preferred the regular chairs reported that they preferred inflexible chairs which they found to be more comfortable.

Over half (57.1% and 57.7% of students, for Classes A and B respectively), reported that they found it easier to complete their schoolwork when seated in BodyfurnFlex chairs compared to 10.7%

and 3.8% who found it easier in the regular chairs. Students who reported that the BodyfurnFlex chair made it easier to complete their schoolwork commented that they felt the improved comfort of the BodyfurnFlex chairs allowed them to better focus/concentrate on their work which helped them be more productive. Additionally, some students reported that the flexibility of the BodyfurnFlex chair enabled them to easily adjust their position which allowed them to find the appropriate position for the task they were doing. Students who felt the regular chairs made it easier to complete their schoolwork reported that they were more comfortable in the regular chair which allowed them to better focus on their work, while one student commented that they found the flexibility/movement of the BodyfurnFlex chair to be distracting.

Table 7

Participant Survey Responses for Classes A and B

		Which Chair Did You Prefer Sitting In?			Which Chair Did You Find It Easier to Complete Your Schoolwork In?		
Class	*n*	Regular	Bodyfurn	No Preference	Regular	Bodyfurn	No Difference
A	28	5 (17.9%)	20 (71.4%)	3 (10.7%)	3 (10.7%)	16 (57.1%)	9 (32.1%)
B	26	2 (7.7%)	21 (80.7%)	3 (11.5%)	1 (3.8%)	15 (57.7%)	10 (38.5%)

Discussion

The aim of the current study was to investigate the effect that BodyfurnFlex chairs had on the behaviour and movement of students in comparison to regular classroom chairs. The environmental conditions of the classroom were also measured as potential confounding variables. Additionally, social validity data was collected to assess students' preferences and if they felt the chairs made it easier to complete their schoolwork.

The results of this study demonstrated a clear functional relationship between the chairs and on-task behaviour, with the BodyfurnFlex chairs causing significant increases in on-task behaviour in comparison to the regular classroom chairs. This effect was replicated across two separate groups of students from different classrooms, age groups, time periods, school subjects, and brand of regular chairs. Furthermore, the results show that BodyfurnFlex chairs resulted in sizeable decreases in out-of-seat behaviour, which is an indicator of off-task behaviour (Austin & Soeda, 2008; Godwin et al., 2016). These findings provide strong evidence that dynamic chairs can significantly improve students' on-task behaviour in the classroom.

The study also found that the mean frequency of disruptive behaviours decreased when students used BodyfurnFlex chairs, although this effect was only statistically significant for Group B. Additionally, the results also suggest that BodyfurnFlex chairs resulted in sizeable decreases in out-of-seat behaviour and chair tipping, which are common types of disruptive behaviour (Axup & Gersch, 2008; Cogswell et al., 2020; Zuniga & Cividini-Motta, 2022; Infantino & Little, 2005). These results suggest that dynamic chairs could be an effective intervention for reducing classroom disruptions.

The results also revealed that both in-chair and overall movement in the classroom increased for both groups when students used BodyfurnFlex chairs; however, these increases were only statistically significant for Group B. These findings are consistent with other research that found dynamic chairs increased movement of occupants in comparison to traditional chairs (Garcia et al., 2016; Stanić et al., 2022), and that movement integration in classrooms resulted in improvements in student behaviour (Broad et al., 2023; McGowan et al., 2021; Wells, 2012). These results suggest that BodyfurnFlex chairs may be an effective intervention to increase student movement through active sitting while reducing unproductive/disruptive movements, such as chair tipping and out-of-seat behaviour.

The results of the participant survey revealed that most students not only preferred the BodyfurnFlex chairs in comparison to the regular chairs but also felt that they made it easier to complete their schoolwork. Participants reported that the comfort and flexibility of BodyfurnFlex chairs were the reasons for their responses. These findings are consistent with other studies that have found students prefer dynamic chairs and that they are more comfortable in comparison to traditional chairs (Garcia et al., 2016; Stanić et al., 2022). Considering that student engagement is positively associated with comfort (Aga, 2024) and better perceptions of the physical learning environment (Edgerton & McKechnie, 2023), these findings further indicate that dynamic chairs can improve students' engagement.

The environmental data revealed no significant differences between the baseline and intervention conditions for CO_2, temperature, and humidity levels, indicating that these variables were not confounding factors in this study. The recommended range for learning environments listed by the Ministry of Education is a CO_2 concentration below 800 ppm (parts per million), temperatures between 18-25 °C, and relative humidity between 35-70% (Ministry of Education, 2022). CO_2, temperature, and humidity levels remained well within the guidelines for learning recommended by the Ministry of Education, indicating they had a negligible effect on student learning in this study.

Implications of Research

The findings of the current study highlight the impact that chairs can have on student behaviour. Despite several studies showing that dynamic seating options such as stability balls can improve on-task behaviour and reduce some disruptive behaviours of specific populations (Fedewa & Erwin, 2011; Matin Sadr et al., 2017; Schilling, 2003; Schilling & Schwartz, 2004), there is a lack of research that compares the effect of dynamic and traditional chairs on students' behaviour (Rollo et al., 2019). This study fills an important gap in the literature and demonstrates that dynamic chairs can improve students' behaviour in the classroom.

Considering that on-task behaviour has a significant positive correlation with academic achievement (Lei et al., 2018; Wong et al., 2024) and disruptive behaviour has a significant negative correlation with the academic performance of not only students who display disruptive behaviour (Finn et al., 1995) but the entire classroom (Blank & Shavit, 2016), the findings of this study suggest that BodyfurnFlex chairs may be able to improve the academic achievement of students in comparison to regular classroom chairs. Given the importance of academic achievement reaches far beyond the classroom and is associated with improved well-being, quality of life, and positive societal effects (Edgerton et al., 2012; Machin et al., 2011; Woessmann, 2016), interventions that could potentially improve the academic outcomes of students are of great importance.

In addition to academic achievement, the behavioural variables in this study also have important social implications. Behavioural engagement has a significant positive correlation with the subjective well-being of students (Wong et al., 2024), while disruptive behaviours in the classroom are negatively associated with the well-being of teachers (Okeke et al., 2023) and can lead to teacher burnout (Bibou-Nakou et al., 1999; Otero-Lopez et al., 2009). In addition to being disruptive, chair tipping can also pose a serious safety concern as it is one of the most common causes of classroom injuries (Salminen et al., 2014; van Dyne, 2010). The results of this study suggest that BodyfurnFlex chairs may be able to improve the well-being of students and teachers, while also creating a safer learning environment.

Prolonged static postures are associated with musculoskeletal disorders (MSD) (De Sio et al., 2018; Dong et al., 2022), while musculoskeletal pain/discomfort has been shown to reduce with frequent postural changes (Akkarakittichoke et al., 2023; Waongenngarm et al., 2021) and increased in-chair movement (Arippa et al., 2022). Reducing static sitting postures and increasing movement and postural changes may be an effective intervention for preventing the development of MSDs (Dong et al., 2022; Putsa et al., 2022). The results of this study suggest that BodyfurnFlex chairs promote active sitting by increasing the in-chair movement of students while also reducing unproductive and disruptive movements, such as chair tipping and out-of-seat behaviour. Additionally, students also reported that the flexibility of the BodyfurnFlex chairs increased comfort and, in some cases, reduced pain. These findings suggest that BodyfurnFlex chairs reduced static sitting of students and could potentially be beneficial in the prevention of MSDs.

Limitations of Research

One limitation of the study was the sampling method. Purposive sampling was used to select a representative sample from the classroom and to minimise floor/ceiling effects. Although the selection criteria were created by the researchers, the participants were selected by the teachers, potentially introducing selection bias. Furthermore, while selecting middling/average students may have been beneficial for the study, it could affect the generalizability of the findings to the general population. Specifically, students with learning difficulties or behavioural problems may particularly benefit from BodyfurnFlex chairs.

There were several limitations related to the environmental and movement data. Connection issues with the smart classroom system meant that movement and environmental data was unavailable for several sessions. Additionally, in-chair movement data actually measured the movement of the chairs and not the students. While the movement of the chairs is a good indicator of student movement, it was not a direct measure of student movement. However, the inclusion of overall movement as a measure helped provide greater insight into the movement of students.

It is also important to acknowledge that a functional definition was used for recording disruptive behaviour. Behaviours were only recorded as disruptive if they actually caused another student to stop their on-task behaviour or the teacher to stop teaching. It is unclear whether the frequency of disruptive type behaviours decreased when students were seated in BodyfurnFlex chairs or if students were just less likely to be disrupted by another students' behaviour.

Only one specific design/brand of dynamic chair, the BodyfurnFlex chair, was assessed in this study. Although this study was able to show that BodyfurnFlex chairs could improve student behaviour, these findings should not be generalised to all types/designs of dynamic chairs.

Future Research

While the findings of this study have shown that BodyfurnFlex chairs could significantly improve student behaviours, it is important to investigate if these changes translate to real life socially significant outcomes. In particular, it would be good to know if BodyfurnFlex chairs improve the academic achievement of students in comparison to regular classroom chairs.

Conclusion

The current study provides important empirical evidence and fills a gap in the current literature about the effect that dynamic chairs have on learning in the classroom. The findings of this study indicate that BodyfurnFlex chairs could be an effective intervention for improving students' engagement and reducing disruption in the classroom.

References:

Aga, K. (2024). Comfort in active learning spaces–students' perceptions and preferences. *European Journal of Engineering Education,* 1-22. https://doi.org/10.1080/03043797.2024.2341756

Akkarakittichoke, N., Waongenngarm, P., & Janwantanakul, P. (2023). Effects of Postural Shifting Frequency on Perceived Musculoskeletal Discomfort During 1-Hour Sitting in Office Workers. *Journal of Manipulative and Physiological Therapeutics, 46*(2), 76-85. https://doi.org/10.1016/j.jmpt.2023.06.003

Antle, D. M., Cormier, L., Findlay, M., Miller, L. L., & Côté, J. N. (2018). Lower limb blood flow and mean arterial pressure during standing and seated work: Implications for workplace posture recommendations*. Preventive Medicine Reports, 10*, 117-122. https://doi.org/10.1016/j.pmedr.2018.02.016

Arippa, F., Nguyen, A., Pau, M., & Harris-Adamson, C. (2022). Postural strategies among office workers during a prolonged sitting bout. *Applied Ergonomics, 102*, 103723. https://doi.org/10.1016/j.apergo.2022.103723

Austin, J. L., & Soeda, J. M. (2008). Fixed-time teacher attention to decrease off-task behaviors of typically developing third graders. *Journal of Applied Behavior Analysis, 41*(2), 279-283. https://doi.org/10.1901/jaba.2008.41-279

Axup, T., & Gersch, I. (2008). Challenging behaviour: the impact of challenging student behaviour upon teachers' lives in a secondary school: teachers' perceptions. *British Journal of Special Education*, *35*(3), 144-151. https://doi.org/10.1111/j.1467-8578.2008.00388.x

Becherer, J., Köller, O., & Zimmermann, F. (2021). Externalizing behaviour, task-focused behaviour, and academic achievement: An indirect relation?. *British Journal of Educational Psychology, 91*(1), 27-45. https://doi.org/10.1111/bjep.12347

Bibou-Nakou, I., Stogiannidou, A., & Kiosseoglou, G. (1999). The relation between teacher burnout and teachers' attributions and practices regarding school behaviour problems. *School Psychology International, 20*(2), 209-217. https://doi.org/10.1177/0143034399020002004

Blank, C., & Shavit, Y. (2016). The Association Between Student Reports of Classmates' Disruptive Behavior and Student Achievement. *AERA Open*, *2*(3), 233285841665392. https://doi.org/10.1177/2332858416653921

Brink, H. W., Loomans, M. G., Mobach, M. P., & Kort, H. S. (2021). Classrooms' indoor environmental conditions affecting the academic achievement of students and teachers in higher education: A systematic literature review. *Indoor Air, 31*(2), 405-425. https://doi.org/10.1111/ina.12745

Broad, A. A., Bornath, D. P., Grisebach, D., McCarthy, S. F., Bryden, P. J., Robertson-Wilson, J., & Hazell, T. J. (2023). Classroom activity breaks improve on-task behavior and physical activity levels regardless of time of day. *Research Quarterly for Exercise and Sport, 94*(2), 331-343. https://doi.org/10.1080/02701367.2021.1980189

Cardenas, A., Albert, W., Leger, M., Dion, C., & Cardoso, M. (2024). Effects of implementing an active sitting protocol compared to using a traditional office chair and standing workstation. *International Journal of Industrial Ergonomics, 101*, 103587. https://doi.org/10.1016/j.ergon.2024.103587

Cardon, G., De Clercq, D., De Bourdeaudhuij, I., & Breithecker, D. (2004). Sitting habits in elementary schoolchildren: a traditional versus a "Moving school". *Patient Education and Counseling*, *54*(2), 133-142. https://doi.org/10.1016/S0738-3991(03)00215-5

Caromano, F. A., de Amorim, C. A. P., de Fátima Rebelo, C., Contesini, A. M., Fávero, F. M., Frutuoso, J. R. C., Kawai, M. M., & Voos, M. C. (2015). Prolonged sitting and physical discomfort in university students. *Acta Physiatrica, 22*(4), 176-180.. https://doi.org/10.5935/0104-7795.20150034

Carriere, J. S., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology, 67*(1), 19. https://doi.org/10.1037/a0031438

Carton, Q., De Coninck, S., Kolarik, J., & Breesch, H. (2023). Assessing the effect of a classroom IEQ on student satisfaction, engagement and performance. *E3S Web of Conferences 396*, 01052. https://doi.org/10.1051/e3sconf/202339601052

Camahalan F. M. G., & Ipock A. R. (2015). Physical activity breaks and student learning: A teacher-research project. *Education, 135*(3), 291–298. https://go.gale.com/ps/i.do?p=AONE&u=anon~3a4dbb5a&id=GALE%7CA406162560&v=2.1&it=r&sid=googleScholar&asid=dc7ebadc

Castellucci, H. I., Arezes, P. M., Molenbroek, J. F. M., de Bruin, R., & Viviani, C. (2017). The influence of school furniture on students' performance and physical responses: results of a systematic review. *Ergonomics*, *60*(1), 93-110. https://doi.org/10.1080/00140139.2016.1170889

Cogswell, S., Carr, A., Abbott, N., & Monks, C. P. (2020). The development and validation of a teacher-reported low-level classroom disruption scale (LLCD-S). *Emotional and Behavioural Difficulties, 25*(3-4), 230-243. https://doi.org/10.1080/13632752.2020.1816651

Coley, D. A., Greeves, R., & Saxby, B. K. (2007). The effect of low ventilation rates on the cognitive function of a primary school class. *International Journal of Ventilation, 6*(2), 107-112. https://doi.org/10.1080/14733315.2007.11683770

De Sio, S., Traversini, V., Rinaldo, F., Colasanti, V., Buomprisco, G., Perri, R., Mormone, F., La Torre. G., & Guerra, F. (2018). Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella review. *PeerJ, 6*, e4154. https://doi.org/10.7717/peerj.4154

Dong, Y., Jiang, P., Jin, X., Jiang, N., Huang, W., Peng, Y., Shen, Y., He, I., Forsman, M., & Yang, L. (2022). Association between long-term static postures exposure and musculoskeletal disorders among university employees: A viewpoint of inflammatory pathways. *Frontiers in Public Health, 10*, 1055374. https://doi.org/10.3389/fpubh.2022.1055374

Edgerton, E., & McKechnie, J. (2023). The relationship between student's perceptions of their school environment and academic achievement. *Frontiers in Psychology, 13*, 959259. https://doi.org/10.3389/fpsyg.2022.959259

Edgerton, J. D., Roberts, L. W., & von Below, S. (2012). Education and Quality of Life. In K. C. Land, A. C. Michalos, & M. J. Sirgy (Eds.), *Handbook of Social Indicators and Quality of Life Research* (pp. 265-296). Springer Netherlands. https://doi.org/10.1007/978-94-007-2421-1_12

Farley, J., Risko, E., & Kingstone, A. (2013). Everyday Attention and Lecture Retention: The Effects of Time, Fidgeting, and Mind Wandering. *Frontiers in Psychology, 4,* 619. https://doi.org/10.3389/fpsyg.2013.00619

Fedewa, A., Davis, M. A., & Ahn, S. (2015). Effects of stability balls on children's on-task behavior, academic achievement, and discipline referrals: A randomized controlled trial. *The American Journal of Occupational Therapy, 69*(2), 6902220020p1-6902220020p9. https://doi.org/10.5014/ajot.2015.014829

Fedewa, A. L., & Erwin, H. E. (2011). Stability balls and students with attention and hyperactivity concerns: Implications for on-task and in-seat behavior. *The American Journal of Occupational Therapy*, *65*(4), 393-399. https://doi.org/10.5014/ajot.2011.000554

Furnware. (n.d.). BodyfurnFlex Sled Chair. https://www.furnware.com/en-nz/products/bodyfurn-flex/bodyfurn-flex-sled-chair

Finn, J. D., Pannozzo, G. M., & Voelkl, K. E. (1995). Disruptive and Inattentive-Withdrawn Behavior and Achievement among Fourth Graders. *The Elementary School Journal, 95*(5), 421-434. https://doi.org/10.1086/461853

Frey, M., Barrett, M., & De Carvalho, D. (2021). Effect of a dynamic seat pan design on spine biomechanics, calf circumference and perceived pain during prolonged sitting. *Applied Ergonomics, 97*, 103546. https://doi.org/10.1016/j.apergo.2021.103546

Garcia, J. M., Huang, T. T., Trowbridge, M., Weltman, A., & Sirard, J. R. (2016). Comparison of the effects of stable and dynamic furniture on physical activity and learning in children. *The Journal of Primary Prevention, 37*, 555-560. https://doi.org/10.1007/s10935-016-0451-6

Godwin, K. E., Almeda, M. V., Seltman, H., Kai, S., Skerbetz, M. D., Baker, R. S., & Fisher, A. V. (2016). Off-task behavior in elementary school children. *Learning and Instruction, 44*, 128-143. https://doi.org/10.1016/j.learninstruc.2016.04.003

Groenewald, C. B., Tham, S. W., & Palermo, T. M. (2020). Impaired school functioning in children with chronic pain: a national perspective. *The Clinical Journal of Pain, 36*(9), 693-699. https://doi.org/10.1097/AJP.0000000000000850

Hahn, R. A., & Chattopadhyay, S. K. (2019). Linking studies to assess the life expectancy associated with eighth grade school achievement. *Preventive Medicine Reports*, *16*, 100980. https://doi.org/https://doi.org/10.1016/j.pmedr.2019.100980

Hulac, D. M., Mickelson, L. R., Briesch, A. M., Maroeca, H., Hartjes, C., Anderson, K., & Ederveen, K. (2020). Stability balls and student on-task behavior. *Journal of Behavioral Education*, 1-18. https://doi.org/10.1007/s10864-020-09412-3

Huntington, R. N., Badgett, N. M., Rosenberg, N. E., Greeny, K., Bravo, A., Bristol, R. M., Byun, Y. H., & Park, M. S. (2023). Social validity in behavioral research: A selective review. *Perspectives on Behavior Science, 46*(1), 201-215. https://doi.org/10.1007/s40614-022-00364-9

Imms, W., & Byers, T. (2017). Impact of classroom design on teacher pedagogy and student engagement and performance in mathematics. *Learning Environments Research, 20*, 139-152. https://doi.org/10.1007/s10984-016-9210-0

Imms, W., Morris, J., & Grunseit, D. (2020). Innovative Furniture and Student Engagement. In M. Peters, & R. Heraud (Eds). *Encyclopedia of Educational Innovation* (pp 1-5). Springer. https://doi.org/10.1007/978-981-13-2262-4_194-1

Infantino, J., & Little, E. (2005). Students' perceptions of classroom behaviour problems and the effectiveness of different disciplinary methods. *Educational Psychology*, *25*(5), 491-508. https://doi.org/10.1080/01443410500046549

Knight, G., & Noyes, J. A. N. (1999). Children's behaviour and the design of school furniture. *Ergonomics, 42*(5), 747-760. https://doi.org/10.1080/001401399185423

Kremer, K. P., Flower, A., Huang, J., & Vaughn, M. G. (2016). Behavior problems and children's academic achievement: A test of growth-curve models with gender and racial differences. *Children and Youth Services Review, 67*, 95-104. https://doi.org/10.1016/j.childyouth.2016.06.003

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal, 46(*3), 517-528. https://doi.org/10.2224/sbp.7054

Lettau, J. (2021). The Impact of Children's Academic Competencies and School Grades on their Life Satisfaction: What Really Matters? *Child Indicators Research*, *14*(6), 2171-2195. https://doi.org/https://doi.org/10.1007/s12187-021-09830-3

Liu, J., Peng, P., Zhao, B., & Luo, L. (2022). Socioeconomic status and academic achievement in primary and secondary education: A meta-analytic review. *Educational Psychology Review, 34*(4), 2867-2896. https://doi.org/10.1007/s10648-022-09689-y

López-López, J. A., Kwong, A. S. F., Washbrook, L., Tilling, K., Fazel, M. S., & Pearson, R. M. (2021). Depressive symptoms and academic achievement in UK adolescents: a cross-lagged analysis with genetic covariates. *Journal of Affective Disorders*, *284*, 104-113. https://doi.org/https://doi.org/10.1016/j.jad.2021.01.091

López-Martín, E., Gutiérrez-de-Rozas, B., González-Benito, A. M., & Expósito-Casas, E. (2023). Why do teachers matter? A meta-analytic review of how teacher characteristics and competencies affect students' academic achievement. *International Journal of Educational Research, 120*, 102199. https://doi.org/10.1016/j.ijer.2023.102199

Lozano-Blasco, R., Quílez-Robres, A., Usán, P., Salavera, C., & Casanovas-López, R. (2022). Types of intelligence and academic performance: A systematic review and meta-analysis. *Journal of Intelligence, 10*(4), 123. https://doi.org/10.3390/jintelligence10040123

Machin, S., Marie, O., & Vujić, S. (2011). The crime reducing effect of education. *The Economic Journal*, *121*(552), 463-484. https://doi.org/https://doi.org/10.1111/j.1468-0297.2011.02430.x

Mammadov, S. (2022). Big Five personality traits and academic performance: A meta-analysis. *Journal of personality, 90*(2), 222-255. https://doi.org/10.1111/jopy.12663

Matin Sadr, N., Haghgoo, H. A., Samadi, S. A., Rassafiani, M., Bakhshi, E., & Hassanabadi, H. (2017). The Impact of Dynamic Seating on Classroom Behavior of Students with Autism Spectrum Disorder. *Iranian Journal of Child Neurology, 11*(1), 29-36. https://doi.org/10.22037/ijcn.v11i1.11193

McGowan, A. L., Gerde, H. K., Pfeiffer, K. A., & Pontifex, M. B. (2021). Physically active learning in preschoolers: Improved self-regulation, comparable quantity estimation. *Trends in Neuroscience and Education, 22*, 100150. https://doi.org/10.1016/j.tine.2021.100150

Metsäpelto, R.-L., Zimmermann, F., Pakarinen, E., Poikkeus, A.-M., & Lerkkanen, M.-K. (2020). School grades as predictors of self-esteem and changes in internalizing problems: A longitudinal study from fourth through seventh grade. *Learning and Individual Differences*, *77*, 101807. https://doi.org/https://doi.org/10.1016/j.lindif.2019.101807

Ministry of Education (2022). *Designing Quality Learning Spaces (DQLS) Indoor Air Quality and Thermal Comfort*. https://web-assets.education.govt.nz/s3fs-public/2024-10/Indoor-Air-Quality-and-Thermal-Comfort-V2-v2.0-2022.pdf?VersionId=FWYjUT5Ej_GCPwenx3OqguCG8.phJHEy

Morishima, T., Restaino, R. M., Walsh, L. K., Kanaley, J. A., Fadel, P. J., & Padilla, J. (2016). Prolonged sitting-induced leg endothelial dysfunction is prevented by fidgeting. *American Journal of*

Physiology. Heart and Circulatory Physiology, 311(1), H177-H182. https://doi.org/10.1152/ajpheart.00297.2016

Morris, J. E., & Imms, W. (2023). What Are Innovative Learning Environments and How Can You Explore What Environments Have Impact?. In J. E. Morris, & W. Imms (Eds), *Teachers as Researchers in Innovative Learning Environments* (pp. 1-10). Springer, Singapore. https://doi.org/10.1007/978-981-99-7367-5_1

Nordic Semiconductor. (n.d.). Nordic Thingy:52. https://www.nordicsemi.com/Products/Development-hardware/Nordic-Thingy:52

Okeke, C., Thomas, A., & Botha, A. (2023). The impact of learners' disruptive behaviour on teachers' well-being: a qualitative approach. *International Journal of Research in Business and Social Science, 12*(8), 504-511. https://doi.org/10.20525/ijrbs.v12i8.2917

Otero-López, J. M., Castro, C., Villardefrancos, E., & Santiago, M. J. (2009). Job dissatisfaction and burnout in secondary school teachers: Students' disruptive behaviour and conflict management examined. *European Journal of Education and Psychology, 2*(2), 99–111. https://doi.org/10.30552/ejep.v2i2.25

Perrykkad, K., & Hohwy, J. (2020). Fidgeting as self-evidencing: A predictive processing account of non-goal-directed action. *New Ideas in Psychology, 56*, 100750. https://doi.org/10.1016/j.newideapsych.2019.100750

Pettit-Mee, R. J., Ready, S. T., Padilla, J., & Kanaley, J. A. (2021). Leg Fidgeting During Prolonged Sitting Improves Postprandial Glycemic Control in People with Obesity. *Obesity, 29*(7), 1146-1154. https://doi.org/10.1002/oby.23173

Pulay, A., & Williamson, A. (2019). A case study comparing the influence of LED and fluorescent lighting on early childhood student engagement in a classroom setting. *Learning Environments Research, 22*(1), 13-24. https://doi.org/10.1007/s10984-018-9263-3

Putsa, B., Jalayondeja, W., Mekhora, K., Bhuanantanondh, P., & Jalayondeja, C. (2022). Factors associated with reduced risk of musculoskeletal disorders among office workers: a cross-sectional study 2017 to 2020. *BMC Public Health, 22*(1), 1503. https://doi.org/10.1186/s12889-022-13940-0

Raghupathi, V., & Raghupathi, W. (2020). The influence of education on health: An empirical assessment of OECD countries for the period 1995–2015. *Archives of Public Health*, *78*(1), 1-18. https://doi.org/https://doi.org/10.1186/s13690-020-00402-5

Randall, E. T., Shapiro, J. B., Smith, K. R., Jervis, K. N., & Logan, D. E. (2019). Under pressure to perform: Impact of academic goal orientation, school motivational climate, and school engagement on pain and somatic symptoms in adolescents. *The Clinical Journal of Pain, 35*(12), 967-974. https://doi.org/10.1097/AJP.0000000000000765

Raspberry Pi. (n.d.). Raspberry Pi Camera Module 3. https://www.raspberrypi.com/products/camera-module-3/

Rollo, S., Crutchlow, L., Nagpal, T. S., Sui, W., & Prapavessis, H. (2019). The effects of classroom-based dynamic seating interventions on academic outcomes in youth: A systematic review. *Learning Environments Research, 22*(2), 153-171. https://doi.org/10.1007/s10984-018-9271-3

Salminen, S., Kurenniemi, M., Råback, M., Markkula, J., & Lounamaa, A. (2014). School environment and school injuries. *Frontiers in Public Health, 1*, 76. https://doi.org/10.3389/fpubh.2013.00076

Schilling, D. L., & Schwartz, I. S. (2004). Alternative seating for young children with autism spectrum disorder: Effects on classroom behavior*. Journal of Autism and Developmental Disorders, 34*(4), 423-432. https://doi.org/10.1023/B:JADD.0000037418.48587.f4

Schilling, D. L., Washington, K., Billingsley, F. F., & Deitz, J. (2003). Classroom seating for children with attention deficit hyperactivity disorder: Therapy balls versus chairs*. The American Journal of Occupational Therapy, 57*(5), 534-541. https://doi.org/10.5014/ajot.57.5.534

See, C. (2012). The use of music and movement therapy to modify behaviour of children with autism. *Pertanika Journal of Social Sciences & Humanities, 20*(4), 1103-1116.

http://psasir.upm.edu.my/id/eprint/57742/1/JSSH%20Vol.%2020%20%284%29%20Dec.%202012%20%28View%20Full%20Journal%29.pdf#page=167

Spencer-Mueller, E. K., & Fenske, M. J. (2024). Note-taking for the win: Doodling does not reduce boredom or mind-wandering, nor enhance attention or retention of lecture material. *Quarterly Journal of Experimental Psychology, 77*(8), 1780-1796. https://doi.org/10.1177/17470218231222402

Stanić, V., Žnidarič, T., Repovš, G., & Geršak, G. (2022). Dynamic Seat Assessment for Enabled Restlessness of Children with Learning Difficulties. *Sensors, 22*(9), 3170. https://doi.org/10.3390/s22093170

Stranden, E. (2000). Dynamic leg volume changes when sitting in a locked and free floating tilt oé ce chair. *Ergonomics, 43*(3), 421-433. https://doi.org/10.1080/001401300184503

Swartz, A. M., Tokarek, N. R., Strath, S. J., Lisdahl, K. M., & Cho, C. C. (2020). Attentiveness and fidgeting while using a stand-biased desk in elementary school children. *International Journal of Environmental Research and Public Health, 17*(11), 3976. https://doi.org/10.3390/ijerph17113976

Taylor, F. C., Pinto, A. J., Maniar, N., Dunstan, D. W., & Green, D. J. (2022). The Acute Effects of Prolonged Uninterrupted Sitting on Vascular Function: A Systematic Review and Meta-analysis. *Medicine and Science in Sports and Exercise, 54*(1), 67-76. https://doi.org/10.1249/MSS.0000000000002763

Triglav, J., Howe, E., Cheema, J., Dube, B., Fenske, M. J., Strzalkowski, N., & Bent, L. (2019). Physiological and cognitive measures during prolonged sitting: Comparisons between a standard and multi-axial office chair. *Applied Ergonomics, 78*, 176-183. https://doi.org/10.1016/j.apergo.2019.03.002

Udo, H., Fujimura, M., & Yoshinaga, F. (1999). The effect of a tilting seat on back, lower back and legs during sitting work. *Industrial Health, 37*(4), 369-381. https://doi.org/10.2486/indhealth.37.369

van Dyne, P. R. (2010). School District Injuries, Injury Rates and Loss Source Controls. *In ASSE Professional Development Conference and Exposition.* . https://onepetro.org/ASSPPDCE/proceedings-abstract/ASSE10/All-ASSE10/76762

Velcro. (n.d.). VELCRO® Brand Stick On Hook & Loop Dots. https://www.velcro.com.au/products/adhesive-backed/velcro-brand-dots/

Wannarka, R., & Ruhl, K. (2008). Seating arrangements that promote positive academic and behavioural outcomes: A review of empirical research. *Support for Learning, 23*(2), 89-93. https://doi.org/10.1111/j.1467-9604.2008.00375.x

Waongenngarm, P., Rajaratnam, B. S., & Janwantanakul, P. (2015). Perceived body discomfort and trunk muscle activity in three prolonged sitting postures. *Journal of Physical Therapy Science, 27*(7), 2183-2187. https://doi.org/10.1589/jpts.27.2183

Waongenngarm, P., van der Beek, A. J., Akkarakittichoke, N., & Janwantanakul, P. (2021). Effects of an active break and postural shift intervention on preventing neck and low-back pain among high-risk office workers: a 3-arm cluster-randomized controlled trial. *Scandinavian Journal of Work, Environment & Health, 47*(4), 306. https://doi.org/10.5271/sjweh.3949

Webster, C. A., Russ, L., Vazou, S., Goh, T. L., & Erwin, H. (2015). Integrating movement in academic classrooms: understanding, applying and advancing the knowledge base. *Obesity Reviews, 16*(8), 691-701. https://doi.org/10.1111/obr.12285

Wells, S. L. (2012). Moving through the curriculum: The effect of movement on student learning, behavior, and attitude. *Rising Tide, 5*, 1-17. http://mat2012wells.pbworks.com/w/file/fetch/54431635/Wells,%20MRP.pdf

Woessmann, L. (2016). The economic case for education. *Education Economics*, *24*(1), 3-32. https://doi.org/https://doi.org/10.1080/09645292.2015.1059801

Wong, Z. Y., Liem, G. A. D., Chan, M., & Datu, J. A. D. (2024). Student engagement and its association with academic achievement and subjective well-being: A systematic review and meta-analysis. *Journal of Educational Psychology, 116*(1), 48–75. https://doi.org/10.1037/edu0000833

Zemp, R., Fliesser, M., Wippert, P. M., Taylor, W. R., & Lorenzetti, S. (2016). Occupational sitting behaviour and its relationship with back pain–A pilot study. *Applied Ergonomics, 56*, 84-91. https://doi.org/10.1016/j.apergo.2016.03.007

Zuniga, A. N., & Cividini-Motta, C. (2022). Using Class Pass Intervention to Decrease Disruptive Behavior in Young Children. *Journal of Behavioral Education*, *31*(3), 524-542. https://doi.org/10.1007/s10864-020-09411-4

Chapter 4: Study 2

Active Sitting as an Intervention: The Effect of Movement on Student Behaviour

Study 2: Active Sitting as an Intervention: The Effect of Movement on Student Behaviour is formatted as a journal article and is presented as a standalone piece of work. Data for Study 2 was collected at the same time as Study 1.

Introduction

Integrating movement into the classroom using movement breaks has been shown to significantly improve on-task behaviour (Broad et al., 2022; Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011) and decrease disruptive behaviours (Camahalan & Ipock, 2015; McGowan et al., 2021; Moon et al., 2020; Wells, 2012). Although effective at improving student behaviour, movement breaks require a break in the lesson (stopping valuable learning time) and training for teachers on how/when to implement the breaks (Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011). A potential way to integrate movement into the classroom without requiring a break in the lesson or teacher training is through active sitting. Dynamic chairs, which are designed to promote active sitting, have been shown to significantly increase in-chair movement in comparison to static (non-dynamic) chairs (Garcia et al., 2016; Grooten et al., 2017; Nüesch et al., 2018; Stanić et al., 2022; Tanoue et al., 2016), suggesting that they could have a positive effect on student behaviour. However, there is currently a lack of research into the relationship between in-chair movement and student behaviour. The large out-of-seat macro-movements associated with movement breaks (e.g., jumping jacks) are not directly comparable to the smaller in-chair micro-movements associated with active sitting. Hence, there is a need to investigate whether in-chair movement can improve the behaviour of students.

Another key factor that may influence students’ behaviour and requires further investigation is the environmental conditions within the classroom. Despite extensive research demonstrating the significant effects of carbon dioxide (CO_2), temperature, humidity, and noise on students' attention, cognitive function, and performance (Aydin & Goktas, 2023; Cho, 2017; Haverinen-Shaughnessy & Shaughnessy, 2015; Fernandes et al., 2019; Shield & Dockrell, 2008; Woo et al., 2022), there is limited research into how these environmental variables relate to on-task and disruptive behaviours. Moreover, while noise can be environmental (e.g., air conditioning, electrical noise, traffic, weather), it can also be behavioural (e.g., students talking or making noise). Behavioural noise in the classroom is often typically viewed as a sign of off-task (Chapman et al., 2023; Ludyga et al., 2021) and disruptive behaviour (Douglas et al., 2016; Olota, 2022), suggesting that BodyfurnFlex may also be able to reduce classroom noise levels.

In an effort to address these issues, Resero (Resero, n.d.), a New Zealand-based innovative furniture company, partnered with Callaghan Innovation (Callaghan Innovation, n.d.), a government agency that supports New Zealand businesses through R&D support and funding, to develop the Smart Classroom System. The Smart Classroom System is a network of sensors that monitor various environmental variables and types of movement in the classroom, designed to achieve two primary goals. First, to examine how different types of chairs influence student movement and behaviour. Second, to evaluate the environmental conditions in the classroom and their impact on student movement and behaviour. Additionally, apart from serving as a research instrument, the Smart Classroom System was developed as a potential evaluation and assessment tool to gauge classroom quality and provide feedback on learning environments. There is a need for tools that can accurately assess environmental conditions in classrooms to ensure students have suitable learning spaces. Although the Ministry of Education has strict guidelines on environmental conditions in learning spaces (Ministry of Education, 2022), research shows that many New Zealand classrooms fail meet the required standards for learning (Building Research Association of New Zealand, 2019a, 2019b).

The aim of the current study was to utilise the Smart Classroom System to investigate the effect that BodyfurnFlex chairs had on student movement in comparison to regular classroom chairs, and how this movement was related to their behaviour (on-task, disruptive, out-of-seat, and chair-tipping behaviour). Two types of movement were recorded: in-chair motion (which included movement, acceleration, and rotation) and overall movement in the classroom. Additionally, we examined whether BodyfurnFlex chairs affect noise levels in the classroom. The Smart Classroom System was also used to monitor the environmental conditions (CO_2, temperature, and humidity) in the classroom and to explore potential associations between these variables and students' movement and behaviour.

Methods

Participants

Data was collected from two separate classrooms (Class A and Class B). Class A was an intermediate school maths class with a total of 31 students, aged 11-13 years. Class B was a secondary school English class of 29 students, aged 13-14 years. Overall movement, noise, and environmental data were collected for the entire classroom. In contrast, in-chair motion data (including movement, acceleration, and rotation) were collected for 10 students (the same 10 students from Study 1) in each of the two classrooms (Groups A and B). In-chair motion data was only collected for 10 students because it is the current limit of the Smart Classroom System, and so it could be correlated with the behavioural data from Study 1.

Materials

Chairs

Two types of chairs were used in the study: the regular classroom chairs and BodyfurnFlex chairs (as described in Study 1).

Smart Classroom System

The Smart Classroom system includes: 20 Nordic Thingy:52 sensors, two Raspberry Pi cameras and tripods, a laptop with the Smart Classroom Application (software), and a modem.

The Nordic Thingy:52 (Nordic Semiconductor, n.d.) is a compact, multi-sensor device designed to measure various movement and environmental variables. It features several sensors that monitor CO_2 levels, temperature, humidity, and sound. Additionally, it contains motion sensors: an accelerometer that detects changes in velocity (i.e., acceleration), a gyroscope that measures changes in orientation (i.e., rotation), and a magnetometer that tracks changes in direction. Each of these sensors detects motion along three axes: the x-axis (horizontal or left/right), the y-axis (vertical or up/down), and the z-axis (depth or forward/back). Collectively, these three sensors enable nine-axis motion sensing (three types of motion across three axes), providing a comprehensive measurement of the Thingy:52's movement. The sensors wirelessly connect to the laptop via Bluetooth.

The Raspberry Pi (Raspberry Pi, n.d.-b) is a single-board computer (a small computer built on a single circuit board), designed to be low-cost and versatile. The Raspberry Pis utilised in the Smart Classroom System were adapted to act as motion sensors by using the Raspberry Pi camera module (Raspberry Pi, n.d.-a). This add-on enables the Raspberry Pi to function as a camera. The Raspberry Pi cameras capture black-and-white video footage, which is then used to detect motion through a method called frame differencing. Frame differencing is a computer vision technique that identifies motion in video footage by comparing pixel changes between frames. Larger pixel changes from one frame to the next indicate greater movement or motion in the video. For example, a video of a person walking across the screen will cause significant pixel changes between frames, whereas a still image will produce minimal pixel changes. The Raspberry Pi cameras connect wirelessly to the laptop via the modem (i.e., the cameras connect to the modem, which in turn connects to the laptop), allowing movement data to be transmitted directly to the laptop.

The Smart Classroom App was developed by engineers at Callaghan Innovation using Python (a programming language). The app is used to control the sensors remotely (i.e., start/stop recording), with data sent directly from the sensors to the app. The data is stored and organised into sessions, with each recording from start to stop considered one session. Users can download session data directly from the app in Excel spreadsheets, which include a complete list of every measurement and recording for each variable. Each measurement is timestamped, allowing users to select relevant data and exclude unrelated data (e.g., from specific time frames). The Thingy:52 sensors measure every 1,000 milliseconds (ms), while the Raspberry Pi cameras record every 500 ms. All variables recorded by the Thingy:52 sensors were converted to the group mean (i.e., the average value of all 20 sensors), while the Raspberry Pi motion data was averaged across both Raspberry Pi cameras. Prior to data collection, all sensors were calibrated by the engineers and developers to ensure accurate measurements.

Procedure

Design

A multiple baseline with ABAB reversal design was used in this study, alternating between baseline (regular chairs) and intervention (BodyfurnFlex chairs) conditions. Phase changes were made after several sessions of stable on-task behaviour (collected in Study 1) had been established.

Dependent Variables

The dependent variables in this study were in-chair movement, in-chair acceleration, in-chair rotation, overall movement in the classroom, noise levels, CO_2 concentration, temperature, and humidity.

In-chair movement was calculated using nine-axis motion data and converted into a movement index that indicates the size or magnitude of movement (i.e., displacement). This movement index is a ratio variable (i.e., an index of 0 indicates no movement, and an index of 2 signifies twice the movement of an index of 1). Like other ratio variables (e.g., weight, height, speed), there is no upper limit to this measure.

In-chair acceleration was calculated using the three-axis acceleration data and converted to an acceleration index that represents the change in velocity (i.e., acceleration). Likewise, in-chair rotation was calculated using the three-axis rotation data and converted to a rotation index that represents the change in orientation (i.e., rotation). Both the acceleration and rotation indexes are also ratio variables.

Overall movement in the classroom was converted into a turbidity index, which represents the proportion of pixel changes from one video frame to the next, with a value of 0 indicating no pixel changes and a value of 1 indicating every single pixel changed.

Noise data was transformed into a sound index representing the noise level in the classroom. This was necessary because the standard measurement unit for noise or sound, decibels (dB), uses a logarithmic rather than a linear scale (i.e., each unit indicates a multiplicative increase, not an additive one). This means that 100 dB is not twice as loud as 50 dB, but rather sound ‘doubles’ every

10 dB increase (for example, 60 dB is twice as loud as 50 dB). This can make calculating correlations and visual analysis both challenging and misleading.

CO_2 concentration, temperature, and humidity are all represented by their standard units of measurement of parts per million (ppm), degrees Celsius (°C), and percentage (%), respectively.

Setting

Classrooms were arranged in a traditional layout, with the teacher positioned at the front and students seated around tables. Two Thingy:52 sensors were attached to the 10 chairs of the selected participants (Groups A and B) in each classroom using Velcro patches (Velcro, n.d.). One sensor was placed under the seat, and the other on the back of the backrest, in the same location on each chair

The Velcro patches stayed on the chairs throughout data collection to ensure consistent sensor placement. The chairs were arranged around two adjacent tables, with five chairs at each. The two motion sensor cameras were placed on tripods and set up in opposite corners of the classroom so that each camera could cover the blind spots of the other. the classroom layout, including the arrangement of tables and cameras, remained the same throughout data collection.

Data Collection

Data was collected during regular class periods with all equipment set up prior to and removed after each session. When students entered the classroom for their lesson, the researcher waited until all students were seated and checked that they were in the correct seats (i.e., the 10 selected students were in the designated chairs) before starting the recording. Only data from the first 25 minutes of each session (the same 25 minutes from Study 1) were included in the results. Data collection for Class A began two weeks prior to Class B. Data were gathered twice a week for each classroom, with a total of 25 sessions for Class A and 24 for Class B.

Due to technical problems, several sessions contained corrupted or incomplete data and were therefore excluded from the results. A total of four sessions were excluded for both Class A (sessions 4, 10, 17, and 22) and Class B (sessions 7, 11, 22, and 23). Furthermore, the Raspberry Pi cameras were not operational during the first half of data collection, resulting in overall movement data being gathered only during the second baseline and intervention phases. Additionally, noise levels were recorded prior to several sessions for each class to establish out-of-class noise levels (i.e., the noise level in the classroom when it was empty). Only out-of-class noise measurements lasting at least 5 minutes were included in the results.

Data Analysis

Each dependent variable was graphed throughout data collection, with each data point representing the mean value for that session. Visual analysis involved comparing the differences in trend, level, and variability of data between the baseline and intervention phases. Tau-U was used to calculate effect size, while Spearman's rank correlation coefficient was used to analyse relationships between variables. Data from both groups were pooled for the correlation analysis.

Results

In-Chair Movement

Mean in-chair movement for Groups A and B are presented in Figure 1 and summarised in Table 1.

Figure 1 shows that the Group A baseline in-chair movement levels (A1) remained very stable across all sessions (range: 322.1-361.1, M = 338.3). The introduction of the intervention (B1) coincided with a noticeable increase in the variability of in-chair movement (range: 278.2-424.8) and a small increase in mean from the baseline (M = 356.6). The reinstatement of the baseline conditions resulted in a return to the baseline mean (M = 335.6) and stable in-chair movement levels across all sessions (range: 327.5-345.5). The reintroduction of the intervention again coincided with increased variability in in-chair movement levels (range: 282.4-351.9), but did not cause a noticeable change in the mean (M = 338.6).

The Group B baseline levels of in-chair movement were relatively stable with a slight decreasing trend (range: 322.7-388.6, M = 345.9). The first intervention phase coincided with an immediate increase in in-chair movement (M = 416.7) and showed moderate variability with a slight increasing trend (range: 364.9-479.5). The return to baseline conditions coincided with a noticeable drop in in-chair movement level (M = 384.2), which was relatively stable across sessions (range: 353.2--406.5). The second intervention phase exhibited moderate variability in in-chair movement (range: 357.3-456.9), but resulted in only a small increase in the mean (M = 394.1).

Figure 1

Mean In-Chair Movement across Sessions for Groups A and B

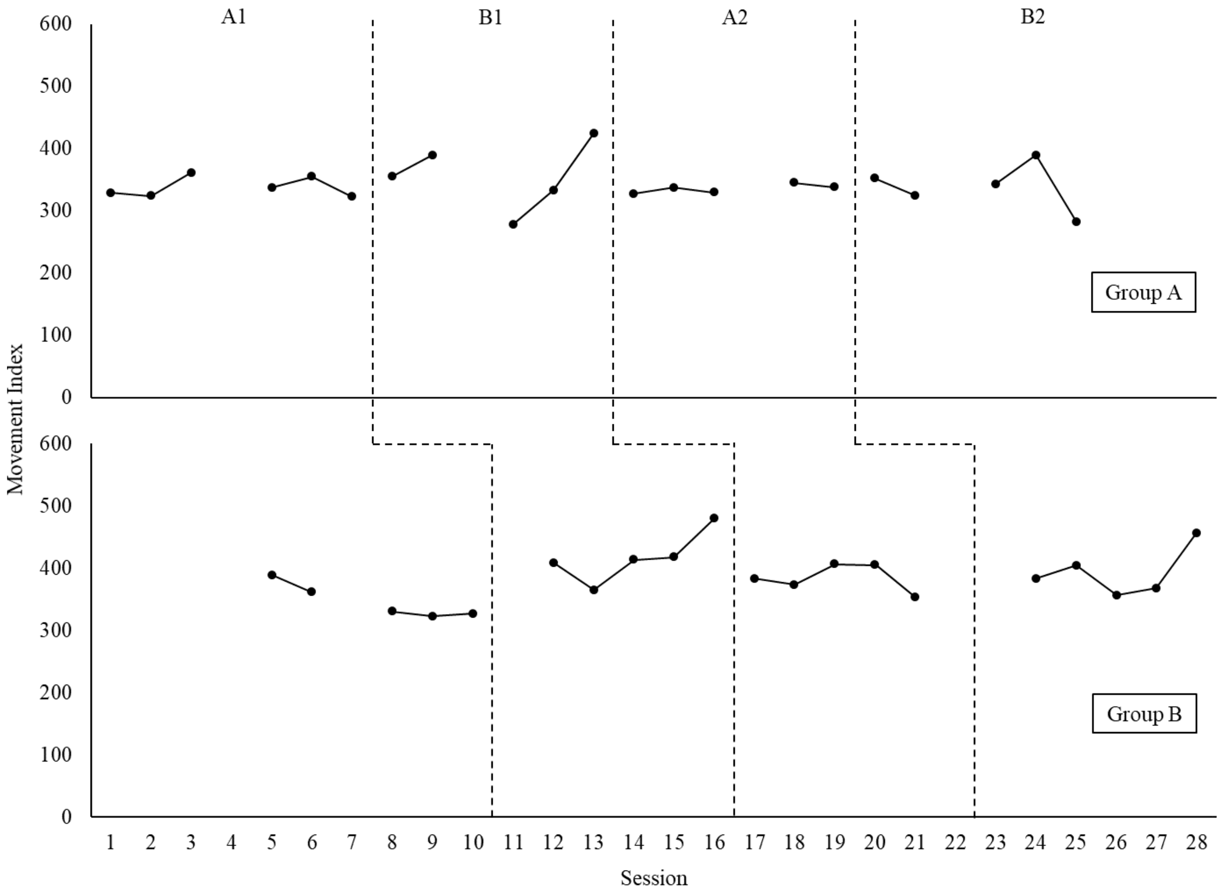


Table 1 shows that the mean in-chair movement levels increased during the BodyfurnFlex chair condition for both groups, with a small non-significant increase in Group A (.23, p = .39) and a significant moderate increase in Group B (.64, p < .05).

Table 1

Mean In-Chair Movement across Conditions with Ranges and Effect Sizes for Groups A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Group A	337.1	322.1-361.1	347.6	278.2-424.8	.23
Group B	365.1	322.7-406.5	405.4	357.3-479.5	.64*

Note: $*p < .05$, $**p < .01$

In-Chair Acceleration

Mean in-chair acceleration for Groups A and B are presented in Figure 2 and summarised in Table 2.

Figure 2 shows that Group A baseline levels of in-chair acceleration were stable across sessions (range: 141.5-173.7, $M = 155.0$). The introduction of the intervention coincided with a small but noticeable increase in in-chair acceleration ($M = 172.4$) and, except for session 8, remained stable (range: 159.6-194.5). The second baseline phase was associated with a noticeable decrease in in-chair acceleration ($M = 140.1$), with all but one session (session 19) remaining below B1 levels (range: 116.9-180.5). In-char acceleration levels during the second intervention phase, except for session 25, were stable (range: 166.0-207.7) and showed a noticeable increase in mean ($M = 177.9$).

Group B baseline in-chair acceleration levels were relatively stable (range: 125.3-156.0, $M = 144.3$). The first intervention phase exhibited a moderate increasing trend (range: 175.3-253.0) and a noticeable increase in mean in-chair acceleration level from the baseline ($M = 199.3$). The return of the baseline conditions coincided with a visible decrease in in-chair acceleration ($M = 164.3$), which showed moderate variability across sessions (range: 143.4-194.2). The second intervention phase exhibited some variability in in-chair acceleration levels (range: 167.0-219.4) and a noticeable increase in mean ($M = 194.0$).

Figure 2

Mean In-Chair Acceleration across Sessions for Groups A and B

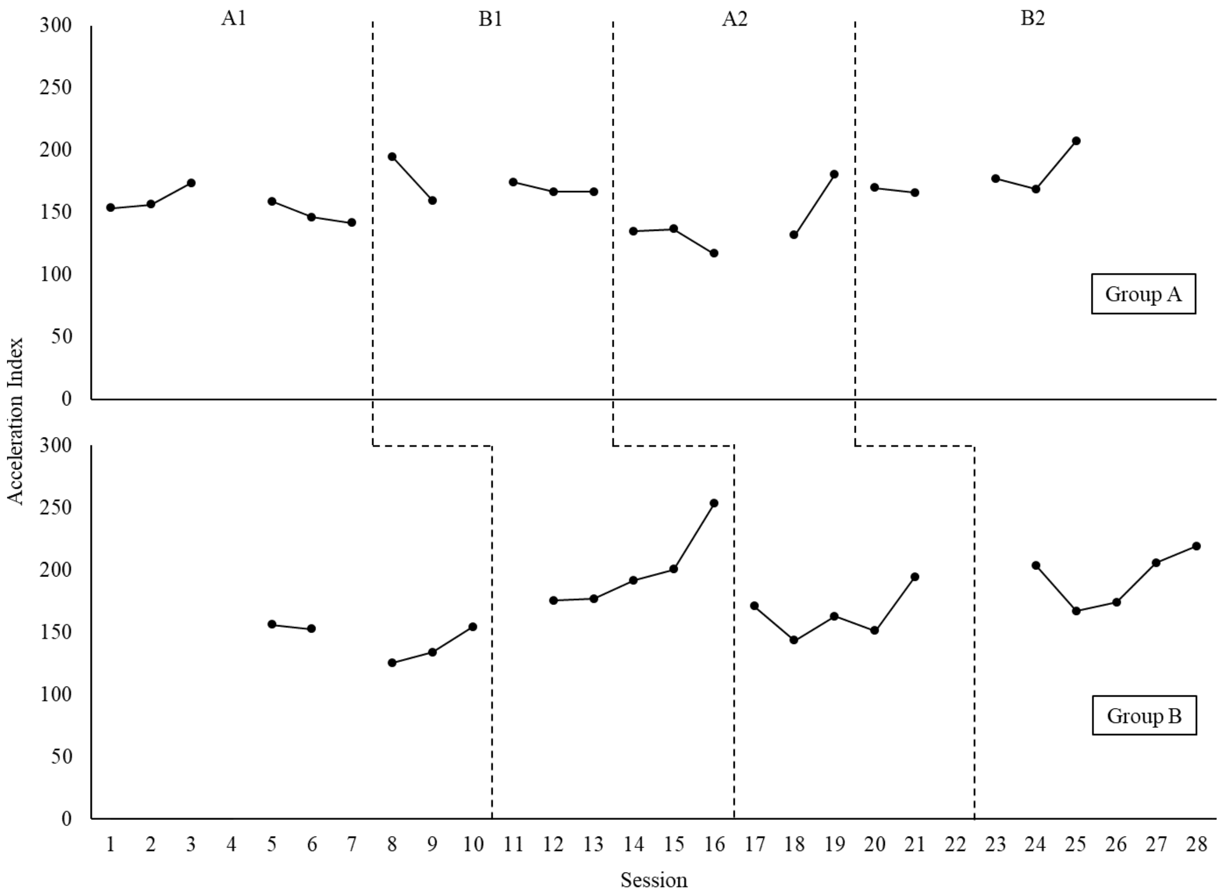


Table 2 shows that in-chair acceleration increased during the BodyfurnFlex chair condition for both groups, with a large, significant increase in Group A (.74, $p < .01$) and Group B (.88, $p < .01$).

Table 2

Mean In-Chair Acceleration across Conditions with Ranges and Effect Sizes for Groups A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Group A	148.3	116.9-180.5	175.1	159.6-207.7	.74**
Group B	154.4	125.3-194.2	196.7	167.0-253.0	.88**

In-Chair Rotation

Mean in-chair rotation for Groups A and B are presented in Figure 3 and summarised in Table 3.

Figure 3 shows that Group A baseline levels of in-chair rotation showed moderate variability (range: 185.6-239.0, *M* = 213.1). The first intervention phase also exhibited moderate variability in in-chair rotation levels (range: 133.8-205.1) but a decrease in mean from the baseline (*M* = 179.6). The second baseline phase continued to show moderate variability in in-chair rotation levels (range: 164.8-220.7) and a small increase in mean (*M* = 195.5). The reintroduction of intervention again resulted in a decrease in mean in-chair rotation (*M* = 160.7), but no change in variability (range: 113.7-182.0).

The Group B baseline exhibited moderate variability in in-chair rotation levels across sessions (range: 195.8-249.6, *M* = 217.5). The introduction of the intervention resulted in a decrease in mean in-chair rotation (*M* = 199.6) and variability (range: 183.9-215.0). The reinstatement of the baseline conditions resulted in a return to the baseline mean (*M* = 215.9) and an increase in variability of in-chair rotation levels (range: 171.0-243.3). The second intervention phase also resulted in a decrease in both mean in-chair rotation (*M* = 202.0) and variability (range: 189.5-219.6).

Figure 3

Mean In-Chair Rotation across Sessions for Groups A and B

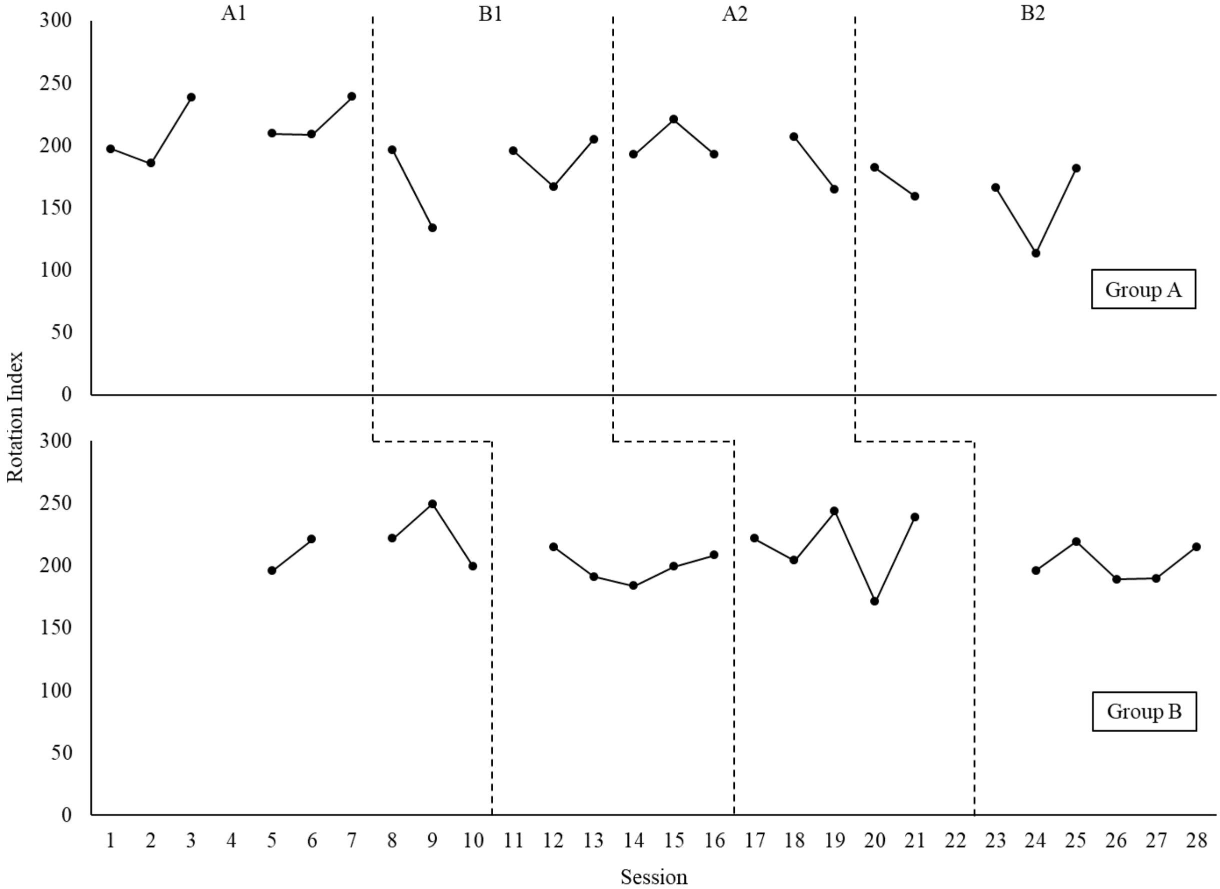


Table 3 shows that in-chair rotation decreased during the BodyfurnFlex chair condition for both groups, with a large, significant decrease in Group A (-.75, $p < .01$) and a non-significant decrease in Group B (-.52, $p = .05$).

Table 3

Mean In-Chair Rotation across Conditions with Ranges and Effect Sizes for Groups A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Group A	205.1	164.8-239.0	170.2	113.7-205.1	-.75**
Group B	216.7	171.0-249.6	200.8	183.9-219.6	-.52

Overall Movement in the Classroom

Mean overall movement levels for Classes A and B are presented in Figure 4 and summarised in Table 4. Overall movement data was unavailable for the first half of data collection, with only data from the second regular and BodyfurnFlex chair phases included.

Figure 4 shows that the baseline levels of overall movement for Class A showed moderate variability (range: .036-.058, *M* = .045). The intervention phase also displayed moderate variability (range: .037-.057) with only a small increase in mean overall movement (*M* = .048).

The baseline overall movement levels for Class B showed a decreasing trend (range: .044-.069, *M* = .061). The introduction of the intervention was associated with a noticeable increase in overall movement (*M* = .075) which remained relatively stable across sessions (range: .068-.081).

Figure 4

Mean Overall Movement in the Classroom across Sessions for Classes A and B

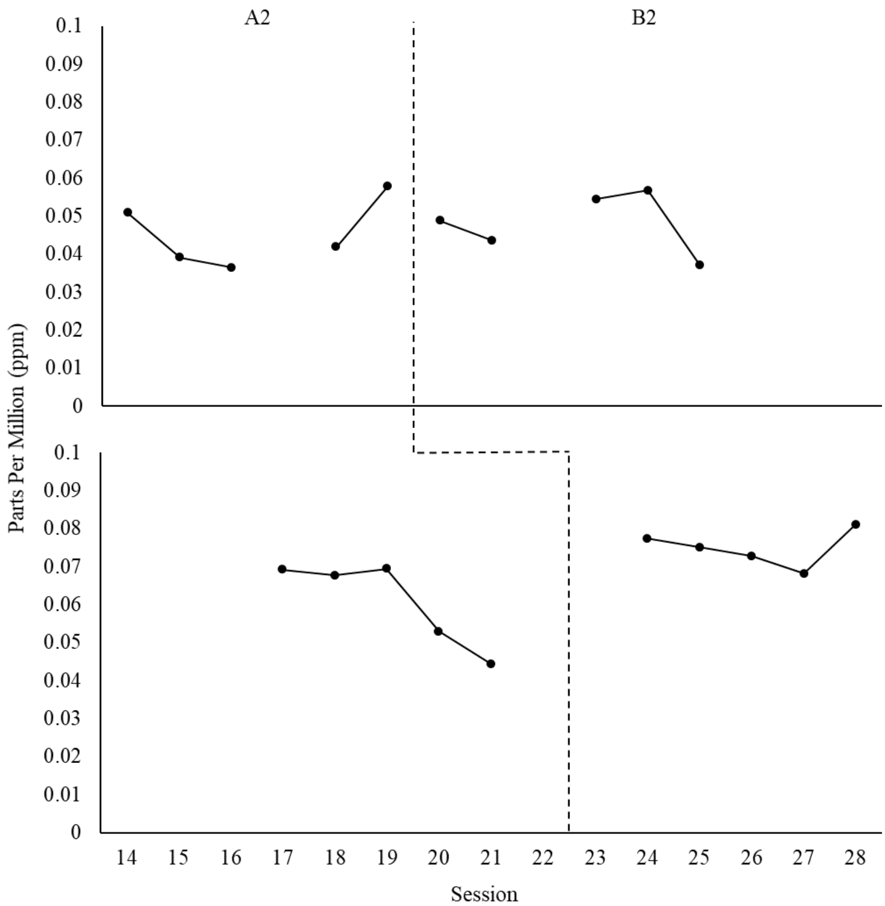


Table 4 shows that the mean overall movement levels increased during the BodyfurnFlex chair conditions for both groups, with a small non-significant increase for Class A (.20, $p = .30$) and a large significant increase for Class B (.84, $p < .05$).

Table 4

Mean In-Chair Rotation across Conditions with Ranges and Effect Sizes for Groups A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Class A	.045	.036-.058	.048	.037-.057	.20
Class B	.061	.044-.069	.075	.068-.081	.84*

Noise

Mean out-of-class noise levels were recorded in sessions 1, 6, 9, 11, 12, and 18 for Class A and sessions 1, 4, 6, 11, and 19 for Class B (Table 5).

As shown in table 5, the mean out-of-class nose levels for Class A was 36.4 and were relatively stable (range: 32.2-38.9) while the Class B mean out of class noise level was 46.7 and also remained relatively stable (range: 43.5-49.5).

Table 5

Mean Out-of-Class Noise Levels with Ranges for Classes A and B

	n	*M*	Range
Class A	6	35.4	32.2-38.9
Class B	5	46.7	43.5-49.5

Mean in-class and out-of-class noise levels for Classes A and B are presented in Figure 5, while in-class noise levels are summarised in Table 6.

Figure 5 shows that Class A baseline in-class noise levels showed moderate variability (range: 80.7-105.8, $M = 91.3$). During the first intervention phase, in-class noise levels were relatively stable (range: 70.8-86.7) and showed a decrease in mean from the baseline ($M = 79.9$). The return to baseline conditions resulted in a slight increase in mean in-class noise levels (M = 86.1) and some variability across sessions (range: 75.3-94.0). In-class noise levels from the second intervention phase were also relatively stable (range: 81.2-91.5) but did not result in a noticeable change in mean (*M* = 87.5).

Class B baseline in-class noise levels were stable except for session 9 (range: 86.3-108.2, *M* = 102.3). The introduction of the intervention was associated with a noticeable decrease in in-class noise levels (*M* = 85.2) and, with the exception of session 14, remained stable across sessions (range: 74.7-90.3). The reinstatement of the baseline conditions resulted in an increase in mean in-class noise levels (*M* = 93.8) and variability (range: 80.8-103.2). During the second intervention phase, in-class noise levels stabilised (range: 91.7-101.5) and there was a small increase in the mean from A2 (*M* = 96.7).

Figure 5

Mean Classroom Noise Levels across Sessions for Classes A and B

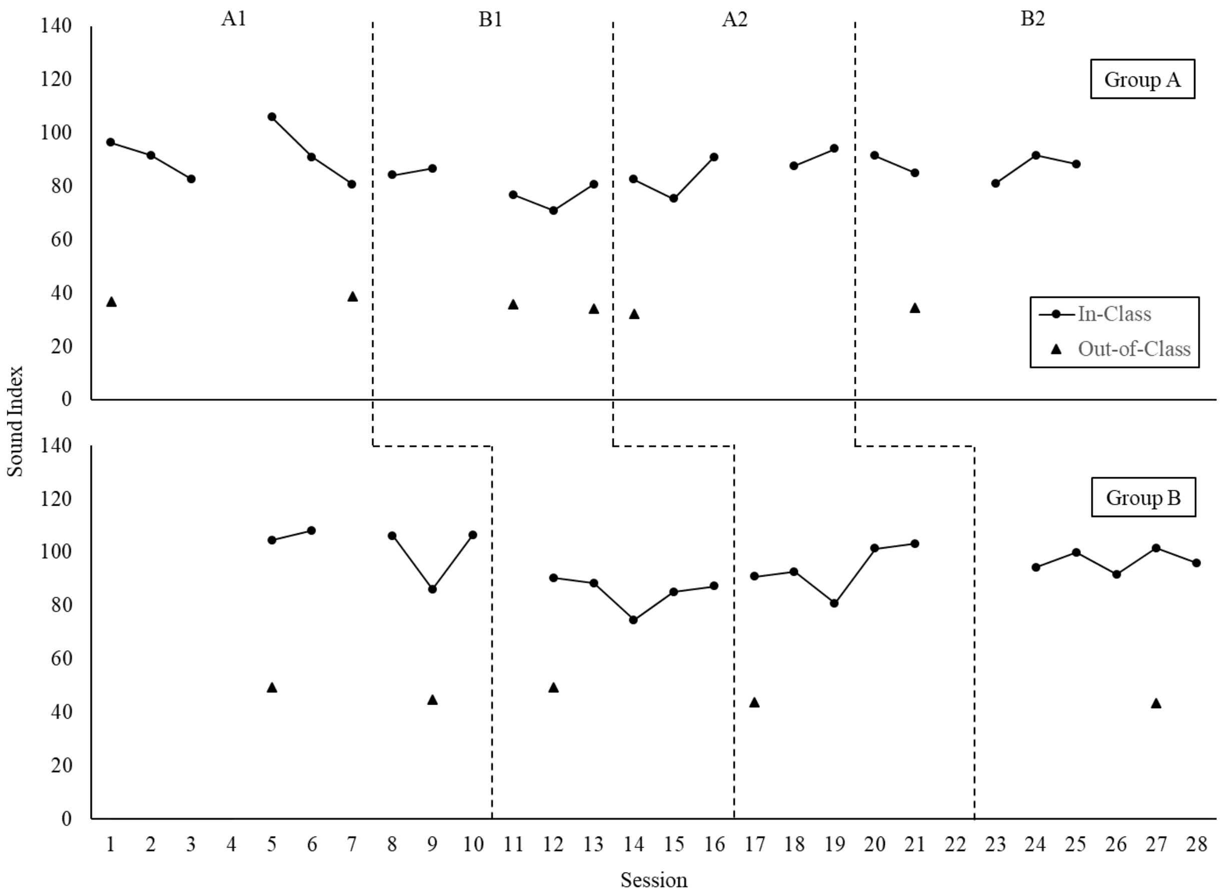


Table 6 shows that mean in-class noise levels decreased during the BodyfurnFlex chair condition for both classes; however, these decreases were small and non-significant for Class A (-.28, p = .29) and Class B (-.28, p = .30).

Table 6

Mean In-Class Noise Levels across Conditions with Ranges and Effect Sizes for Classes A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Class A	88.9	75.3-105.8	83.7	70.8-91.5	-.28
Class B	98.1	80.8-108.2	91.0	74.7-90.3	-.28

Environmental Variables

The Ministry of Education requires the daily average CO_2 concentration to stay below 1,250 ppm, while the classroom temperature and humidity must remain between 18-25 °C and 35-70%, respectively (Ministry of Education, 2022).

Carbon Dioxide (CO_2)

Mean CO_2 concentrations for Classes A and B are presented in Figure 6 and summarised in Table 7.

Figure 6 shows that Class A CO_2 levels during the first baseline phase were low (M = 243.8 ppm) and stable across sessions (range: 217.3-275.1 ppm). CO_2 levels during the first intervention phase remained stable (range: 206.5-370.7 ppm), except for session 9, and did not show a noticeable difference in mean from phase A1 (M = 257.3 ppm). During the second baseline phase CO_2 levels continued to remain stable (range: 217.6-283.1 ppm) with no visible change in mean (M = 240.6 ppm). The second intervention phase was associated with a slight increase in both variability (range: 221.6-395.7 ppm) and mean CO_2 levels (M = 303.2 ppm).

CO_2 levels during the first baseline phase for Class B were also very low (M = 291.8 ppm) and showed a very slight increasing trend (range: 249.4-356.5 ppm). During the first intervention phase, CO_2 levels also remained stable (range: 246.4-304.2 ppm), with a small decrease in the mean from phase A1 (M = 263.6 ppm). Except for session 18, the CO_2 concentration remained stable during the second baseline phase (range: 241.6-349.9 ppm), with no noticeable change in the mean from B1 (*M* = 269.4 ppm). The second intervention phase continued to display low levels of CO_2 concentration (*M* = 261.7 ppm) that remained stable across sessions (range: 222.5-284.2 ppm).

Figure 6

Mean CO_2 Concentration across Sessions for Classes A and B

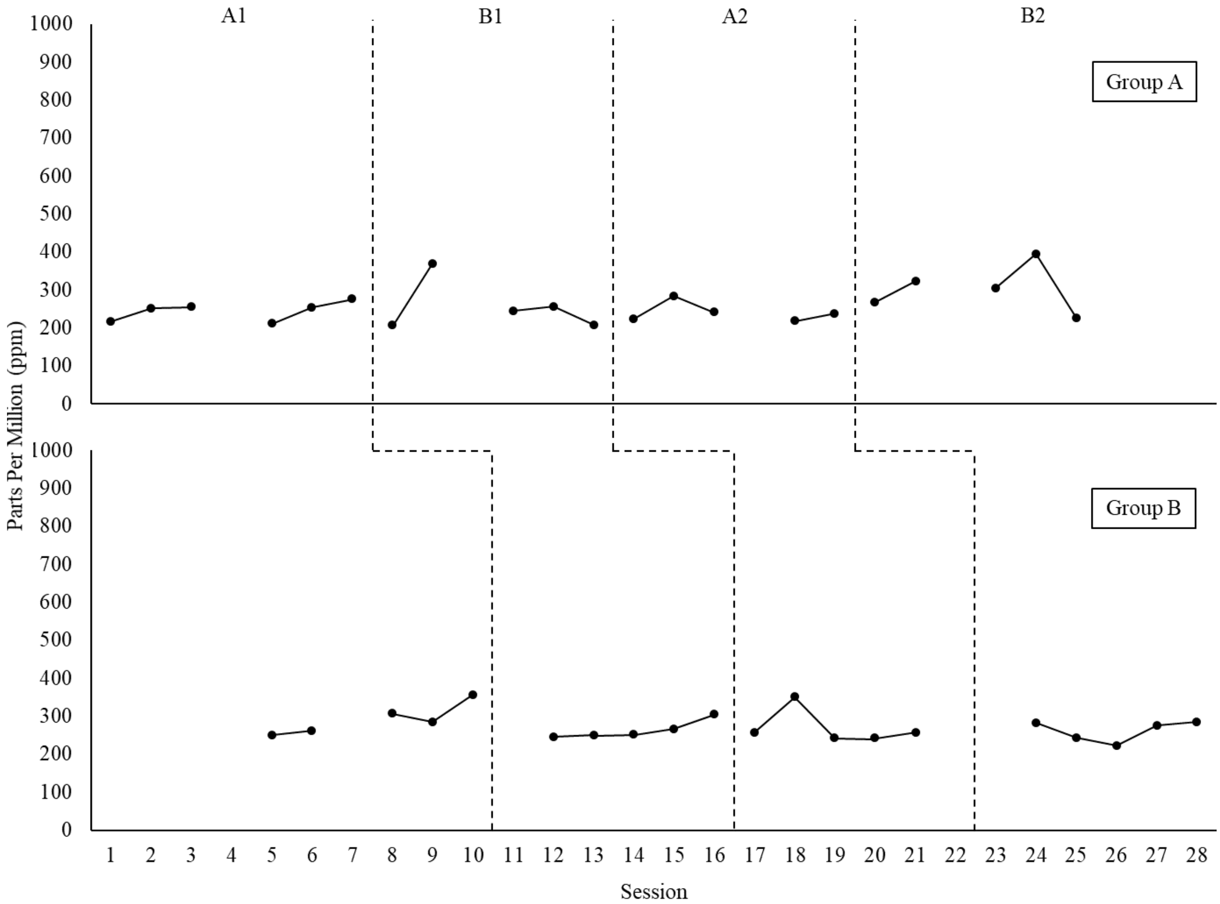


Table 7 shows that mean classroom CO_2 concentrations remained well below the required Ministry of Education limit of 1,250 ppm for all sessions, and there were no significant differences in the mean CO_2 concentration between conditions for Class A (.26, p = .32) or Class B (-.32, p = .24).

Table 7

Mean Classroom CO_2 Concentration across Conditions with Ranges and Effect Sizes for Classes A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Class A	242.4 ppm	217.3-283.1 ppm	280.2 ppm	206.5-395.7 ppm	.26
Class B	280.6 ppm	241.6-356.5 ppm	262.7 ppm	222.5-304.2 ppm	-.32

Temperature

The mean classroom temperature for Classes A and B are presented in Figure 7 and summarised in Table 8.

Figure 7 shows that classroom temperatures in the first baseline phase of Class A were stable, except for session 2 (range: 21.2-24.6 °C, *M* = 22.2°C). During the first intervention phase, classroom temperatures remained stable (range: 18.8-22.9 °C), except for session 12, and showed a slight decrease in mean from A1 (*M* = 20.2 °C). Classroom temperature during the second baseline phase remained stable (range: 21.5-22.8 °C) and showed a slight increase in mean (*M* = 22.1 °C). During the second intervention phase, classroom temperatures showed no noticeable change in level or stability (range: 20.8-23.0 °C, *M* = 22.0 °C).

Classroom temperatures during Class B’s first baseline phase showed moderate variability across sessions (range: 20.2-24.6 °C, *M* = 22.1 °C). Temperatures during the first intervention phase continued to exhibit moderate variability across sessions (range: 18.3-23.3 °C), with no discernible change in the mean from A1 (*M* = 21.7 °C). There was no change in the mean classroom temperature (*M* = 21.6 °C) during the second baseline phase, with temperatures remaining stable across sessions (range: 20.5-23.1 °C). There was a slight increase in mean classroom temperature during the second intervention phase (*M* = 22.8 °C), which displayed a moderate increasing trend (range: 18.9-25.9 °C).

Figure 7

Mean Classroom Temperature across Sessions for Classes A and B

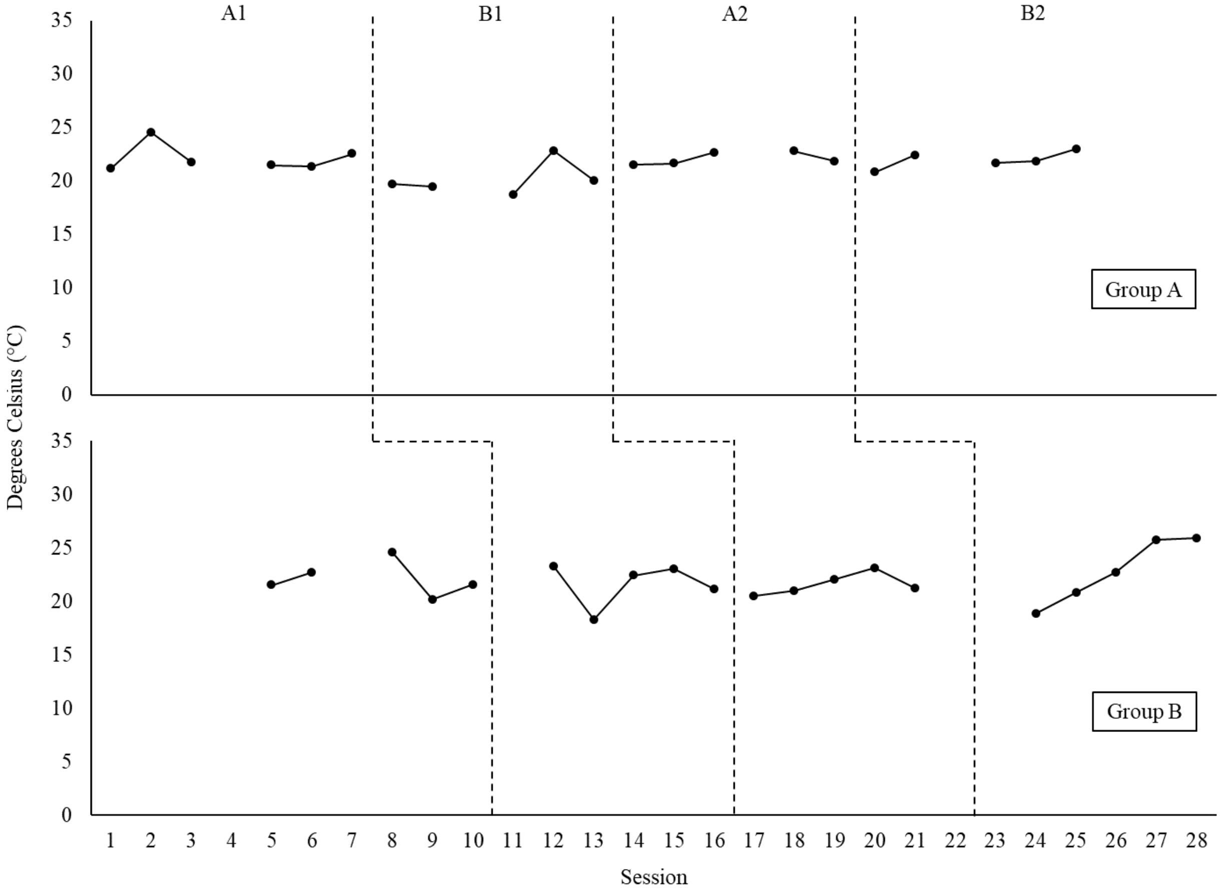


Table 8 shows that the mean classroom temperatures remained within the required Ministry of Education range of 18-25 °C for all sessions, and there were no significant differences in the mean classroom temperature between conditions for Class A (-.32, p = .22) and Class B (.08, p = .77).

Table 8

Mean Classroom Temperature across Conditions with Ranges and Effect Sizes for Classes A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Class A	22.1 °C	21.2-24.6 °C	21.1 °C	18.8-23.0 °C	-.32
Class B	21.9 °C	18.3-23.3 °C	22.0 °C	18.3-25.9 °C	.08

Humidity

Mean classroom humidity for Classes A and B are presented in Figure 8 and summarised in Table 9.

Figure 8 shows that classroom humidity during the initial baseline phase for Class A exhibited a high degree of variability across sessions (range: 42.0-75.4%, *M* = 58.3%). During the first intervention phase, there was moderate variability in classroom humidity levels (range: 43.2-69.6%), with no change in the mean from A1 (*M* = 57.6%). Classroom humidity during the second baseline phase exhibited a moderate decreasing trend (range: 44.6-69.0%); however, there was no change in the mean from B1 (*M* = 60.5%). During the second intervention phase, humidity showed moderate variability (range: 46.6-61.4%) and a slight reduction in mean from A2 (*M* = 54.4%).

Classroom humidity during the initial baseline phase of Class B remained relatively stable across sessions (range: 52.2-63.8%, *M* = 57.7%). There was no noticeable change in mean classroom humidity during the first intervention phase (*M* = 56.2%), which also remained fairly stable (range: 50.3-64.0%). Classroom humidity during the second baseline phase remained stable (range: 51.4-56.3%) with no notable change in the mean (*M* = 53.3%). The second baseline phase showed increased variability in classroom humidity levels (range: 50.0-65.1%), but again, no apparent change in the mean (*M* = 56.3%).

Figure 8

Mean Classroom Humidity across Sessions for Classes A and B

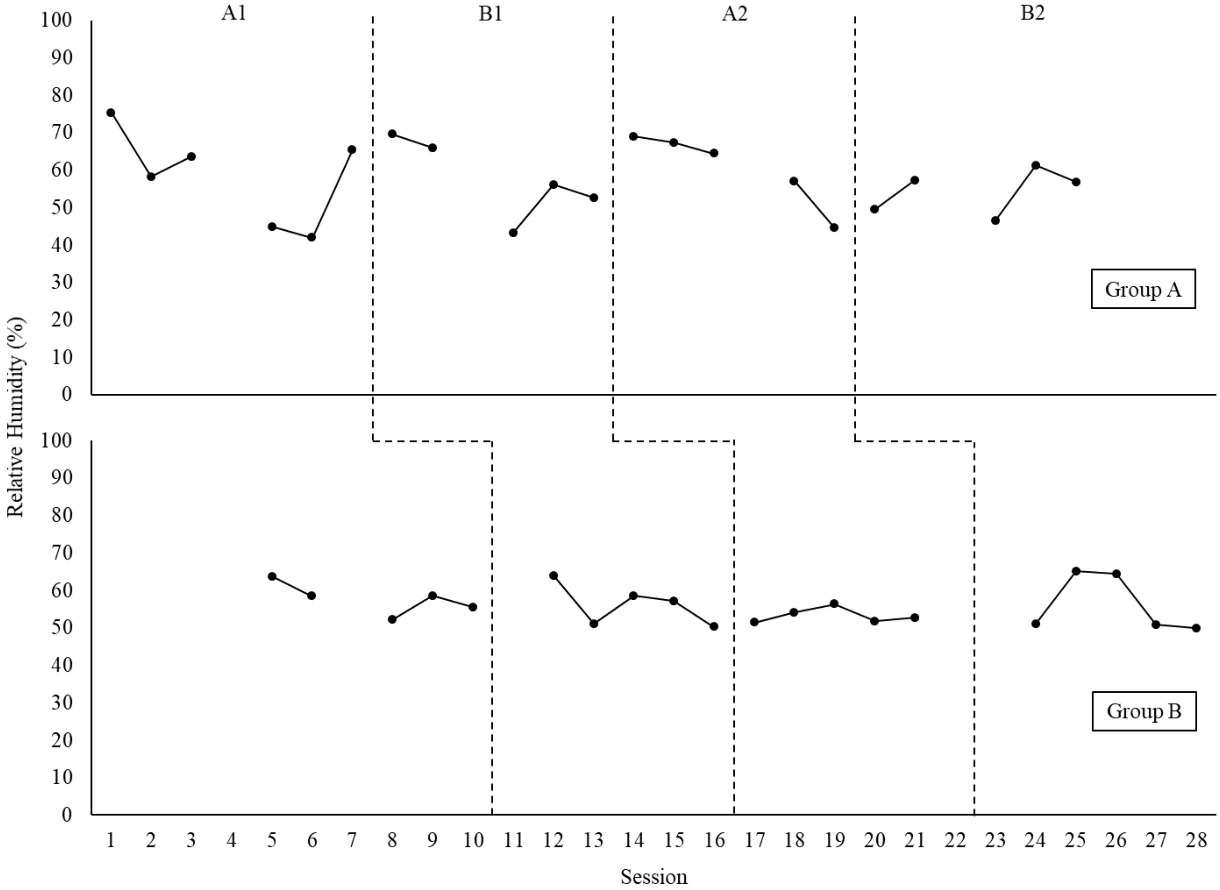


Table 9 shows that the mean classroom humidity remained within the required Ministry of Education range of 35-70% for all sessions, and there were no significant differences in the mean classroom humidity between conditions for both Class A (-.02, *p* = .94) and Class B (-.16, *p* = .55).

Table 9

Mean Classroom Humidity across Conditions with Ranges and Effect Sizes for Classes A and B

	Baseline		Intervention		
	M	Range	*M*	Range	Tau-U
Class A	59.3%	42.0-75.4%	56.0%	43.2-69.6%	-.02
Class B	55.5%	51.4-63.8%	56.3%	50.0-65.1%	-.16

Correlations

A Spearman's rank correlation analysis was conducted to explore possible relationships between movement, environmental, and behavioural (collected in Study 1) variables. The results are presented in Table 10.

As shown in Table 10, several significant correlations were observed between variables. In-chair acceleration had moderate positive correlation with on-task behaviour ($r_s(39) = .62$, $p < .01$) and moderate negative correlations with out-of-seat behaviour ($r_s(39) = -.37$, $p < .05$) and chair tipping ($r_s(39) = -.46$, $p < .01$). Conversely, in-chair rotation had a large positive correlation with chair tipping ($r_s(39) = .56$, $p < .05$) and moderate positive correlation with out-of-seat behaviour ($r_s(39) = .38$, $p < .05$). In-chair movement had large positive correlations with both in-chair acceleration ($r_s(39) = .51$, $p < .01$) and overall movement in the classroom ($r_s(18) = .53$, $p < .05$).

Additionally, on-task behaviour had moderate to large negative correlations with disruptive behaviour ($r_s(47) = -.56$, $p < .01$), chair tipping ($r_s(47) = -.38$, $p < .05$), and classroom noise levels ($r_s(47) = -.46$, $p < .05$). Meanwhile, chair tipping had a moderate positive correlation with disruptive behaviour ($r_s(47) = .30$, $p < .05$), and a large positive correlation with out-of-seat behaviour ($r_s(47) = .56$, $p < .01$). All three environmental variables (CO_2, temperature, and humidity) had small non-significant correlations with all other variables.

Table 10

Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. On-Task Behaviour	-											
2. Disruptive Behaviour	-.56**	-										
3. Out-of-Seat Behaviour	-.26	.21	-									
4. Chair Tipping	-.38*	.30*	.56**	-								
5. In-Chair Movement	.16	-.14	-.24	-.25	-							
6. In-Chair Acceleration	.42**	-.26	-.37*	-.46**	.51**	-						
7. In-Chair Rotation	-.39	.44	.38*	.56*	.33	-.23	-					
8. Overall Movement	.24	.19	-.30	-.41	.53*	.44	.22	-				
9. Noise	-.46*	.16	-.15	-.03	.06	-.06	.09	.44	-			
10. CO_2 Concentration	-.05	.17	-.16	-.20	.03	.03	.01	.19	.07	-		
11. Temperature	-.06	-.22	-.05	-.02	-.05	-.04	-.08	-.15	.14	.01	-	
12. Humidity	-.09	-.17	.05	.02	-.10	-.24	.06	-.22	-.21	-.14	.07	-

Note: $*p < .05$, $**p < .01$

Discussion

The aim of the current study was to investigate whether BodyfurnFlex chairs increased students' movement compared to regular classroom chairs and whether that movement was linked to their behaviour. Additionally, environmental factors (CO_2, temperature, humidity) and noise data were considered as potential confounding variables.

The results showed that in-chair movement increased for both Groups A and B when students sat in BodyfurnFlex chairs; however, this effect was only significant for Group B. These results are consistent with other research that has found dynamic chairs increase the movement of participants compared to regular (static) chairs (Garcia et al., 2015; Grooten et al., 2017; Nüesch et al., 2018; Stanić et al., 2022; Tanoue et al., 2016). Furthermore, the results showed that there was noticeably more variation in the levels of in-chair movement across sessions during the intervention condition. One explanation for these findings could be that BodyfurnFlex chairs enable students to move as much as they need/want depending on the task they were completing that session. While in comparison, when seated in the regular chairs, students essentially move the same amount every lesson, regardless of the task or situation. However, the results did not find clear evidence to suggest that in-chair movement is associated with the on-task or disruptive behaviours of students, with small non-significant correlations between in-chair movement and all student behaviours.

The results also found that in-chair acceleration was increased when students were seated in BodyfurnFlex chairs, with a large positive effect in both groups. Considering that acceleration is the change in velocity (i.e., a higher mean acceleration tells us that an object's velocity is changing more frequently), the results suggest that on average students were moving more frequently/consistently when seated in BodyfurnFlex chairs in comparison to the regular classroom chairs (i.e., when the chair is not moving the velocity does not change, but when the chair is constantly moving the velocity will consistently change). Additionally, in-chair acceleration had a strong positive correlation with on-task behaviour and moderate negative correlations with out-of-seat behaviour and chair tipping. These findings suggest that consistent in-chair movement is associated with increased engagement and a reduction in unproductive and disruptive movements, such as out-of-seat behaviour and chair tipping.

Conversely, in-chair rotation decreased when students used BodyfurnFlex chairs; however, this effect was only significant for Group A. Furthermore, in-chair rotation had a large positive correlation with chair tipping. Considering that rotation is the change in orientation (i.e., as an object rotates, its orientation changes), these findings suggest that in-chair rotation reflects large movements that alter the angle of the chairs (e.g., chair tipping. It is important to note that although the backrest and seat of the BodyfurnFlex chairs can pivot, these movements are minor and unlikely to cause significant changes in orientation compared to chair tipping, which results in a substantial shift in orientation. In-chair rotation also had a significant positive correlation with out-of-seat behaviour. A potential reason for this could be that as students get out of their seats, they are required to move the chair (from under the desk), which could result in a substantial change in orientation (especially for the regular chairs, which cannot slide out like the BodyfurnFlex chair).

The in-chair motion data (movement, acceleration, and rotation) indicates that students not only moved more when seated in BodyfurnFlex chairs, but also more consistently. Furthermore, the results showed that the size or magnitude of in-chair movement was not significantly related to on-task behaviour, but the consistency of that movement (i.e., in-chair acceleration) was. These findings suggest that behavioural engagement is not related to how much students move but instead to how consistently they move. The results also indicated that students not only moved less (in both amount and consistency) when seated in the regular chairs, but the movement that they did engage in appeared to be large, unproductive, and disruptive movements, such as chair tipping and out-of-seat behaviour.

The overall movement data showed that movement in the classroom increased when students were seated in BodyfurnFlex chairs in both classes; however, this effect was only significant for Class B. Furthermore, a large positive correlation was found between overall movement and in-chair movement. These findings suggest that the in-chair movement exhibited by students when seated in BodyfurnFlex chairs was substantial enough to result in a discernible increase in overall movement in the classroom.

The sound data showed that out-of-class noise levels remained consistent across all readings and were substantially below the mean in-class noise levels. These results indicate that a substantial proportion of the in-class noise was behavioural (i.e., from the students and teacher) and not just environmental. The mean in-class noise levels decreased when students were seated in BodyfurnFlex chairs; however, this effect was small for both groups. Although classroom noise is often seen as a sign of disruptive behaviour (Douglas et al., 2016; Olota, 2022), this study found no evidence to support this view, with a small, non-significant correlation between the two variables. However, there was a moderate negative correlation between noise and on-task behaviour. Given that the results indicate that a substantial portion of classroom noise was behavioural (i.e., generated by students), this finding supports the assertion that classroom noise is indicative of off-task behaviour (Chapman et al., 2023; Ludyga et al., 2021).

The environmental data revealed that mean classroom CO_2, temperature, and humidity remained within the Ministry of Education guidelines of < 1,250 ppm, 18-25 °C, and 35-70% (Ministry of Education, 2022) across all sessions for both groups. Additionally, Tau-U showed that there was no significant difference in mean CO_2, temperature, and humidity levels between conditions for both groups. Furthermore, all three environmental variables had small, non-significant correlations with all other variables. These findings suggest that classroom CO_2, temperature, and humidity were not confounding variables in this study and did not have a significant effect on the behaviour or movement of students.

Implications of Research

Despite research showing that dynamic chairs can increase movement in comparison to regular (static) chairs (Garcia et al., 2015; Grooten et al., 2017; Nüesch et al., 2018; Stanić et al., 2022; Tanoue et al., 2016), it has not been shown that this in-chair movement is associated with student behaviour. The results of the current study show that BodyfurnFlex chairs significantly improved the consistency of in-chair movement compared to regular classroom chairs, and that consistent movement while seated was associated with better on-task behaviour and a reduction in disruptive behaviour (namely chair tipping and out-of-seat behaviour). These findings suggest that dynamic chairs could be an effective alternative to movement breaks for incorporating movement into the classroom. This would enable the behavioural benefits linked to movement integration, such as increased engagement (Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011) and decreased disruptive behaviour (McGowan et al., 2021; Moon et al., 2020), without interrupting the lesson (which reduces valuable learning time) and requiring the teacher training associated with movement break interventions (Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011

Aside from student behaviour, movement has several other crucial implications. Incorporating movement into the classroom has been shown to positively influence academic achievement (Donnelly & Lambourne, 2011; Petrigna et al., 2022; Shoval et al., 2018; Watson et al., 2017). Furthermore, prolonged static postures are associated with musculoskeletal disorders (MSD) (De Sio et al., 2018; Dong et al., 2022). In-chair movement and frequent postural changes have been shown to reduce musculoskeletal pain/discomfort (Akkarakittichoke et al., 2023; Arippa et al., 2022; Waongenngarm et al., 2021) and may be an effective intervention for preventing the development of MSDs (Dong et al., 2022; Putsa et al., 2022). The results of this study indicate that BodyfurnFlex chairs not only increase the amount of in-chair movement but also the frequency/consistency of that movement (suggesting frequent postural changes), indicating that they may be able to improve student comfort and help prevent the development of MSDs.

The study also demonstrated the use of a new potential tool for evaluating learning conditions in classrooms, in the form of the Smart Classroom System. CO_2, temperature, and humidity not only affect students' attention, cognitive functioning, and performance (Aydin & Goktas, 2023; Cho, 2017; Haverinen-Shaughnessy & Shaughnessy, 2015; Fernandes et al., 2019; Shield & Dockrell, 2008; Woo et al., 2022) but can also have significant adverse health and social effects, including respiratory infections, allergies, headaches, fatigue, agitation, feelings of depression, and decreased school attendance (Angelon-Gaetz et al., 2016; Derby & Pasch, 2017; Jaakkola et al., 2014; Mäkinen et al., 2009; Tu et al., 2021). Research has shown that many New Zealand classroom do not fit within the required ranges for learning spaces (Building Research Association of New Zealand, 2019a, 2019b), indicating that many students are not only currently at a learning disadvantage but also risk of adverse health outcomes. A tool like the Smart Classroom System could be a valuable resource that enables the assessment of learning space quality and identifies which classrooms require interventions (e.g., air conditioning, heating, cooling, etc.) to ensure students receive adequate and healthy learning environments.

Limitations of Research

One limitation to consider is that the in-chair motion data measured the motion of the chairs, not the students. However, while the movement of the chairs is considered a good indication of student movement, it is commonly used as a proxy for student movement in other studies (Grooten et al., 2017; Nüesch et al., 2018). However, including overall movement as a measure provided further evidence that students' movement (not just the chairs) indeed increased when they sat in BodyfurnFlex chairs. Overall movement increased in both groups during the intervention condition, and a large positive correlation was observed between in-chair movement and overall movement in the classroom.

Another limitation was that there was minimal variation in the environmental data, and what variation there was remained within the recommended ranges (i.e., indicating they did not affect the learning conditions). This meant that we were unable to gain insight into how the environmental variables influenced student movement and behaviour. However, this is also a positive aspect, as it meant that the environmental variables measured in this study could be ruled out as potential confounding variables, adding further validity to the effect that the chairs had on student movement and behaviour.

Future Research

Although the findings of this study suggest that BodyfurnFlex chairs may serve as a viable alternative to movement breaks for enhancing student behaviour, it should be noted that the effect size of movement breaks and dynamic chairs on student behaviour was not compared in this study. Considering that dynamic chairs do not require a break in the lesson, which takes away from learning time, it is possible that they may be more effective than movement breaks at increasing the amount of time students spend on-task. Future research should consider comparing the impact of movement breaks and dynamic chairs on student behaviour.

Furthermore, considering that integrating movement into the classroom can improve students' academic achievement (Donnelly & Lambourne, 2011; Petrigna et al., 2022; Shoval et al., 2018; Watson et al., 2017), our results suggest that dynamic chairs, by promoting student movement, may also positively influence academic outcomes. Since academic achievement can significantly influence students' future quality of life (Edgerton et al., 2012; Starr et al., 2024), Interventions that enhance achievement are valuable and warrant further study.

Conclusion

The current study offers valuable insights into how dynamic chairs can influence student movement and addresses a gap in existing literature regarding how such movement relates to behaviour. The findings suggest that BodyfurnFlex chairs could be an effective intervention for promoting student movement through active sitting and support the hypothesis that active sitting can enhance student engagement and minimise disruption in the classroom.

References:

Akkarakittichoke, N., Waongenngarm, P., & Janwantanakul, P. (2023). Effects of Postural Shifting Frequency on Perceived Musculoskeletal Discomfort During 1-Hour Sitting in Office Workers. *Journal of Manipulative and Physiological Therapeutics, 46*(2), 76-85. https://doi.org/10.1016/j.jmpt.2023.06.003

Arippa, F., Nguyen, A., Pau, M., & Harris-Adamson, C. (2022). Postural strategies among office workers during a prolonged sitting bout. *Applied Ergonomics, 102*, 103723. https://doi.org/10.1016/j.apergo.2022.103723

Austin, J. L., & Soeda, J. M. (2008). Fixed-time teacher attention to decrease off-task behaviors of typically developing third graders. *Journal of Applied Behavior Analysis, 41*(2), 279-283. https://doi.org/10.1901/jaba.2008.41-279

Axup, T., & Gersch, I. (2008). Challenging behaviour: the impact of challenging student behaviour upon teachers' lives in a secondary school: teachers' perceptions. *British Journal of Special Education*, *35*(3), 144-151. https://doi.org/10.1111/j.1467-8578.2008.00388.x

Aydın, A., & Göktaş, Y. (2023). Examining the Effects of Physical Variables in Classrooms on Students' Attention via the Internet of Things. *Participatory Educational Research, 10*(1), 160-177. https://doi.org/10.17275/per.23.9.10.1

Bhandari, N., Tadepalli, S., & Gopalakrishnan, P. (2024). Investigation of acoustic comfort, productivity, and engagement in naturally ventilated university classrooms: Role of background noise and students' noise sensitivity. *Building and Environment, 249*, 111131. https://doi.org/10.1016/j.buildenv.2023.111131

Blank, C., & Shavit, Y. (2016). The Association Between Student Reports of Classmates' Disruptive Behavior and Student Achievement. *AERA Open*, *2*(3), 233285841665392. https://doi.org/10.1177/2332858416653921

Broad, A. A., Bornath, D. P., Grisebach, D., McCarthy, S. F., Bryden, P. J., Robertson-Wilson, J., & Hazell, T. J. (2023). Classroom activity breaks improve on-task behavior and physical activity levels regardless of time of day. *Research Quarterly for Exercise and Sport, 94*(2), 331-343. https://doi.org/10.1080/02701367.2021.1980189

Building Reserach Association of New Zealand. (2019a). *An overview of indoor air contaminants in New Zealand schools*. https://d39d3mj7qio96p.cloudfront.net/media/documents/BRANZ-RN-Indoor_Air_Quality_2.pdf

Building Reserach Association of New Zealand. (2019b). *Indoor air pollution at a New Zealand urban primary school*. https://d39d3mj7qio96p.cloudfront.net/media/documents/BRANZ-RN-Indoor_Air_Quality_6.pdf

Callaghan Innovation. (n.d.). *Callaghan Innovation*. https://www.callaghaninnovation.govt.nz/

Camahalan F. M. G., & Ipock A. R. (2015). Physical activity breaks and student learning: A teacher-research project. *Education, 135*(3), 291–298. https://go.gale.com/ps/i.do?p=AONE&u=anon~3a4dbb5a&id=GALE%7CA406162560&v=2.1&it=r&sid=googleScholar&asid=dc7ebadc

Carton, Q., De Coninck, S., Kolarik, J., & Breesch, H. (2023). Assessing the effect of a classroom IEQ on student satisfaction, engagement and performance*. E3S Web of Conferences 396*, 01052. https://doi.org/10.1051/e3sconf/202339601052

Chapman, B. N., Drevon, D. D., & Jasper, A. D. (2023). The impact of the quiet Classroom game on On-Task Behavior and Classroom noise level in three Middle School classrooms. *Journal of Behavioral Education, 32*(1), 109-126. https://doi.org/10.1007/s10864-021-09444-3

Cogswell, S., Carr, A., Abbott, N., & Monks, C. P. (2020). The development and validation of a teacher-reported low-level classroom disruption scale (LLCD-S). *Emotional and Behavioural Difficulties, 25*(3-4), 230-243. https://doi.org/10.1080/13632752.2020.1816651

De Sio, S., Traversini, V., Rinaldo, F., Colasanti, V., Buomprisco, G., Perri, R., Mormone, F., La Torre. G., & Guerra, F. (2018). Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella review. *PeerJ, 6*, e4154. https://doi.org/10.7717/peerj.4154

Dong, Y., Jiang, P., Jin, X., Jiang, N., Huang, W., Peng, Y., Shen, Y., He, I., Forsman, M., & Yang, L. (2022). Association between long-term static postures exposure and musculoskeletal disorders among university employees: A viewpoint of inflammatory pathways. *Frontiers in Public Health, 10*, 1055374. https://doi.org/10.3389/fpubh.2022.1055374

Donnelly, J. E., & Lambourne, K. (2011). Classroom-based physical activity, cognition, and academic achievement. *Preventive Medicine*, *52*, S36-S42. https://doi.org/10.1016/j.ypmed.2011.01.021

Douglas, J., Moyes, D., & Douglas, A. (2016). The Impact of Disruptive Behavior in the Classroom: the student perspective. *ST-6: Education Excellence, 5*(3), 143-51. https://www.researchgate.net/profile/Jacqueline-Douglas/publication/309390995_The_Impact_of_Disruptive_Behavior_in_the_Classroom_the_student_perspective/links/580dc56e08aea8ecfaf1de0d/The-Impact-of-Disruptive-Behavior-in-the-Classroom-the-student-perspective.pdf

Edgerton, J. D., Roberts, L. W., & von Below, S. (2012). Education and Quality of Life. In K. C. Land, A. C. Michalos, & M. J. Sirgy (Eds.), *Handbook of Social Indicators and Quality of Life Research* (pp. 265-296). Springer Netherlands. https://doi.org/10.1007/978-94-007-2421-1_12

Fernandes, R. A., Vidor, D. C. G. M., & Oliveira, A. A. d. (2019). The effect of noise on attention and performance in reading and writing tasks. *CoDAS*, 31. https://doi.org/10.1590/2317-1782/20182017241

Finn, J. D., Pannozzo, G. M., & Voelkl, K. E. (1995). Disruptive and Inattentive-Withdrawn Behavior and Achievement among Fourth Graders. *The Elementary School Journal, 95*(5), 421-434. https://doi.org/10.1086/461853

Gao, N., Shao, W., Rahaman, M. S., & Salim, F. D. (2020). n-gage: Predicting in-class emotional, behavioural and cognitive engagement in the wild. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 4*(3), 1-26. https://doi.org/10.1145/3411813

Garcia, J. M., Huang, T. T., Trowbridge, M., Weltman, A., & Sirard, J. R. (2016). Comparison of the effects of stable and dynamic furniture on physical activity and learning in children. *The Journal of Primary Prevention, 37*, 555-560. https://doi.org/10.1007/s10935-016-0451-6

Godwin, K. E., Almeda, M. V., Seltman, H., Kai, S., Skerbetz, M. D., Baker, R. S., & Fisher, A. V. (2016). Off-task behavior in elementary school children. *Learning and Instruction, 44*, 128-143. https://doi.org/10.1016/j.learninstruc.2016.04.003

Goh, T. L., Fu, Y., Brusseau, T., & Hannon, J. (2018). On-task behavior of elementary students during movement integration*. Journal of Physical Education and Sport, 18*(1), 103-106. https://doi.org//10.7752/jpes.2018.01013

Grooten, W. J., Äng, B. O., Hagströmer, M., Conradsson, D., Nero, H., & Franzén, E. (2017). Does a dynamic chair increase office workers' movements?–results from a combined laboratory and field study. *Applied Ergonomics, 60*, 1-11. https://doi.org/10.1016/j.apergo.2016.10.006

Infantino, J., & Little, E. (2005). Students’ perceptions of classroom behaviour problems and the effectiveness of different disciplinary methods. *Educational Psychology*, *25*(5), 491-508. https://doi.org/10.1080/01443410500046549

Kerpan, S., Humbert, M. L., Rodgers, C. D., & Stoddart, A. L. (2019). Improving Kindergarten and Grade One Indigenous Students' On-Task Behavior With the Use of Movement Integration. *Journal of American Indian Education, 58*(1-2), 84-107. https://doi.org/10.5749/jamerindieduc.58.1-2.0084

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal, 46(*3), 517-528. https://doi.org/10.2224/sbp.7054

Liu, C., Zhang, Y., Sun, L., Gao, W., Jing, X., & Ye, W. (2021). Influence of indoor air temperature and relative humidity on learning performance of undergraduates. *Case Studies in Thermal Engineering, 28*, 101458. https://doi.org/10.1016/j.csite.2021.101458

Ludyga, S., Gerber, M., Brand, S., Möhring, W., & Pühse, U. (2022). Do different cognitive domains mediate the association between moderate-to-vigorous physical activity and adolescents' off-task behaviour in the classroom?. *British Journal of Educational Psychology, 92*(1), e12445. https://doi.org/10.1111/bjep.12445

Mahar, M. T. (2011). Impact of short bouts of physical activity on attention-to-task in elementary school children*. Preventive Medicine, 52*, S60-S64. https://doi.org/10.1016/j.ypmed.2011.01.026

McGowan, A. L., Gerde, H. K., Pfeiffer, K. A., & Pontifex, M. B. (2021). Physically active learning in preschoolers: Improved self-regulation, comparable quantity estimation. *Trends in Neuroscience and Education, 22*, 100150. https://doi.org/10.1016/j.tine.2021.100150

Moon, J., Webster, C. A., Herring, J., & Egan, C. A. (2022). Relationships between systematically observed movement integration and classroom management in elementary schools*. Journal of Positive Behavior Interventions, 24*(2), 122-132. https://doi.org/10.1177/1098300720947034

Ministry of Education (2022). *Designing Quality Learning Spaces (DQLS) Indoor Air Quality and Thermal Comfort*. https://web-assets.education.govt.nz/s3fs-public/2024-10/Indoor-Air-Quality-and-Thermal-Comfort-V2-v2.0-2022.pdf?VersionId=FWYjUT5Ej_GCPwenx3OqguCG8.phJHEy

Nordic Semiconductor. (n.d.). *Nordic Thingy:52*. https://www.nordicsemi.com/Products/Development-hardware/Nordic-Thingy:52

Nüesch, C., Kreppke, J. N., Mündermann, A., & Donath, L. (2018). Effects of a dynamic chair on chair seat motion and trunk muscle activity during office tasks and task transitions. *International Journal of Environmental Research and Public Health, 15*(12), 2723. https://doi.org/10.3390/ijerph15122723

Okeke, C., Thomas, A., & Botha, A. (2023). The impact of learners' disruptive behaviour on teachers' well-being: a qualitative approach. *International Journal of Research in Business and Social Science, 12*(8), 504-511. https://doi.org/10.20525/ijrbs.v12i8.2917

Olota, P. O. (2022). Effect of Class Rules on Noisemaking and Interruption Behaviour of Pupils in Uruan Local Government Area. *South Asian Research Journal of Humanities and Social Sciences, 4*(3), 201-206. https://doi.org/10.36346/sarjhss.2022.v04i03.010

Otero-López, J. M., Castro, C., Villardefrancos, E., & Santiago, M. J. (2009). Job dissatisfaction and burnout in secondary school teachers: Students' disruptive behaviour and conflict management examined. European Journal of Education and Psychology, 2(2), 99–111. https://doi.org/10.30552/ejep.v2i2.25

Petrigna, L., Thomas, E., Brusa, J., Rizzo, F., Scardina, A., Galassi, C., Lo Verde, D., Caramazza, G., & Bellafiore, M. (2022). Does learning through movement improve academic performance in primary schoolchildren? A systematic review. *Frontiers in Pediatrics*, *10*, 841582. https://doi.org/10.3389/fped.2022.841582

Putsa, B., Jalayondeja, W., Mekhora, K., Bhuanantanondh, P., & Jalayondeja, C. (2022). Factors associated with reduced risk of musculoskeletal disorders among office workers: a cross-sectional study 2017 to 2020. BMC Public Health, 22(1), 1503. https://doi.org/10.1186/s12889-022-13940-0

Raspberry Pi. (n.d.-a). *Camera*. https://www.raspberrypi.com/documentation/accessories/camera.html

Raspberry Pi. (n.d.-b). *Raspberry Pi*. https://www.raspberrypi.com/

Resero. (n.d.). *Resero Group*. https://www.reserogroup.com/

Shoval, E., Sharir, T., Arnon, M., & Tenenbaum, G. (2018). The effect of integrating movement into the learning environment of kindergarten children on their academic achievements. *Early Childhood Education Journal*, *46*, 355-364. https://doi.org/10.1007/s10643-017-0870-x

Shumate, E. D., & Wills, H. P. (2010). Classroom-based functional analysis and intervention for disruptive and off-task behaviors. *Education and Treatment of Children, 33*(1), 23-48. https://doi.org/10.1353/etc.0.0088

Stanić, V., Žnidarič, T., Repovš, G., & Geršak, G. (2022). Dynamic Seat Assessment for Enabled Restlessness of Children with Learning Difficulties. *Sensors, 22*(9), 3170. https://doi.org/10.3390/s22093170

Starr, A., Haider, Z. F., & von Stumm, S. (2024). Do school grades matter for growing up? Testing the predictive validity of school performance for outcomes in emerging adulthood. *Developmental Psychology, 60*(4), 665–679. https://doi.org/10.1037/dev0001548

Tanoue, H., Mitsuhashi, T., Sako, S., Goto, R., Nakai, T., & Inaba, R. (2016). Effects of a dynamic chair on pelvic mobility, fatigue, and work efficiency during work performed while sitting: a comparison of dynamic sitting and static sitting. *Journal of Physical Therapy Science, 28*(6), 1759-1763. https://doi.org/10.1589/jpts.28.1759

Tu, Z., Li, Y., Geng, S., Zhou, K., Wang, R., & Dong, X. (2021). Human responses to high levels of carbon dioxide and air temperature. *Indoor Air, 31*(3), 872-886. https://doi.org/10.1111/ina.12769

Vehviläinen, T., Lindholm, H., Rintamäki, H., Pääkkönen, R., Hirvonen, A., Niemi, O., & Vinha, J. (2016). High indoor CO_2 concentrations in an office environment increases the transcutaneous CO_2 level and sleepiness during cognitive work. *Journal of Occupational and Environmental Hygiene, 13*(1), 19-29. https://doi.org/10.1080/15459624.2015.1076160

Velcro. (n.d.). *VELCRO® Brand Stick On Hook & Loop Dots*. https://www.velcro.com.au/products/adhesive-backed/velcro-brand-dots/

Waongenngarm, P., van der Beek, A. J., Akkarakittichoke, N., & Janwantanakul, P. (2021). Effects of an active break and postural shift intervention on preventing neck and low-back pain among high-risk office workers: a 3-arm cluster-randomized controlled trial. *Scandinavian Journal of Work, Environment & Health, 47*(4), 306. https://doi.org/10.5271/sjweh.3949

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*, 1-24. https://doi.org/10.1186/s12966-017-0569-9

Wells, S. L. (2012). Moving through the curriculum: The effect of movement on student learning, behavior, and attitude. *Rising Tide, 5*, 1-17. http://mat2012wells.pbworks.com/w/file/fetch/54431635/Wells,%20MRP.pdf

Wong, Z. Y., Liem, G. A. D., Chan, M., & Datu, J. A. D. (2024). Student engagement and its association with academic achievement and subjective well-being: A systematic review and meta-analysis. *Journal of Educational Psychology, 116*(1), 48–75. https://doi.org/10.1037/edu0000833

Woo, J., Rajagopalan, P., & Andamon, M. M. (2022). An evaluation of measured indoor conditions and student performance using d2 Test of Attention. *Building and Environment, 214*, 108940. https://doi.org/10.1016/j.buildenv.2022.108940

Zuniga, A. N., & Cividini-Motta, C. (2022). Using Class Pass Intervention to Decrease Disruptive Behavior in Young Children. *Journal of Behavioral Education*, *31*(3), 524-542. https://doi.org/10.1007/s10864-020-09411-4

Chapter 5: Study 3

Can Dynamic Chairs Improve the Academic Achievement of Students?

Study 3: Can Dynamic Chairs Improve the Academic Achievement of Students? is a manuscript submitted for publication in Learning Environments Research and formatted according to the journal's requirements.

Can Dynamic Chairs Improve the Academic Achievement of Students?

Isaac Martin, Angelika Anderson, Nicola Starkey

School of Psychological and Social Sciences, The University of Waikato, Hamilton, New Zealand

Author Note

Isaac Martin https://orcid.org/0009-0009-6183-3384

Angelika Anderson https://orcid.org/0000-0003-1156-4066

Nicola Starkey https://orcid.org/0000-0002-4370-8186

Correspondence concerning this article should be addressed to Isaac Martin. Email: im47@waikato.students.ac.nz

Statements and Declarations

Funding

This study received funding from Callaghan Innovation (contract number: FURNW2102) and research support from Resero in the form of supplying the BodyfurnFlex chairs.

Competing Interests

The authors declare that they have no competing interests.

Ethics Approval

The study received ethical approval from the University of Waikato Human Ethics Research Committee (Ref: FS2024-15).

Consent

Consent was obtained from participating teachers, students, and the parents/guardians of students.

Note

Callaghan Innovation (https://www.callaghaninnovation.govt.nz/).

Resero (https://www.reserogroup.com/). Resero is the parent company of Furnware (https://www.furnware.com/en-nz) who are the developers of BodyfurnFlex chairs.

Abstract

Recently many schools have begun to introduce dynamic seating options in an effort to improve learning in the classroom. In contrast to standard classroom chairs, which are typically inflexible and restrict movement, dynamic chairs are made to be flexible and encourage natural movements which is believed to improve comfort and in-turn achievement. The present study investigated if a new type of dynamic classroom chair, the BodyfurnFlex chair, could improve students' academic achievement and comfort in comparison to standard classroom chairs. A pre-post intervention between-groups design was used to track the academic progression of students across several mathematics assessments while focus group discussions were conducted to investigate participants' opinions of the chairs. The results revealed that there was no significant difference between the test grades of the control and intervention group. However, there were several indications that BodyfurnFlex chairs may have had a positive effect on the achievement of students, including the intervention group having a larger effect size and a higher percentage of students improving upon their baseline grades. Students reported far greater satisfaction with BodyfurnFlex chairs in comparison to the standard chairs, stating that they were more comfortable, functional, aided their ability to do their schoolwork and felt they had a positive effect on their test results. The findings indicate that BodyfurnFlex chairs can increase student comfort and satisfaction, and may be able to have a positive effect on academic achievement.

Keywords: dynamic chairs, academic achievement, physical learning environment, flexible furniture, classroom comfort, student perceptions

Introduction

Academic achievement plays a crucial role in enhancing an individual's overall quality of life (Edgerton et al., 2012; Starr et al., 2024). Higher academic performance is linked to better well-being (Nordlander & Stensöta, 2014), greater life satisfaction (Lettau, 2021), boosted self-esteem (Metsäpelto et al., 2020), expanded job opportunities and higher earnings (Hahn & Chattopadhyay, 2019; Lallukka et al., 2019), enhanced physical and mental health (Kosik et al., 2018; Lê-Scherban et al., 2014), promotion of economic growth (Heller-Sahlgren & Jordahl, 2024; Woesserman, 2016), and a decrease in crime rates (Lankester et al., 2025; Martins et al., 2022). A variety of personal/individual variables can affect academic performance, such as an individual's intelligence level (Lozano-Blasco et al., 2022; Roth et al., 2015), personality traits (Mammaddov, 2022), study habits (Elango & Manimozhi, 2021; Walck-Shannon et al., 2021), motivation (Kriegbaum et al., 2021), and attitude (Solpuk, 2017). While these personal factors can be difficult to change, there are numerous external/environmental factors related to academic achievement that can be modified. These include teaching style (Lopez-Martin et al., 2022), the overall school and classroom climate (Erdem et al., 2024), and the physical learning environment (Barrett et al., 2015; Byers, Mahat, et al., 2018; Cheryan et al., 2014; Fadhli et al., 2022; Opio et al., 2024). Several aspects of the physical environment, such as the classroom noise levels (Brill & Wang, 2021; Shield & Dockrell, 2008), temperature and air quality (Cho, 2017; Haverinen-Shaughnessy & Shaughnessy, 2015), classroom layout and seating arrangements (Byers, Imms, et al., 2018; Imms & Byers, 2017; Nja et al., 2023), and lighting type/intensity (Heschong et al., 2002; Mogas-Recalde & Palau, 2021), have all been shown to significantly affect students' academic performance.

A key aspect of the physical learning environment is classroom seating (Al-Hinai et al., 2018; Chen & Tsai, 2024; Harvey & Kenyon, 2013). Recently, many schools have started replacing traditional/standard chairs with dynamic/flexible seating options in an effort to enhance students' learning and comfort (Anderson & Hartley, 2018; Attai et al., 2021; Cole et al., 2021; Putman et al., 2024). Unlike standard classroom chairs, which are usually inflexible and limit movement, dynamic seating encourages flexibility and promotes active postural changes. Several studies have compared the effects of dynamic seating options and standard classroom chairs on the academic achievement of students (Fedewa et al., 2015; Joubert et al., 2017; Mead et al., 2016; Torbeyns et al., 2017). One study found that stability balls had no effect on the test scores of students in comparison to standard classroom chairs (Fedewa et al., 2015), while another found that they had a positive effect on a mathematics comprehension test but no effect on a mathematics academic progression test (Mead et al., 2016). Other studies have investigated the influence that cycle/bike chairs (a stationary chair with a bike pedal attached at the base which allows students to pedal while sitting at their desks) had on learning but found that they had no effect on the test scores of students in comparison to standard classroom chairs (Joubert et al., 2017; Torbeyns et al., 2017). After conducting a systematic review on the effects of dynamic seating interventions on academic outcomes, Rollo et al. (2017) concluded that there is currently no clear evidence that dynamic seating has a beneficial effect on the academic achievement of students. Rollo et al. (2017) also highlighted that dynamic seating other than stability balls and cycling chairs requires attention. While stability balls and cycle chairs are considered dynamic seating options (they promote and encourage movement), they are not directly comparable to dynamic chairs (an ergonomically designed chair that incorporates dynamic/flexible features). Furthermore, stability balls can have negative effects on the behaviour of students in mainstream classrooms, including reducing on-task behaviour (Fedewa et al., 2015; Hulac et al., 2020). Cycle chairs also present several shortcomings, including being uncomfortable (Fedewa et al., 2017), expensive (Torbeyns et al., 2017), and students having difficulty riding and engaging in class simultaneously (Polo-Recuro et al., 2021).

Research has shown that dynamic chairs can reduce discomfort/pain (Cardenas et al., 2024; Cardoso et al., 2021; Frey et al., 2021; Martin et al., 2025; Pennington & Putman, 2022), increase movement (Garcia et al., 2016; Grooten et al., 2017; Martin et al. 2025; Stanić et al., 2022; Tanoue et al., 2016), and lead to better satisfaction/perceptions of the learning environment (Attai et al., 2021; Martin et al., 2025; Pennington et al., 2022; Putman et al., 2024) in comparison to standard classroom chairs. Discomfort/pain can have a significant negative effect on academic achievement (Grimby-Ekman et a., 2018; Kosola et al., 2017; Ragnarsson et al., 2022; Voerman et al., 2017) while integrating movement into the classroom (Donnelly & Lambourne, 2011; Petrigna et al., 2022; Shoval et al., 2018; Watson et al., 2017) and better satisfaction/perceptions of the physical learning environment (Edgerton & McKechnie, 2023; Hopland & Nyhus, 2015; Opio et al., 2024; Salar et al., 2024) can have a significant positive effect on academic achievement. These findings indicate that the academic outcomes of students could be significantly improved by dynamic chairs. Martin et al. (2025) found that BodyfurnFlex chairs (a dynamic chair), significantly increased the movement of students in comparison to standard classroom chairs, and the majority of participants reported that they preferred BodyfurnFlex chairs and found them to be more comfortable. Furthermore, BodyfurnFlex chairs significantly improved on-task behaviour and decreased disruptive behaviour of students in comparison to standard classroom chairs. These findings suggest that BodyfurnFlex chairs may be able to improve the academic achievement of students without the negative behavioural effects of stability balls and the discomfort/cost effects associated with cycle chairs.

The present study compared the effect that dynamic and standard classroom chairs had on the academic achievement of students. Academic achievement was measured by tracking the progression/improvement of students across several mathematics assessments. Furthermore, focus group discussions were conducted to gather social validity data from students and teachers. Social validity data is essential for determining the acceptability of an intervention and whether participants found it valuable (Common & Lane, 2017; Ferguson & Cihon, 2021; Huntington et al., 2023). This is important because even if learning interventions are effective, they are only useful if teachers and students are willing to use/implement it.

Methods

Participants

Six Year 9 mathematics classes, consisting of students aged 13-14, participated in this study. Three classrooms were randomly assigned to the control group and the other three to the intervention group. Test grades were collected from a total of 172 students, with 87 in the control group and 85 in the intervention group.

At the end of the study, we invited teachers and students from the intervention group to take part in focus groups to discuss their views on the classroom chairs. Three teachers and six students from the intervention classrooms (18 students in total) volunteered to participate in the focus group discussions (participants from the control group only experienced the usual classroom chairs so were not included).

Passive consent was obtained from all students and their parents or guardians prior to data collection. Parents and/or children could opt to have their test data excluded from the study. Additional signed consent was obtained from the teachers, students, and the parents of students who participated in the focus group discussions.

Materials

Classroom Chairs

The dynamic chair used in this study was the BodyfurnFlex chair (Furnware, n.d.). The chair has a sled base with separate polypropylene (plastic) backrest and seat panels that move/pivot with the user and include an aeration pattern for ventilation and cooling (Figure 2). The chair stands 872mm tall with a seat height of 460mm. The seat panel measures 416mm x 431mm, the backrest panel is 374 x 350mm, and the base area is 495mm x 575mm.

The standard chair used in this study (Figure 2) was a standard monobloc polypropylene school chair that was 805mm tall and had a seat height of 460mm. The dimensions of the seat, backrest, and base area were 365mm x 415mm, 400mm x 345mm, and 485mm x 510mm, respectively.

Figure 1

Dynamic Chair

Figure 2

Standard Chair

Assessment

Students were taught following the New Zealand Curriculum (Ministry of Education, n.d.-b) guidelines as required by the Ministry of Education for all state schools in New Zealand. Data was collected for two separate mathematics subjects; Number and Algebra (Ministry of Education, n.d.-c). Students were assessed using e-asTTle (Ministry of Education, n.d.-a), an online assessment tool, that assigns students a grade based on the New Zealand Curriculum level system. A student receives a grade based on their level (1-10) and sub-level (Basic, Proficient, and Advanced). Based on the student's age (13-14 years old), students were expected to receive a grade within levels 3-6, with students who failed to meet the minimum grade (Level 3 Basic) assigned a Developing grade (i.e., fail) and students who achieved above the maximum grade (Level 6 Advanced) assigned a Beyond grade.

Focus Group Discussions

A total of four focus group discussions were conducted, one with the teachers and one with the students from each of the three intervention classrooms. Several different prompt questions were created by researchers to facilitate the focus group discussions, these were; You have now had the opportunity to try out two different types of chairs/have two different types of chairs in your classroom, what are your impressions of them?, How do you feel that the different chairs affected your/the students' behaviour?, How do you feel the different chairs affected your/the student's ability to do their schoolwork?, What effect do you think the different chairs had on your/the student's test scores?, Do you have any other comments/feedback about the chairs or the study?.

Focus group discussions were recorded using an android phone and then transferred to a password protected computer for transcription. The audio recordings were transcribed using Otter.ai (Otter.ai, n.d.), an automatic transcription software, and then checked, edited, and analysed by one of the researchers.

Procedures

Dependent Variable

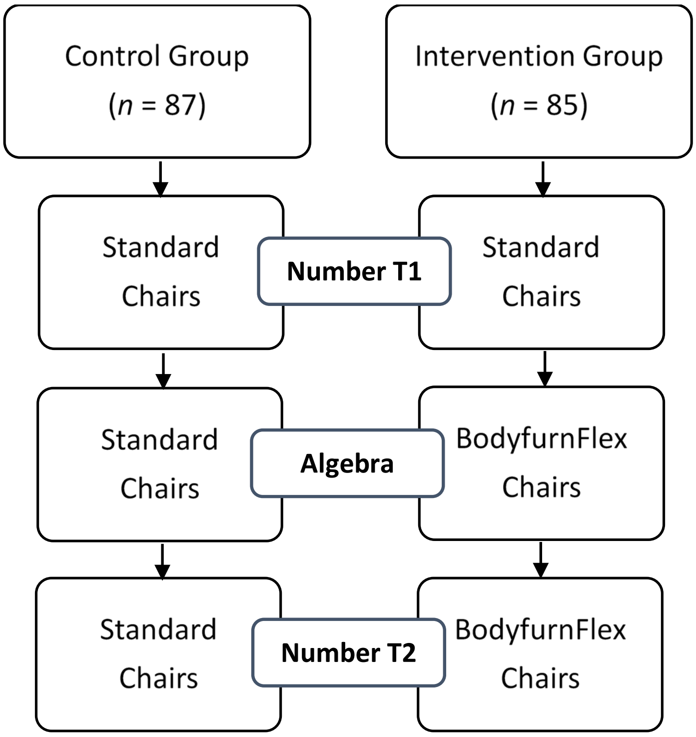
The dependent variable in this study was the test grades of students. Three different grades were collected for each student; Number test 1 (T1), Number test 2 (T2), and Algebra.

Experimental Design

A pre-post intervention between-groups design was used to compare the progression of students' Number grades (from T1 to T2) for the control and intervention groups. Both groups used the standard classroom chairs during the baseline (pre-intervention) condition, after which the intervention group switched to the BodyfurnFlex chairs while the control group continued to use the standard chairs. The Number T1 topic was taught during the pre-intervention condition, while Number T2 and Algebra was taught during the post-intervention condition (Figure 3).

Figure 3

Research Design



Data Collection

All classrooms followed the same learning and assessment schedule, being taught the subject material during the same time period and taking the e-asTTle test at the end of the teaching period (Table 1). Test grades were anonymised and shared with researchers after the completion of the final test (Number T2). Focus group discussions were conducted after the completion of the final test and were led by one of the researchers.

Table 1

Teaching Schedule

Subject	Start Date	End Date	Duration
Number T1	18 March 2024	5 April 2024	3 weeks
Algebra	22 July 2024	30 August 2024	6 weeks
Number T2	14 October 2024	1 November 2024	3 weeks

Coding of Data

Test grades were each assigned a numerical value for data analysis (Table 2).

Table 2

Test Grades and their Assigned Numerical Code

Grade	Code
Developing	0
Level 3 Basic	1
Level 3 Proficient	2
Level 3 Advanced	3
Level 4 Basic	4
Level 4 Proficient	5
Level 4 Advanced	6
Level 5 Basic	7
Level 5 Proficient	8
Level 5 Advanced	9
Level 6 Basic	10
Level 6 Proficient	11
Level 6 Advanced	12
Beyond	13

Data Analysis

The distribution of grades was presented using box-and-whisker plots for each test. The Mann-U Whitney test was used to compare the grades between the control and intervention group while the Wilcoxon signed-rank test was used to compare the T1 and T2 Number grades for each group. Key themes from the focus group discussions were summarised and supported with direct quotes.

Results

Number Grades

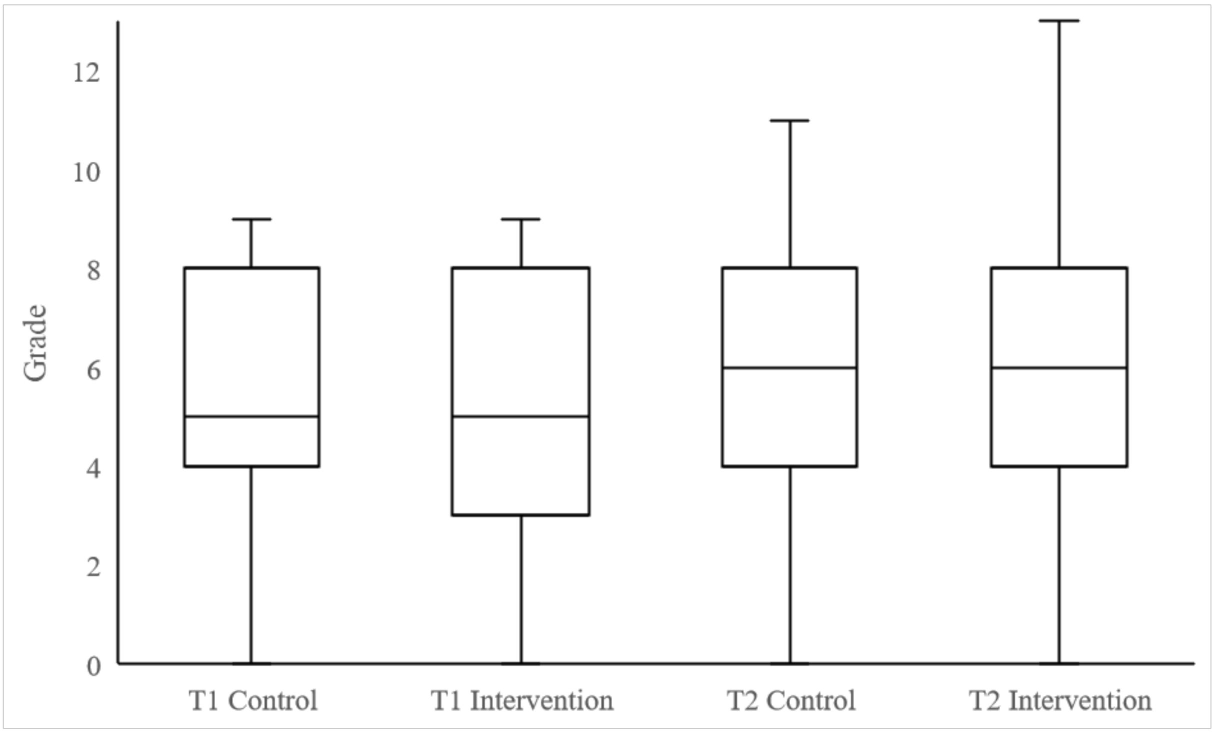
The distribution of the Number T1 and T2 grades for the control and intervention groups is displayed in figure 4.

As seen in figure 4, the Number T1 test the control group had a median grade of 5 (IQR: 4-8) while the intervention group also had a median grade of 5 (IQR: 3-8). The Mann-Whitney U test revealed that there was no significant difference between the Number T1 grades of the control and intervention groups (U = 3621, z = -0.24, p = .81, r = -0.02).

For the Number T2 test the control group had a median grade of 6 (IQR: 4-8) while the intervention group also had a median grade of 6 (IQR: 4-8). The Mann-Whitney U test revealed that there was no significant difference between the Number T2 grades of the control and intervention groups (U = 3654, z = -0.14, p = .89, r = 0.01).

Figure 4

Number T1 and T2 Grades for Control and Intervention Groups



The Wilcoxon signed-rank test revealed that there was a significant difference between the Number T1 and T2 grades for the control (z = -4.41, p < .01, r = .47) and intervention group (z = -5.02, p < .01, r = .54), with the control condition having a significant moderate positive effect on the academic progression of students while the intervention condition had a significant large positive effect on the academic progression of students.

The results also revealed that the percentage of students who improved upon their baseline grade (i.e., progressed) was higher for the intervention group (64.7%) than the control group (56.3%). Furthermore, the percentage of students that received a worse grade in Number T2 than T1 (i.e., regressed) was higher for the control group (16.1%) than the intervention group (12.9%) (Table 3).

Table 3

Academic Progression of Number Test Grades for Control and Intervention Groups

	Control (n = 87)	Intervention (n = 85)
Progressed	49 (56.3%)	55 (64.7%)
Regressed	14 (16.1%)	11 (12.9%)
No Difference	24 (27.6%)	19 (22.4%)

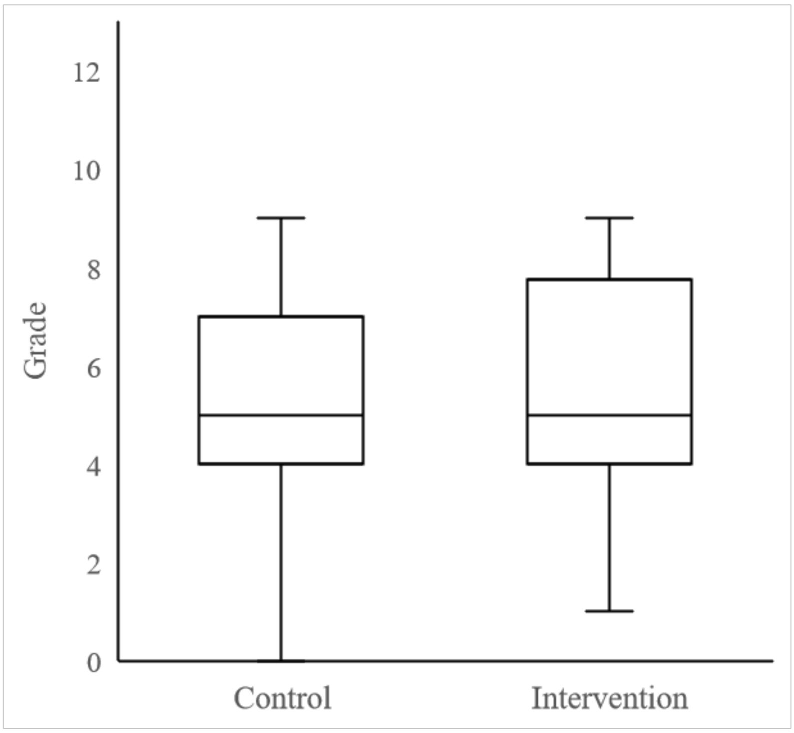
Algebra Grades

The distribution of the Algebra grades for the control and intervention groups is displayed in figure 5.

As shin in figure 5, the control group had a median grade of 5 (IQR: 4-7) for the Algebra test while the intervention group also had a median grade of 5 (IQR: 4-8). The Mann-Whitney U test revealed that there was no significant difference between the Algebra grades of the control and intervention groups (U = 3241, z = -0.52, p = .60, r = 0.04).

Figure 5

Algebra Grades for Control and Intervention Groups



Focus Group Discussions

Comfort

All students agreed that they preferred the BodyfurnFlex chairs in comparison to the standard classroom chairs, with the key reason being that they were more comfortable. One student stated, “Those chairs (standard) are just, you know, hard and sore. But this one (BodyfurnFlex chair), you can just get comfortable straight away.” This sentiment was reiterated by the teachers, with one teacher stating, “When there was a changeover of chairs, they (students) did make a lot of comments about liking the new chairs (BodyfurnFlex) and them being more comfortable.”

Pain was a common reason given for why the standard chairs were less comfortable than the BodyfurnFlex chairs, with one student stating, “They (BodyfurnFlex chairs) don’t make my butt hurt, like the other chairs (standard).” Another student explained, “Those chairs (standard) are really stiff and hurt your back.”

The ventilation provided by the BodyfurnFlex chairs was another common reason given by students for finding them more comfortable. One student explained, “These kind of chairs (BodyfurnFlex) have the holes and are not as sticky. Usually I get sweaty and stick to the other (standard) chairs when it’s hot, but not with these ones.”. This sentiment was echoed by the teachers who felt that the ventilation of the BodyfurnFlex chairs was not only beneficial for improving student comfort but also for removing potential embarrassment. One teacher stated in reference to the BodyfurnFlex chairs,

> The breathability of the chair, in terms of having the holes, means that they (students) are not sticking to their chair and needing to peel themselves off. So, it provides more personal comfort and that little bit more protection of dignity by not having that “kerrr” (sound of peeling off chair) when they get out of the chair. So, I think definitely that creates a situation for a little bit more confidence within the class in terms of, okay, I don’t need to constantly lift and get out of my chair to ensure that does not happen.”

However, the flexibility of the BodyfurnFlex chairs was the most frequent reason given for finding them more comfortable. In reference to the standard chairs, student explained, ‘They’re very uncomfortable, you can’t move around in them and you have to hunch at your desk. But if you lean forward with the other chairs (BodyfurnFlex) it goes with you and supports you.” The difference in movement/flexibility was also noticeable to the teachers, with one teacher stating: “I would say that they (students) definitely move a little bit more on these (BodyfurnFlex) chairs versus the normal (standard) ones.”

Functionality

The functionality of the chairs was another theme that appeared throughout all the discussions. Several students mentioned that they found the sled base of the BodyfurnFlex chair to be beneficial for being able to slide in and out from under the desks and to adjust position when needed. Conversely, the standard chairs cannot slide and require the students to get out of the chair to move it. When referring to the BodyfurnFlex chairs, one student mentioned, “They are easier to slide out from under the desk, because the other ones (standard chairs) are quite hard to pull out, but these ones are quite smooth.”.

One teacher also mentioned that the BodyfurnFlex chairs appeared to be more durable than the standard chairs. Noting that over time the standard chairs tend to bend out of shape when students rock on them, stating:

> “One thing I’ve noticed is that when students rock and play on them, especially the older heavier students, they bend. And so, within a couple years of having the chairs, they don't seem to last. So, then it creates this group of chairs that have been bent and you sit really awkwardly at a table. But I haven't noticed it (bending) happening to the new chairs (BodyfurnFlex).”

Effect on Schoolwork

The majority of the students, 14 out of 18 (77.8%), felt that the BodyfurnFlex chairs had a positive effect on their schoolwork in comparison to the standard classroom chairs. The other four students (22.2%) stated that they felt that the chairs didn't make a difference, with no students feeling the standard chairs made it easier to do their schoolwork. The most common reason given was that the improved comfort of the BodyfurnFlex chairs helped them to better focus on their work. One student explained, "I feel like I could concentrate on my work more because I wasn't focused on my posture and I was actually comfortable."

One student mentioned that they were able to get more work done in the BodyfurnFlex chairs because they didn't feel the need to leave their seat, stating, "I've been doing much more work honestly, because my butt is not numb and I don't have the need to want to get up walk around as much." Another student stated that they were able to get more work done in the BodyfurnFlex chairs because they were less likely to fidget:

> "Yes, because I don't know about you guys, but I like to fidget a lot. Having that extra little bit of wobble in the fern (Bodyfurn) chairs, I don't really need to like, fidget with others things like a pencil."

Some students also felt that the BodyfurnFlex chairs were less distracting by not making squeaking noises like the standard chairs when their legs scrape on the floor as students moved in them, with one student stating, "They are good for when you get up, they are not too loud when you slide out (from under the desk), so it doesn't disturb others."

Conversely, there were some students that felt the chairs didn't make a difference to their ability to do their schoolwork, with one student stating, "No, I don't really think a chair can help with that (doing schoolwork)."

The teachers stated that they didn't notice any observable difference between the standard and BodyfurnFlex chairs effect on the students doing their schoolwork. However, they did feel that BodyfurnFlex chairs were beneficial, in theory, with one teacher stating:

> "I can't say that I have noticed any difference. But if you're more comfortable, that should increase your likelihood of how well you can sit and actually keep your focus. So, I think theoretically there should be at least a small improvement."

Effect on Test Grades

The majority of students, 12 out of 18 (66.7%), also felt that BodyfurnFlex chairs had a positive effect on their test grades, while the other six (33.3%) felt like they didn't make a difference or were unsure. Of the students who felt the BodyfurnFlex chairs had a positive impact on their test grades, the general consensus was that they felt they got more work done in the BodyfurnFlex chairs and that translated to a better grade, with one student stating, "Yeah, I got a better score when I used the Bodyfurn chairs, at the start (T1) I got a 3B and then when we did it again (T2) I got a 4A.". When asked by the moderator why they thought that was, the student responded, "Because when you're more comfortable you can just get more work done and learn better." However, some students were unsure, with one student stating, "I got a better score (in T2), but I don't know if that was because of the chair".

The teachers were unsure whether the chairs made a meaningful impact on the test grades of the students with one teacher stating:

> "That's always a difficult question, because there's so many factors that go into learning. And it even comes down to, can we say that the student's improvement over the year is because the chairs have changed? Or is it that, just in general, students improve throughout the year. We're meant to see improvement. Whether or not we can say that that is because of the chairs, it's hard to say."

Discussion

The present study examined how BodyfurnFlex chairs impacted students' academic achievement and opinions/perceptions in comparison to standard classroom chairs. The results revealed that there was no significant difference in the grades between the control and intervention groups across all three tests, indicating that the chairs did not have a significant effect on the academic achievement of students. These results are consistent with other research that found dynamic seating options such as stability balls and cycle chairs had no significant effect on the test scores/grades of students (Fedewa et al., 2015; Joubert et al., 2017; Torbeyns et al., 2017). However, several limitations to the data may have prevented finding significant results. Firstly, the New Zealand Curriculum employs a level grading system (Ministry of Education, n.d.-b) which can make detecting small changes/differences difficult (Cain et al., 2022; Guskey & Bailey, 2001; Micha et al, 2015). Secondly, on average students displayed very little progression in their test grades from Number T1 to T2, with both groups showing a median grade increase of only one sub-level (from Level 4 Proficient to Level 4 Advanced). Such small academic progression makes it unlikely for an intervention effect to be detected. And thirdly, the teaching periods for each topic were relatively short, with students only being taught the subject material for 3-6 weeks before for each test/assessment. The short time period that students experienced the intervention made it less likely for academic progression to be seen (Watson et al., 2017).

Despite this, there were several indications that the BodyfurnFlex chairs may have had a positive effect on the academic performance of students. Firstly, although both groups showed significant improvement in the median grade from T1 to T2, the Wilcoxon signed-rank test revealed that there was a larger z-score for the intervention group ($z = -5.02$, $p < .01$) than the control group ($z = -4.41$, $p < .01$), indicating a larger difference between the T1 and T2 medians for the intervention group. Secondly, the results revealed that there was a larger effect size for the intervention group ($r = .54$) than the control group ($r = .46$), indicating the BodyfurnFlex chairs had a large positive effect on the test grades of students while the standard chairs had a moderate positive effect. Finally, a higher percentage of students from the intervention group (64.7%) improved upon their T1 Number test grade compared to the control group (56.4%). Although small differences, these results indicate that BodyfurnFlex chairs may be able to have a small positive effect on the academic achievement of students.

The focus groups revealed that all students who participated in the discussions preferred the BodyfurnFlex chairs and found them to be more comfortable than the standard classroom chairs. These results are consistent with the findings of Martin et al. (2025) who also found the majority of students preferred BodyfurnFlex chairs over standard classroom chairs. A number of students stated that the standard classroom chairs caused pain to their backside and/or back, which supports the current research that found dynamic/flexible seating options caused less pain and were more comfortable than traditional classroom chairs (Cardenas et al., 2024; Cardoso et al., 2021; Frey et al., 2021; Pennington et al., 2022). However, the most common reason given for why the BodyfurnFlex chairs were more comfortable was their flexibility. Students explained that being able to move and adjust positions freely enabled them to be more comfortable and better focus on their work. Considering that discomfort/pain are negatively associated with academic achievement (Grimby-Ekman et a., 2018; Kosola et al., 2017; Ragnarsson et al., 2022; Voerman et al., 2017) and students who express better perceptions/satisfaction with their physical learning environment have significantly better academic outcomes (Edgerton & McKechnie, 2023; Hopland & Nyhus, 2015; Opio et al., 2024; Salar et al., 2024), these findings support the hypothesis that BodyfurnFlex chairs could have a positive effect on the academic achievement of students in comparison to standard classroom chairs.

The majority of students (77.8%) reported that they felt the BodyfurnFlex chairs had a positive effect on their ability to do their schoolwork. A number of students mentioned that they felt they were able to get more work done in the BodyfurnFlex chairs for several different reasons, including; not feeling the need to leave their seat because of discomfort/pain, reducing fidgeting, and not being distracted by other students squeaking on the standard chairs. These findings are consistent with Martin et al. (2025) who found the majority of students reported that BodyfurnFlex chairs made it easier to complete their schoolwork and that BodyfurnFlex chairs resulted in a significant decrease in out-of-seat behaviour and instances of students being disrupted/distracted from their work. The majority of students (66.7%) also stated that they felt BodyfurnFlex chairs had a positive effect on their test results. Many participants stated that the BodyfurnFlex chairs were part of the reason why they received a better grade in the Number T2 test, feeling that because they could get more work done during class they were better prepared for the test. These findings support the hypothesis that BodyfurnFlex chairs can make a meaningful impact on the learning and achievement of students in comparison to standard classroom chairs.

Research Implications

While there is research that examines the effect that alternative dynamic seating options such as stability balls (Fedewa et al., 2015; Mead et al., 2016) and cycle chairs (Joubert et al., 2017; Torbeyns et al., 2017) have on the academic achievement of students, there is currently no research on the effect that dynamic chairs have on the achievement of students (Rollo et al., 2019). This study fills an important gap in the literature by evaluating the effect that dynamic chairs have on the academic achievement, progression, and perceptions of students in comparison to traditional classroom chairs.

Although the results did not find any conclusive evidence that BodyfurnFlex chairs could significantly improve the test grades of students, there were several indications that they could have a positive effect on their academic achievement. Considering that better academic achievement is associated with significantly improved personal (Edgerton et al., 2012; Starr et al., 2024) and societal benefits (Heller-Sahlgren & Jordahl, 2024; Lankester et al., 2025; Martins et al., 2022; Woesserman, 2016), these findings suggest that BodyfurnFlex chairs could be an important tool/intervention.

In addition to academic achievement, musculoskeletal pain, which is a prevalent issue among students (Chambers et al., 2024; Gogoi et al., 2024; Kandasamy et al., 2024; Minghelli, 2020; Ogunlana et al., 2021), can also have a significant effect on students’ quality of life and is associated with depression, physiological distress, and poor sleep quality (Alsaadi, 2022; Kitiş et al., 2017). Furthermore, student satisfaction is associated with better school involvement/engagement (Bălţătescu, & Cernea-Radu, 2025; Elmore & Huebner, 2010). The findings of this study suggest that BodyfurnFlex chairs may be able to improve student’s quality of life and increase school engagement by reducing pain and improving student satisfaction.

Research Limitations

As discussed earlier, a key limitation in this study was the level grading system used to assess the students and the relatively short teaching periods before each test. Unfortunately, because all state schools in New Zealand are required to utilise this curriculum and assessment procedure (Te Kete Ipurangi, 2009), this left no room for the researchers to assess longer teaching periods and implement different assessment procedures such as percentage-based testing. Furthermore, the relatively limited academic progression shown by the students greatly limited the results of this study.

Another limitation was that there was no baseline data for the Algebra test. Because there was no pre-intervention test for Algebra, this meant that academic progression could only be analysed for the Number topic. Finally, only one school subject (mathematics), age group of students (13-14 years old), and type of dynamic chair were assessed during this study.

Future Directions

Considering that this study could not find any conclusive evidence that dynamic chairs can significantly improve the academic achievement of students, due to limitations around the data, the impact of dynamic chairs on the academic achievement of students requires further investigation. Future research should look to use percentage-based testing, longer teaching periods, and include different subjects/age groups of participants, in particular students with learning difficulties who have been shown to significantly benefit from dynamic seating interventions (Brennan & Crosland, 2021; Fedewa & Erwin, 2011; Krombach & Miltenberger, 2020; Matin Sadr et al., 2017; Schilling & Schwartz, 2004). Future research should also consider the use of progress monitoring tools/tests which are more likely to show improvement in academic achievement of short-term interventions than standardised tests which are not sensitive to short-term progress (Watson et al., 2017).

Conclusion

The study's findings suggest that BodyfurnFlex chairs may serve as a practical solution for enhancing student comfort, satisfaction, and overall learning experience by encouraging healthy movement through active sitting. While the results did not provide strong evidence that these chairs directly impact students' test scores, there are hints that they might positively influence academic performance, which calls for further investigation.

References:

Al-Hinai, N., Al-Kindi, M., & Shamsuzzoha, A. (2018). An ergonomic student chair design and engineering for classroom environment. *International Journal of Mechanical Engineering and Robotics Research, 7*(5), 534-543. http://dx.doi.org/10.18178/ijmerr.7.5.534-543

Alsaadi, S. M. (2022). Musculoskeletal pain in undergraduate students is significantly associated with psychological distress and poor sleep quality. *International Journal of Environmental Research and Public Health*, *19*(21), 13929. https://doi.org/10.3390/ijerph192113929

Anderson, P. J., & Hartley, M. L. (2018). Flexible seating: Let's get the wiggles out*. Tennessee Educational Leadership*, *46*(10, 55-60. https://www.apsu.edu/education/tel_issues/TEL46-1.pdf#page=55

Attai, S. L., Reyes, J. C., Davis, J. L., York, J., Ranney, K., & Hyde, T. W. (2021). Investigating the impact of flexible furniture in the elementary classroom. *Learning Environments Research, 24*(2), 153-167. https://doi.org/10.1007/s10984-020-09322-1

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. *Building and Environment*, *89*, 118-133. https://doi.org/10.1016/j.buildenv.2015.02.013

Bălţătescu, S., & Cernea-Radu, A. E. (2025). Age-related variations in school satisfaction: The mediating role of school engagement. *Hungarian Educational Research Journal*, *15*(1), 67-87. https://doi.org/10.1556/063.2024.00302

Brennan, J., & Crosland, K. (2021). Evaluating the use of stability ball chairs for children with ASD in a clinic setting. *Behavior Analysis in Practice, 14*, 1079-1084. https://doi.org/10.1007/s40617-021-00606-3

Brill, L. C., & Wang, L. M. (2021). Higher sound levels in K-12 classrooms correlate to lower math achievement scores. *Frontiers in Built Environment*, *7*, 688395. https://doi.org/10.3389/fbuil.2021.688395

Byers, T., Imms, W., & Hartnell-Young, E. (2018). Comparative analysis of the impact of traditional versus innovative learning environment on student attitudes and learning outcomes. *Studies in Educational Evaluation*, *58*, 167-177. https://doi.org/10.1016/j.stueduc.2018.07.003

Byers, T., Mahat, M., Liu, K., Knock, A., & Imms, W. (2018). Systematic Review of the Effects of Learning Environments on Student Learning Outcomes. Melbourne: University of Melbourne, LEaRN. http://www.iletc.com.au/publications/reports

Cain, J., Medina, M., Romanelli, F., & Persky, A. (2022). Deficiencies of traditional grading systems and recommendations for the future. *American Journal of Pharmaceutical Education, 86*(7), 8850. https://doi.org/10.5688/ajpe8850

Cardenas, A., Albert, W., Leger, M., Dion, C., & Cardoso, M. (2024). Effects of implementing an active sitting protocol compared to using a traditional office chair and standing workstation. *International Journal of Industrial Ergonomics, 101*, 103587. https://doi.org/10.1016/j.ergon.2024.103587

Cardoso, M. R., Cardenas, A. K., & Albert, W. J. (2021). A biomechanical analysis of active vs static office chair designs. *Applied Ergonomics*, *96*, 103481. https://doi.org/10.1016/j.apergo.2021.103481

Castro, M., Expósito-Casas, E., López-Martín, E., Lizasoain, L., Navarro-Asencio, E., & Gaviria, J. L. (2015). Parental involvement on student academic achievement: A meta-analysis. *Educational Research Review*, *14*, 33-46. https://doi.org/10.1016/j.edurev.2015.01.002

Chambers, C. T., Dol, J., Tutelman, P. R., Langley, C. L., Parker, J. A., Cormier, B. T., Macfarlane, G. J., Jones, G. T., Chapman, D., Proudfoot, N. and Grant, A., & Marianayagam, J. (2024). The prevalence of chronic pain in children and adolescents: a systematic review update and meta-analysis. *Pain*, *165*(10), 2215-2234. https://doi.org/10.1097/j.pain.0000000000003267

Chen, H. F., & Tsai, C. Y. (2024). The Impact of School Classroom Chair Depth and Height on Learning Tasks. *Education Sciences*, *14*(6), 661. https://doi.org/10.3390/educsci14060661

Cheryan, S., Ziegler, S. A., Plaut, V. C., & Meltzoff, A. N. (2014). Designing classrooms to maximize student achievement. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 4-12. https://doi.org/10.1177/2372732214548677

Cho, H. (2017). The effects of summer heat on academic achievement: A cohort analysis. *Journal of Environmental Economics and Management*, *83*, 185-196. https://doi.org/10.1016/j.jeem.2017.03.005

Cole, K., Schroeder, K., Bataineh, M., & Al-Bataineh, A. (2021). Flexible Seating Impact on Classroom Environment. *Turkish Online Journal of Educational Technology, 20*(2), 62-74. https://files.eric.ed.gov/fulltext/EJ1304613.pdf

Common, E. A., & Lane, K. L. (2017). Social validity assessment. In J. K. Luiselli (Eds), *Applied Behavior Analysis Advanced Guidebook* (pp. 73-92). Academic Press. https://doi.org/10.1016/B978-0-12-811122-2.00004-8

Donnelly, J. E., & Lambourne, K. (2011). Classroom-based physical activity, cognition, and academic achievement. *Preventive Medicine*, *52*, S36-S42. https://doi.org/10.1016/j.ypmed.2011.01.021

Edgerton, E., & McKechnie, J. (2023). The relationship between student's perceptions of their school environment and academic achievement. *Frontiers in Psychology, 13*, 959259. https://doi.org/10.3389/fpsyg.2022.959259

Edgerton, J. D., Roberts, L. W., & von Below, S. (2012). Education and Quality of Life. In K. C. Land, A. C. Michalos, & M. J. Sirgy (Eds.), *Handbook of Social Indicators and Quality of Life Research* (pp. 265-296). Springer Netherlands. https://doi.org/10.1007/978-94-007-2421-1_12

Elango, M., & Manimozhi, G. (2021). Meta analysis of study habits and academic achievement. *Shanlax International Journal of Arts, Science and Humanities, 8*(4), 139-145. https://doi.org/10.34293/sijash.v8i4.3722

Elmore, G. M., & Huebner, E. S. (2010). Adolescents' satisfaction with school experiences: Relationships with demographics, attachment relationships, and school engagement behavior. *Psychology in the Schools*, *47*(6), 525-537. https://doi.org/10.1002/pits.20488

Erdem, C., & Kaya, M. (2024). The relationship between school and classroom climate, and academic achievement: A meta-analysis. *School Psychology International*, *45*(4), 380-408. https://doi.org/10.1177/01430343231202923

Fadhli, R., Komariah, A., Munir, A. B., Kurniady, D. A., & Thahir, M. (2022). Factors that influence student’s achievement. *Journal of Positive School Psychology*, *6*(4), 5931-5944. http://184.168.115.16/index.php/jpsp/article/view/4387

Fedewa, A., Abel, M., & Erwin, H. E. (2017). The effects of using stationary bicycle desks in classrooms on adolescents’ physical activity. *Journal of Occupational Therapy, Schools, & Early Intervention*, *10*(1), 78-89. https://doi.org/10.1080/19411243.2016.1266457

Fedewa, A., Davis, M. A., & Ahn, S. (2015). Effects of stability balls on children’s on-task behavior, academic achievement, and discipline referrals: A randomized controlled trial*. The American Journal of Occupational Therapy, 69*(2), 6902220020p1-6902220020p9. https://doi.org/10.5014/ajot.2015.014829

Fedewa, A. L., & Erwin, H. E. (2011). Stability balls and students with attention and hyperactivity concerns: Implications for on-task and in-seat behavior. *The American Journal of Occupational Therapy*, *65*(4), 393-399. https://doi.org/10.5014/ajot.2011.000554

Ferguson, J.L., & Cihon, J.H. (2021). Social Validity. In F. R. Volkmar (Eds), *Encyclopedia of Autism Spectrum Disorders* (pp. 4487–4490). Springer, Cham. https://doi.org/10.1007/978-3-319-91280-6_102237

Frey, M., Barrett, M., & De Carvalho, D. (2021). Effect of a dynamic seat pan design on spine biomechanics, calf circumference and perceived pain during prolonged sitting. *Applied Ergonomics, 97*, 103546. https://doi.org/10.1016/j.apergo.2021.103546

Furnware. (n.d.). BodyfurnFlex Sled Chair. https://www.furnware.com/en-nz/products/bodyfurn-flex/bodyfurn-flex-sled-chair

Garcia, J. M., Huang, T. T., Trowbridge, M., Weltman, A., & Sirard, J. R. (2016). Comparison of the effects of stable and dynamic furniture on physical activity and learning in children. *The Journal of Primary Prevention*, *37*, 555-560. https://doi.org/10.1007/s10935-016-0451-6

Gogoi, P., Bhattacharyya, N. C. & Saikia, K. C. (2024). The prevalence of musculoskeletal pain among school students and its association with physical fitness in Guwahati urban society: a cross sectional study. *Bulletin of Faculty of Physical Therapy, 29*(1), 49. https://doi.org/10.1186/s43161-024-00215-5

Grimby-Ekman, A., Åberg, M., Torén, K., Brisman, J., Hagberg, M., & Kim, J. L. (2018). Pain could negatively affect school grades-Swedish middle school students with low school grades most affected. *PloS one*, *13*(12), e0208435. https://doi.org/10.1371/journal.pone.0208435

Grooten, W. J., Äng, B. O., Hagströmer, M., Conradsson, D., Nero, H., & Franzén, E. (2017). Does a dynamic chair increase office workers' movements?–results from a combined laboratory and field study. *Applied Ergonomics, 60*, 1-11. https://doi.org/10.1016/j.apergo.2016.10.006

Guskey, T. R., & Bailey, J. M. (2001). *Developing Grading and Reporting Systems for Student Learning*. Corwin Press. https://us.sagepub.com/en-us/nam/book/developing-grading-and-reporting-systems-student-learning

Hahn, R. A., & Chattopadhyay, S. K. (2019). Linking studies to assess the life expectancy associated with eighth grade school achievement. *Preventive Medicine Reports*, *16*, 100980. https://doi.org/https://doi.org/10.1016/j.pmedr.2019.100980

Harvey, E. J., & Kenyon, M. C. (2013). Classroom seating considerations for 21st century students and faculty. *Journal of Learning Spaces, 2*(1). https://libjournal.uncg.edu/jls/article/view/578

Haverinen-Shaughnessy, U., & Shaughnessy, R. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PloS one*, *10*(8), e0136165. https://doi.org/10.1371/journal.pone.0136165

Heller-Sahlgren, G., & Jordahl, H. (2024). Test scores and economic growth: update and extension. *Applied Economics Letters*, *31*(11), 1024-1027. https://doi.org/10.1080/13504851.2023.2168604

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting impacts on human performance in school. *Journal of the Illuminating Engineering Society*, *31*(2), 101-114. https://doi.org/10.1080/00994480.2002.10748396

Hopland, A. O., & Nyhus, O. H. (2015). Does student satisfaction with school facilities affect exam results? An empirical investigation. *Facilities*, *33*(13/14), 760-774. https://doi.org/10.1108/F-09-2014-0076

Hulac, D. M., Mickelson, L. R., Briesch, A. M., Maroeca, H., Hartjes, C., Anderson, K., & Ederveen, K. (2020). Stability balls and student on-task behavior. *Journal of Behavioral Education*, 1-18. https://doi.org/10.1007/s10864-020-09412-3

Huntington, R. N., Badgett, N. M., Rosenberg, N. E., Greeny, K., Bravo, A., Bristol, R. M., ... & Park, M. S. (2023). Social validity in behavioral research: A selective review. *Perspectives on Behavior Science, 46*(1), 201-215. https://doi.org/10.1007/s40614-022-00364-9

Imms, W., & Byers, T. (2017). Impact of classroom design on teacher pedagogy and student engagement and performance in mathematics. *Learning Environments Research, 20*, 139-152. https://doi.org/10.1007/s10984-016-9210-0

Joubert, L., Kilgas, M., Riley, A., Gautam, Y., Donath, L., & Drum, S. (2017). In-class cycling to augment college student academic performance and reduce physical inactivity: Results from an RCT. *International Journal of Environmental Research and Public Health*, *14*(11), 1343. https://doi.org/10.3390/ijerph14111343

Kandasamy, G., Almanasef, M., Almeleebia, T., Orayj, K., Shorog, E., Alshahrani, A. M., Prabahar, K., Veeramani, V. P., Amirthalingam, P., Alqifari, S. F., Alrashidi, F., Aldurum, M., Almutiri, F., Alzaidi, A., & Almutairi, F. (2024). Prevalence of musculoskeletal pain among undergraduate students. *Frontiers in Medicine*, *11*, 1403267. https://doi.org/10.3389/fmed.2024.1403267

Kitiş, A., Büker, N., Ünal, A., & Şavkın, R. (2017). Effects of musculoskeletal system problems on quality of life and depression in students preparing for university entrance exam. *The Korean Journal of Pain*, *30*(3), 192. https://doi.org/10.3344/kjp.2017.30.3.192

Kosik, R., Mandell, G., Fan, A. P., Nguyen, T., Chen, J., & Eaton, W. (2018). The association between childhood educational attainment and adult mental health and status: A thirty-year longitudinal follow up study. *The European Journal of Psychiatry*, *32*(2), 53-62. https://doi.org/10.1016/j.ejpsy.2018.01.001

Kosola, S., Mundy, L. K., Sawyer, S. M., Canterford, L., van der Windt, D. A., Dunn, K. M., & Patton, G. C. (2017). Pain and learning in primary school: a population-based study. *Pain*, *158*(9), 1825-1830. https://doi.org/10.1097/j.pain.0000000000000984

Kriegbaum, K., Becker, N., & Spinath, B. (2018). The relative importance of intelligence and motivation as predictors of school achievement: A meta-analysis. *Educational Research Review, 25*, 120-148. https://doi.org/10.1016/j.edurev.2018.10.001

Krombach, T., & Miltenberger, R. (2020). The effects of stability ball seating on the behavior of children with autism during instructional activities. *Journal of Autism and Developmental Disorders, 50*, 551-559. https://doi.org/10.1007/s10803-019-04283-8

Lallukka, T., Kerkelä, M., Ristikari, T., Merikukka, M., Hiilamo, H., Virtanen, M., Øverland, S., Gissler, M., & Halonen, J. I. (2019). Determinants of long-term unemployment in early adulthood: A Finnish birth cohort study. SSM-population health, 8, 100410. https://doi.org/10.1016/j.ssmph.2019.100410

Lankester, M., Coles, C., Trotter, A., Scott, S., Downs, J., Dickson, H., & Wickersham, A. (2025). The Association Between Academic Achievement and Subsequent Youth Offending: A Systematic Review and Meta-Analysis. *Journal of Developmental and Life-Course Criminology*, 1-24. https://doi.org/10.1007/s40865-025-00266-9

Lê-Scherban, F., Roux, A. V. D., Li, Y., & Morgenstern, H. (2014). Does academic achievement during childhood and adolescence benefit later health?. *Annals of Epidemiology*, *24*(5), 344-355. https://doi.org/10.1016/j.annepidem.2014.02.008

Lettau, J. (2021). The Impact of Children's Academic Competencies and School Grades on their Life Satisfaction: What Really Matters? *Child Indicators Research*, *14*(6), 2171-2195. https://doi.org/https://doi.org/10.1007/s12187-021-09830-3

Liu, J., Peng, P., Zhao, B., & Luo, L. (2022). Socioeconomic status and academic achievement in primary and secondary education: A meta-analytic review. *Educational Psychology Review, 34*(4), 2867-2896. https://doi.org/10.1007/s10648-022-09689-y

López-Martín, E., Gutiérrez-de-Rozas, B., González-Benito, A. M., & Expósito-Casas, E. (2023). Why do teachers matter? A meta-analytic review of how teacher characteristics and competencies affect students' academic achievement. *International Journal of Educational Research, 120*, 102199. https://doi.org/10.1016/j.ijer.2023.102199

Lozano-Blasco, R., Quílez-Robres, A., Usán, P., Salavera, C., & Casanovas-López, R. (2022). Types of intelligence and academic performance: A systematic review and meta-analysis. *Journal of Intelligence, 10*(4), 123. https://doi.org/10.3390/jintelligence10040123

Mammadov, S. (2022). Big Five personality traits and academic performance: A meta-analysis. *Journal of Personality, 90*(2), 222-255. https://doi.org/10.1111/jopy.12663

Martin, I., Anderson, A., & Starkey, N. (2025). *The Effect of BodyfurnFlex Chairs on the Movement and Behaviour of Students.* [Manuscript submitted for publication].

Martins, R. C., Gonçalves, H., Blumenberg, C., Könsgen, B., Houvèssou, G. M., Carone, C., Gill, J. D., Lautenschläger, P., Wehrmeister, F.C., Menezes, A. M. B., & Murray, J. (2022). School performance and young adult crime in a Brazilian birth cohort. *Journal of Developmental and Life-Course Criminology*, *8*(4), 647-668. https://doi.org/10.1007/s40865-022-00214-x

Matin Sadr, N., Haghgoo, H. A., Samadi, S. A., Rassafiani, M., Bakhshi, E., & Hassanabadi, H. (2017). The Impact of Dynamic Seating on Classroom Behavior of Students with Autism Spectrum

Disorder. *Iranian Journal of Child Neurology, 11*(1), 29-36. https://doi.org/10.22037/ijcn.v11i1.11193

Mead, T., Scibora, L., Gardner, J., & Dunn, S. (2016). The impact of stability balls, activity breaks, and a sedentary classroom on standardized math scores. *Physical Educator*, *73*(3), 433. https://doi.org/10.18666/TPE-2016-V73-I3-5303

Metsäpelto, R. L., Zimmermann, F., Pakarinen, E., Poikkeus, A. M., & Lerkkanen, M. K. (2020). School grades as predictors of self-esteem and changes in internalizing problems: A longitudinal study from fourth through seventh grade. *Learning and Individual Differences*, *77*, 101807. https://doi.org/https://doi.org/10.1016/j.lindif.2019.101807

Micha, E., Sekar, S., & Shah, N. (2024). What is best for students, numerical scores or letter grades?. *arXiv:2406.15405*. https://doi.org/10.48550/arXiv.2406.15405

Minghelli, B. (2020). Musculoskeletal spine pain in adolescents: Epidemiology of non-specific neck and low back pain and risk factors. *Journal of Orthopaedic Science*, *25*(5), 776-780. https://doi.org/10.1016/j.jos.2019.10.008

Minstry of Education. (n.d.-a). e-asTTle – Overview and access. https://newzealandcurriculum.tahurangi.education.govt.nz/e-asttle-overview-and-access/5637219681.p

Ministry of Education. (n.d.-b). The New Zealand Curriculum. https://newzealandcurriculum.tahurangi.education.govt.nz/

Ministry of Education. (n.d.-c). The New Zealand Curriculum - Mathematics and Statistics. https://newzealandcurriculum.tahurangi.education.govt.nz/the-new-zealand-curriculum---mathematics-and-statistics/5637209905.p

Mogas-Recalde, J., & Palau, R. (2021). Classroom lighting and its effect on student learning and performance: Towards smarter conditions. In *Ludic, Co-Design and Tools Supporting Smart Learning Ecosystems and Smart Education: Proceedings of the 5th International Conference* *on Smart Learning Ecosystems and Regional Development* (pp. 3-12). Springer Singapore. https://doi.org/10.1007/978-981-15-7383-5_1

Nja, C. O., Anari, M. I., Erim, C. M., Idiege, K. J., Ilhami, A., Ukah, J. U., ... & Cornelius-Ukpepi, B. U. (2023). Learning space, students' collaboration, educational outcomes, and interest: Exploring the physical, social and psychological mediators. *Heliyon*, *9*(4), e15456. https://doi.org/10.1016/j.heliyon.2023.e15456

Nordlander, E., Stensöta, H. O. (2014). Grades – for Better or Worse? The Interplay of School Performance and Subjective Well-Being Among Boys and Girls. *Child Indicators Research, 7*, 861–879. https://doi.org/10.1007/s12187-014-9233-y

Ogunlana, M. O., Govender, P., & Oyewole, O. O. (2021). Prevalence and patterns of musculoskeletal pain among undergraduate students of occupational therapy and physiotherapy in a South African university. *Hong Kong Physiotherapy Journal*, *41*(01), 35-43. https://doi.org/10.1142/S1013702521500037

Opio, G., Ofoyuru, D. T., Hoppers, C. . A. O., Odama, S., Ogwang, T. H., & Monk, D. (2024). The Relationship Between Physical Learning Environment and Academic Achievement of Learners in Inclusion: Across-Sectional Survey with Secondary School Students in Uganda. *Advances in Social Sciences and Management*, *2*(1), 62–72. https://hspublishing.org/ASSM/article/view/347

Otter.ai. (n.d.). Otter.ai. https://otter.ai/

Pennington, C., Putman, R., & Munsey, B. (2022). An examination of flexible seating in the higher education classroom from a physical and kinesthetic perspective. *Journal of Learning Spaces*, *11*(2). https://libjournal.uncg.edu/jls/article/view/2257

Petrigna, L., Thomas, E., Brusa, J., Rizzo, F., Scardina, A., Galassi, C., Lo Verde, D., Caramazza, G., & Bellafiore, M. (2022). Does learning through movement improve academic performance in primary schoolchildren? A systematic review. *Frontiers in Pediatrics*, *10*, 841582. https://doi.org/10.3389/fped.2022.841582

Polo-Recuero, B., Rojo-Tirado, M. Á., Ordóñez-Dios, A., Breitkreuz, D., & Lorenzo, A. (2021). The effects of bike desks in formal education classroom-based physical activity: a systematic review. *Sustainability*, *13*(13), 7326. https://doi.org/10.3390/su13137326

Putman, R. S., Pennington, C. G., Munsey, B. A., Hurless, N., Hill, J. W., & Labansat, H. A. (2024). Does this chair make me look smart? An examination of flexible seating in the higher education classroom. *Learning Environments Research*, 1-19. https://doi.org/10.1007/s10984-024-09509-w

Ragnarsson, S., Johansson, K., Bergström, E., Sjöberg, G., Hurtig, A. K., & Petersen, S. (2022). Recurrent pain in school-aged children: a longitudinal study focusing on the relation to academic achievement. *Pain*, *163*(11), 2245-2253. https://doi.org/10.1097/j.pain.0000000000002625

Rollo, S., Crutchlow, L., Nagpal, T. S., Sui, W., & Prapavessis, H. (2019). The effects of classroom-based dynamic seating interventions on academic outcomes in youth: A systematic review. *Learning Environments Research, 22*(2), 153-171. https://doi.org/10.1007/s10984-018-9271-3

Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., & Spinath, F. M. (2015). Intelligence and school grades: A meta-analysis. *Intelligence, 53*, 118-137. https://doi.org/10.1016/j.intell.2015.09.002

Salar, M., Ragandang, E. F., Orpilla, M. Q., Pagara, P. G., Cabana, S., Paderna, L. J., & Quiño-Justol, J. (2024). Oplan Baklas: Examining the Impact of Classroom Design on the Academic Performance of Grade 3 Learners. *Universal International Journal of Research and Technology*, *5*(8), 108-116. https://uijrt.com/paper/oplan-baklas-examining-impact-classroom-design-academic-performance-grade-3-learners

Schilling, D. L., & Schwartz, I. S. (2004). Alternative seating for young children with autism spectrum disorder: Effects on classroom behavior. *Journal of Autism and Developmental Disorders, 34*(4), 423-432. https://doi.org/10.1023/B:JADD.0000037418.48587.f4

Shield, B. M., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *The Journal of the Acoustical Society of America*, *123*(1), 133-144. https://doi.org/10.1121/1.2812596

Shoval, E., Sharir, T., Arnon, M., & Tenenbaum, G. (2018). The effect of integrating movement into the learning environment of kindergarten children on their academic achievements. *Early Childhood Education Journal*, *46*, 355-364. https://doi.org/10.1007/s10643-017-0870-x

Sölpük, N. (2017). The Effect of Attitude on Student Achievement. In: Karadag, E. (eds) *The Factors Effecting Student Achievement* (pp. 57-73). Springer, Cham. https://doi.org/10.1007/978-3-319-56083-0_4

Stanić, V., Žnidarič, T., Repovš, G., & Geršak, G. (2022). Dynamic Seat Assessment for Enabled Restlessness of Children with Learning Difficulties. *Sensors, 22*(9), 3170. https://doi.org/10.3390/s22093170

Starr, A., Haider, Z. F., & von Stumm, S. (2024). Do school grades matter for growing up? Testing the predictive validity of school performance for outcomes in emerging adulthood. *Developmental Psychology, 60*(4), 665–679. https://doi.org/10.1037/dev0001548

Tanoue, H., Mitsuhashi, T., Sako, S., Goto, R., Nakai, T., & Inaba, R. (2016). Effects of a dynamic chair on pelvic mobility, fatigue, and work efficiency during work performed while sitting: a comparison of dynamic sitting and static sitting. *Journal of Physical Therapy Science, 28*(6), 1759-1763. https://doi.org/10.1589/jpts.28.1759

Te Kete Ipurangi. (2009, March 13). *Requirements and regulations.* *https://nzcurriculum.tki.org.nz/Archives/A-school-curriculum/Requirements-and-regulations#:~:text=The%20New%20Zealand%20Curriculum%20for,align%20with%20the%20national%20curriculum*

Torbeyns, T., de Geus, B., Bailey, S., Decroix, L., Van Cutsem, J., De Pauw, K., & Meeusen, R. (2017). Bike desks in the classroom: energy expenditure, physical health, cognitive performance, brain functioning, and academic performance. *Journal of Physical Activity and Health*, *14*(6), 429-439. https://doi.org/10.1123/jpah.2016-0224

Voerman, J. S., de Klerk, C., Vander Heyden, K. M., Passchier, J., Idema, W., Timman, R., & Jolles, J. (2017). Pain is associated with poorer grades, reduced emotional well-being, and attention problems in adolescents. *The Clinical Journal of Pain*, *33*(1), 44-50. https://doi.org/10.1097/AJP.0000000000000367

Walck-Shannon, E. M., Rowell, S. F., & Frey, R. F. (2021). To what extent do study habits relate to performance?. *CBE—Life Sciences Education, 20*(1), 1-15. https://doi.org/10.1187/cbe.20-05-0091

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*, 1-24. https://doi.org/10.1186/s12966-017-0569-9

Woessmann, L. (2016). The economic case for education. *Education Economics*, *24*(1), 3-32. https://doi.org/https://doi.org/10.1080/09645292.2015.1059801

Chapter 6: General Discussion

In this thesis, we conducted a series of studies that investigated how dynamic chairs, specifically the BodyfurnFlex chair, affected students' behaviour and achievement, and why. In Study 1, we investigated the effect that BodyfurnFlex chairs had on the behaviour, movement, and perceptions of students in comparison to the regular classroom chairs. Additionally, we monitored the environmental conditions in the classroom as potential confounding variables. In Study 2, we carried out a detailed analysis of the movement and environmental data collected during Study 1. This involved examining various aspects of the in-chair movement data, including acceleration and rotation, whether the chairs affected classroom noise levels, and exploring potential links between the movement, environmental, and behavioural variables. Finally, in Study 3, we explored whether the behavioural and movement benefits demonstrated by BodyfurnFlex chairs in the first two studies translated to improvements in academic achievement. Additionally, focus group discussions were conducted to gain a deeper understanding of teachers' and students' perceptions of the chairs and their influence on learning.

In conjunction, the key findings of these three studies showed that BodyfurnFlex chairs can improve students' on-task behaviour and reduce disruptive behaviours, including chair tipping and out-of-seat behaviour. These behavioural improvements were shown to be significantly associated with changes in student movement, specifically in-chair acceleration (i.e., consistent/frequent movement). Furthermore, the results showed that student behaviour was not associated with in-chair movement (i.e., displacement), indicating that students' engagement and disruptive behaviours are not related to the size/magnitude of their movement but rather to how consistently they move. While we were unable to show that the improvements in student behaviour translated into academic achievement, several key limitations, including the grading system, short teaching periods, and minimal academic progression, likely prevented us from finding any significant differences between conditions.

The findings of this research emphasise the importance of consistent movement as a fundamental human need that plays a crucial role in maintaining comfort and engagement. When individuals find themselves in situations where movement is restricted, such as being required to sit for extended periods without breaks, this increases the motivating operations to move. For students, this appears to manifest in off-task/disruptive movements, such as out-of-seat behaviour, chair tipping, and fidgeting. However, when this need for movement cannot be met, it can result in students struggling to focus/concentrate on their work due to discomfort. The results of this thesis suggest that dynamic chairs help to fulfil the basic human need for movement through active sitting, thereby reducing the motivating operations to engage in other types of movements (e.g., out-of-seat behaviour and chair tipping) and allowing students to focus on their work.

Implications for Research

The findings of this thesis also have important implications for future research. Other studies that have investigated the effect of dynamic chairs on the movement of occupants have used different methods for measuring active sitting, including displacement (Grooten et al., 2017; Nüesch et al., 2018) and acceleration (Garcia et al., 2015; Stanić et al., 2022; Synnott et al., 2017; Tanoue et al., 2016). While these are both measures of movement, they are not the same thing and should not be conflated. Displacement refers to how far something has moved (i.e., the size/magnitude of the movement), while acceleration is the change in velocity. However, while movement is a key part of active sitting, the size/magnitude of that movement is not. Active sitting is defined as maintaining consistent movement while seated through postural adjustments (Akkarakittichoke et al., 2023; Arippa et al., 2022; Hyeong et al., 2014). Considering that acceleration is the change in velocity (i.e., a higher mean acceleration tells us that an object's velocity is changing more frequently), this suggests that acceleration is a more accurate measurement of active sitting than displacement. Furthermore, the current research demonstrates that not all movement is beneficial. While students moved less overall in regular chairs, they still exhibited significant movement, but the movement they did engage in appeared to be large, unproductive/disruptive movements, such as chair tipping and out-of-seat behaviour. Future research should consider using acceleration as a measure of active sitting, rather than displacement.

Implications for Practice

This understanding of the necessity of consistent movement has important implications for the way we view other behaviour/movement interventions. Behavioural interventions such as differential reinforcement (Crewdson et al., 2023; Kirkpatrick et al., 2019), self-management strategies (Bulla & Frieder, 2018; Smith et al., 2022), and social stories (Ozdemir, 2008; Scattone et al., 2002) typically target the reduction of unproductive/disruptive movements like out-of-seat behaviour and chair tipping. Although effective at reducing undesired movement, these interventions target the consequence of static sitting. By restricting student movement, these interventions/strategies are preventing a fundamental human need for movement, which is likely to result in decreased engagement (due to discomfort) or, alternatively, students may engage in other disruptive behaviours (e.g., fidgeting) to fulfil this need for movement. Conversely, dynamic chairs can be conceptualised as an environmental adaptation, an antecedent intervention that provides the opportunity for acceptable (non-disruptive) movement, thereby removing the motivating operation (i.e., static sitting) for these undesired behaviours and preventing them from occurring in the first place.

Most commonly, schools have looked to integrate movement into the classroom using movement/physical activity breaks (Gilmore et al., 2024; Turner & Chaloupka, 2016). However, while movement breaks have been shown to be effective at improving students' on-task behaviour (Broad et al., 2023; Mavilidi et al., 2021; Watson et al., 2017) and reducing disruptive behaviours (Broad et al., 2023; McGowan et al., 2021; Moon et al., 2020), they require a break in the lesson and additional teacher training (Goh et al., 2018; Kerpan et al., 2019; Mahar, 2011). However, the current findings suggest that dynamic chairs offer an effective alternative to movement breaks, for meeting the basic need of movement and improving student behaviour, without requiring the lesson to stop (taking away from valuable learning time) or putting extra pressure on teachers to learn how to implement the breaks and finding time to schedule them into their lessons.

The findings of this research also demonstrate that, unlike other dynamic seating options, dynamic chairs can have a positive influence on students' behaviour in general education settings. When implemented in mainstream classrooms, both stability balls and cycle chairs have been shown to have a negative effect on students' behaviour (Fedewa et al., 2015; Fedewa et al., 2024; Hulac et al., 2020). A key reason for this is likely that neither stability balls nor cycle desks have been shown to promote active sitting. Erwin et al. (2016) found that stability balls significantly decreased the in-chair acceleration of students compared to regular classroom chairs, indicating that they actually increased static sitting. Meanwhile, although cycle desks have been shown to increase the energy expenditure and heart rate of students (Fedewa et al., 2017; Torbeyns et al., 2017), there is no evidence that they can promote active sitting. Given that the seats and backrests of the cycle chairs are not dynamic (i.e., don't allow upper body movement), it is unlikely that they can promote active sitting (i.e., postural changes). These findings suggest that schools looking to introduce dynamic seating options should invest in dynamic chairs, rather than other dynamic seating options, such as stability balls and cycle chairs.

Social/Health Implications

The positive effects of BodyfurnFlex chairs shown in this research may also have other important social and health implications. In addition to reducing short-term pain/discomfort (Akkarakittichoke et al., 2023; Arippa et al., 2022; Waongenngarm et al., 2021), active sitting may be an effective intervention for preventing the development of MSDs (soft tissue injuries that affect the muscles, tendons, nerves, ligaments, joints and/or blood vessels) (De Sio et al., 2018; Dong et al., 2022). Given that MSDs are common in schools, impacting more than 1 in 4 students (Chambers et al., 2024), and that prolonged static sitting greatly contributes to this high prevalence (Harithasan et al., 2022; Ogunlana et al., 2021), it is reasonable to assume that decreasing static sitting through the use of dynamic chairs could potentially lower MSD incidence in students.

Disruptive behaviour in the classroom is considered the primary social stressor that increases teaching demands (Kollerova et al., 2023) and is strongly linked to teacher burnout and job dissatisfaction (Otero-Lopez et al., 2009; van den Brink et al., 2024; Vidić et al., 2021). Conversely, increasing on-task behaviour improves teacher-student relationships (Engels et al., 2016) and has a significant positive impact on students' subjective well-being (Wong et al., 2024; Zhu et al., 2019) and self-esteem (Karababa, 2020; Eryılmaz & Kara, 2025). Additionally, chair tipping presents a serious risk for classroom injury (Goss, 1992; Salminen et al., 2014; van Dyne, 2010), while out-of-seat behaviour can be a safety concern, particularly for young and disabled students (Cao et al., 2022; Flower et al., 2014; Pennington et al., 2012). The current research suggests that by improving students' on-task behaviour and reducing disruptive, out-of-seat, and chair tipping behaviours, dynamic chairs could potentially have a positive impact on the well-being of teachers and students, while also creating a safer classroom environment.

The current research also introduced a brand-new tool, the Smart Classroom System. In addition to demonstrating that it can be an effective research tool for investigating different types of movement, the Smart Classroom System also offers a potential solution to the issue of the environmental conditions in New Zealand classrooms (Building Research Association of New Zealand, 2019a, 2019b). The ranges/limits for the environmental conditions set by the Ministry of Education are not just recommended, they are required (Ministry of Education, 2022). However, currently, nothing is being done to enforce these requirements. Considering that the environmental conditions in classrooms have a significant impact on the learning (Haverinen-Shaughnessy & Shaughnessy, 2015; Liu et al., 2021; Wargocki et al., 2019l; Wargocki et al., 2020) and health (Angelon-Gaetz et al., 2016; Derby & Pasch, 2017; Jaakkola et al., 2014; Mäkinen et al., 2009; Tu et al., 2021) of students, tools like the Smart Classroom System could be of great value.

Strengths and Weaknesses

Due to the complex nature of analysing student movement, behaviour, and achievement, the current research was not without limitations. As previously mentioned, limitations to the test data greatly restricted the findings of Study 3. However, due to the structure of the New Zealand curriculum and grading system, we were left with little room to overcome these limitations. Secondly, purposive sampling was used in Studies 1 and 2 to minimise ceiling and floor effects. However, this may restrict the generalisability of the findings to the wider population, particularly students with behavioural issues who may find BodyfurnFlex chairs especially beneficial. Finally, due to connection issues, several sessions in Studies 1 and 2 contained incomplete sensor data, resulting in their exclusion from the results. Additionally, the Raspberry Pi motion cameras were not operational for the first half of data collection.

However, the current research also has a number of strengths that significantly enhance the quality and rigour of the findings. A key strength of this thesis was that we not only examined whether BodyfurnFlex chairs affected the behaviour and outcomes of students, but also investigated why. This is important because if seating conditions for students are to be improved, it is crucial that we understand which aspects of the chairs are actually making a difference, rather than investing in seating options that lack these features. Another strength of this thesis was the use of both data and methodological triangulation. In the first two studies, data was collected from two different classes, school subjects, age groups, timeframes, and types of regular chairs. Additionally, we employed multiple data collection methods, including observations, surveys, focus group discussions, and sensors. The current research also encompassed other aspects of the learning environment, including monitoring environmental conditions, maintaining consistent settings (e.g., classroom layout), and controlling for pedagogical outliers across sessions. Controlling these potential confounding variables significantly enhances the validity of the findings, indicating that the chairs did in fact have an effect on the behaviour and movement of students. Finally, as part of this research, we gathered extensive social validity data from students and teachers. This was not only important for understanding how the chairs affected their behaviour, but also for evaluating their acceptability. Ultimately, even if interventions are effective, they are only useful if both teachers and students believe that they are helpful and are willing to use them.

Future Directions

As with all research, particularly single-case research, there is a need to replicate the results to enhance the generalizability of the findings. In addition, future research should explore the use of different types of dynamic chairs and include students with learning difficulties, who have been shown to benefit significantly from other dynamic seating interventions (Rollo et al., 2019). The current research also suggests that the effect of dynamic chairs on academic achievement warrants further investigation. The use of percentage-based testing or progress monitoring tools, along with longer-term data collection (at least a full year), should be considered to avoid the limitations of Study 3. Researchers may also want to consider studies that investigate the potential long-term social/health benefits of dynamic chairs, including their effect on MSDs, classroom injury, and student and teacher well-being. Finally, the findings of this research suggest that it is worthwhile to investigate the impact of dynamic chairs in settings beyond the classroom. Workplaces, particularly those that require prolonged sitting (e.g., office jobs), may greatly benefit from incorporating dynamic chairs, as conventional office chairs are typically not dynamic (Ellegast et al., 2012; Grooten et al., 2017). By promoting active sitting, dynamic chairs may help improve office workers' comfort, increase work engagement, and eliminate the need for microbreaks (short breaks used to break up prolonged periods of sitting by standing up and walking/stretching; Albulescu et al., 2022; Radwan et al., 2022).

Conclusion

In this thesis, we examined the effect that BodyfurnFlex chairs had on the behaviour, movement, comfort/perceptions and achievement of students. Despite not finding any conclusive evidence to suggest that BodyfurnFlex chairs can improve academic achievement, our findings provided strong evidence that they can significantly improve student engagement and reduce disruptive behaviours in the classroom. The findings show they effectively satisfy the basic need for movement via active sitting, reducing the need for unproductive movements like chair tipping and out-of-seat behaviours. Overall, students reported far greater satisfaction with BodyfurnFlex chairs in comparison to regular chairs, stating that they were more comfortable, functional, aided their ability to do their schoolwork, and enabled them to be better prepared for their assessments.

Behavioural problems, such as disruptive and off-task behaviour, are a common problem in New Zealand classrooms, which are amongst the worst in OECD nations (Education Review Office, 2024). To address this issue, the Education Review Office has emphasised the need for interventions and strategies that target the underlying causes of these behaviours (Education Review Office, 2024). The current research suggests that dynamic chairs are not only an effective intervention for improving student behaviour, but also address a key underlying cause of disruptive/off-task behaviours, preventing them from occurring in the first place, without adding to teacher stress or workload.

References:

Aga, K. (2024). Comfort in active learning spaces–students' perceptions and preferences. European *Journal of Engineering Education, 49*(4), 785-806. https://doi.org/10.1080/03043797.2024.2341756

Akkarakittichoke, N., Waongenngarm, P., & Janwantanakul, P. (2023). Effects of Postural Shifting Frequency on Perceived Musculoskeletal Discomfort During 1-Hour Sitting in Office Workers. *Journal of Manipulative and Physiological Therapeutics, 46*(2), 76-85. https://doi.org/10.1016/j.jmpt.2023.06.003

Alatupa, S., Pulkki-Råback, L., Hintsanen, M., Mullola, S., Lipsanen, J., & Keltikangas-Järvinen, L. (2011). Childhood disruptive behaviour and school performance across comprehensive school: A prospective cohort study. *Psychology, 2*(6), 542-551. http://dx.doi.org/10.4236/psych.2011.26084

Albulescu, P., Macsinga, I., Rusu, A., Sulea, C., Bodnaru, A., & Tulbure, B. T. (2022). " Give me a break!" A systematic review and meta-analysis on the efficacy of micro-breaks for increasing well-being and performance. *PloS ONE, 17*(8), e0272460. https://doi.org/10.1371/journal.pone.0272460

Alkhadim, G. (2024). The detrimental effects of student-disordered behavior at school: evidence from using the cusp catastrophe. *Frontiers in Psychology, 14*, 1346232. https://doi.org/10.3389/fpsyg.2023.1346232

Alqahtani, A. Y., Makki, A. A., & Alidrisi, H. M. (2023). Revealing factors influencing classroom noise in the universities teaching and learning environment: A design of experiments approach. *Journal of Engineering Research, 11*(1), 100009. https://doi.org/10.1016/j.jer.2023.100009

Alter, P., Walker, J. N., & Landers, E. (2013). Teachers' perceptions of students' challenging behavior and the impact of teacher demographics. *Education and Treatment of Children*, 51-69. https://doi.org/10.1353/etc.2013.0040

Amrai, K., Motlagh, S. E., Zalani, H. A., & Parhon, H. (2011). The relationship between academic motivation and academic achievement students. *Procedia-Social and Behavioral Sciences, 15*, 399-402. https://doi.org/10.1016/j.sbspro.2011.03.111

An, Y., Lee, Y., Oh, S. Y., & Lee, J. Y. (2024). How can young adults be civically engaged? The role of academic achievement standards in enhancing civic and social engagement in the case of South Korea. *International Journal of Educational Development, 110*, 103115. https://doi.org/10.1016/j.ijedudev.2024.103115

Angelon-Gaetz, K. A., Richardson, D. B., Marshall, S. W., & Hernandez, M. L. (2016). Exploration of the effects of classroom humidity levels on teachers' respiratory symptoms. *International Archives of Occupational and Environmental Health, 89*, 729-737. https://doi.org/10.1007/s00420-016-1111-0

Antle, D. M., Cormier, L., Findlay, M., Miller, L. L., & Côté, J. N. (2018). Lower limb blood flow and mean arterial pressure during standing and seated work: Implications for workplace posture recommendations. *Preventive Medicine Reports, 10*, 117-122. https://doi.org/10.1016/j.pmedr.2018.02.016

Archambault, I., Janosz, M., Olivier, E., & Dupéré, V. (2022). Student Engagement and School Dropout: Theories, Evidence, and Future Directions. In A. L. Reschly, S. L. Christenson (Eds.), *Handbook of Research on Student Engagement* (pp. 331-355). Springer, Cham. https://doi.org/10.1007/978-3-031-07853-8_16

Arippa, F., Nguyen, A., Pau, M., & Harris-Adamson, C. (2022). Postural strategies among office workers during a prolonged sitting bout. *Applied Ergonomics, 102*, 103723. https://doi.org/10.1016/j.apergo.2022.103723

Asiyai, R. (2014). Students' perception of the condition of their classroom physical learning environment and its impact on their learning and motivation. *College Student Journal, 48*(4), 714-723. https://eric.ed.gov/?id=EJ1095439

Astolfi, A., Puglisi, G. E., Murgia, S., Minelli, G., Pellerey, F., Prato, A., & Sacco, T. (2019). Influence of classroom acoustics on noise disturbance and well-being for first graders. *Frontiers in Psychology, 10*, 2736. https://doi.org/10.3389/fpsyg.2019.02736

Atici, M., & Merry, R. (2001). Misbehaviour in British and Turkish primary classrooms. *Pastoral Care in Education, 19*(2), 32-39. https://doi.org/10.1111/1468-0122.00196

Attridge, N., Eccleston, C., Noonan, D., Wainwright, E., & Keogh, E. (2017). Headache impairs attentional performance: a conceptual replication and extension. *The Journal of Pain, 18*(1), 29-41. https://doi.org/10.1016/j.jpain.2016.09.007

Austin, J. L., & Soeda, J. M. (2008). Fixed-time teacher attention to decrease off-task behaviors of typically developing third graders. *Journal of Applied Behavior Analysis, 41*(2), 279-283. https://doi.org/10.1901/jaba.2008.41-279

Axup, T., & Gersch, I. (2008). Challenging behaviour: the impact of challenging student behaviour upon teachers' lives in a secondary school: teachers' perceptions. *British Journal of Special Education*, *35*(3), 144-151. https://doi.org/10.1111/j.1467-8578.2008.00388.x

Aydın, A., & Göktaş, Y. (2023). Examining the Effects of Physical Variables in Classrooms on Students' Attention via the Internet of Things. *Participatory Educational Research, 10*(1), 160-177. https://doi.org/10.17275/per.23.9.10.1

Bäckström, P. (2021). School composition, disruptive classroom behaviour and student results: A study of mechanisms of peer effects. *Nordic Studies in Education, 41*(2), 167-184. https://doi.org/10.23865/nse.v41.2965

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. *Building and Environment*, *89*, 118-133. https://doi.org/10.1016/j.buildenv.2015.02.013

Becherer, J., Köller, O., & Zimmermann, F. (2021). Externalizing behaviour, task-focused behaviour, and academic achievement: An indirect relation?. *British Journal of Educational Psychology, 91*(1), 27-45. https://doi.org/10.1111/bjep.12347

Belete, Y. (2024). The link between students' community engagement activities and their academic achievement. *Educatione, 3*(1), 61-84. https://doi.org/10.58650/educatione.1358541

Bell, R., Cardello, A. V., & Schutz, H. G. (2005). Relationship between perceived clothing comfort and exam performance. *Family and Consumer Sciences Research Journal, 33*(4), 308-320. https://doi.org/10.1177/1077727X04274115

Blank, C., & Shavit, Y. (2016). The Association Between Student Reports of Classmates' Disruptive Behavior and Student Achievement. *AERA Open*, *2*(3), 233285841665392. https://doi.org/10.1177/2332858416653921

Bidassey-Manilal, S., Wright, C. Y., Engelbrecht, J. C., Albers, P. N., Garland, R. M., & Matooane, M. (2016). Students' perceived heat-health symptoms increased with warmer classroom temperatures. *International Journal of Environmental Research and Public Health, 13*(6), 566. https://doi.org/10.3390/ijerph13060566

Bogdanovica, S., Zemitis, J., & Bogdanovics, R. (2020). The effect of CO2 concentration on children's well-being during the process of learning. *Energies, 13*(22), 6099. https://doi.org/10.3390/en13226099

Bierman, K. L., Coie, J., Dodge, K., Greenberg, M., Lochman, J., McMohan, R., Pinderhughes, E., & Conduct Problems Prevention Research Group. (2013). School outcomes of aggressive-disruptive children: Prediction from kindergarten risk factors and impact of the Fast Track prevention program. *Aggressive Behavior, 39*(2), 114-130. https://doi.org/10.1002/ab.21467

Brennan, J., & Crosland, K. (2021). Evaluating the use of stability ball chairs for children with ASD in a clinic setting. *Behavior Analysis in Practice, 14*, 1079-1084. https://doi.org/10.1007/s40617-021-00606-3

Brill, L. C., & Wang, L. M. (2021). Higher sound levels in K-12 classrooms correlate to lower math achievement scores. *Frontiers in Built Environment*, *7*, 688395. https://doi.org/10.3389/fbuil.2021.688395

Broad, A. A., Bornath, D. P., Grisebach, D., McCarthy, S. F., Bryden, P. J., Robertson-Wilson, J., & Hazell, T. J. (2023). Classroom activity breaks improve on-task behavior and physical activity levels regardless of time of day. *Research Quarterly for Exercise and Sport, 94*(2), 331-343. https://doi.org/10.1080/02701367.2021.1980189

Bru, E. (2006). Factors associated with disruptive behaviour in the classroom. *Scandinavian Journal of Educational Research, 50*(1), 23-43. https://doi.org/10.1080/00313830500372000

Buchari, & Matondang, N. (2017). The impact of noise level on students' learning performance at state elementary school in Medan. *AIP Conference Proceedings, 1855*, 040002. https://doi.org/10.1063/1.4985498

Building Research Association of New Zealand. (2019a). *An overview of indoor air contaminants in New Zealand schools*. https://d39d3mj7qio96p.cloudfront.net/media/documents/BRANZ-RN-Indoor_Air_Quality_2.pdf

Building Research Association of New Zealand. (2019b). *Indoor air pollution at a New Zealand urban primary school*. https://d39d3mj7qio96p.cloudfront.net/media/documents/BRANZ-RN-Indoor_Air_Quality_6.pdf

Bulla, A. J., & Frieder, J. E. (2018). Self-management as a class-wide intervention: An evaluation of the "Self & Match" system embedded within a dependent group contingency. *Psychology in the Schools, 55*(3), 305-322. https://doi.org/10.1002/pits.22109

Byers, T., Imms, W., & Hartnell-Young, E. (2018). Comparative analysis of the impact of traditional versus innovative learning environment on student attitudes and learning outcomes. *Studies in Educational Evaluation*, *58*, 167-177. https://doi.org/10.1016/j.stueduc.2018.07.003

Byers, T., Mahat, M., Liu, K., Knock, A., & Imms, W. (2018). *Systematic Review of the Effects of Learning Environments on Student Learning Outcomes. Melbourne: University of Melbourne, LEaRN*. http://www.iletc.com.au/publications/reports

Caldarella, P., Larsen, R. A., Williams, L., Wills, H. P., & Wehby, J. H. (2021). “Stop doing that!”: Effects of teacher reprimands on student disruptive behavior and engagement. *Journal of Positive Behavior Interventions, 23*(3), 163-173. https://doi.org/10.1177/1098300720935101

Camahalan F. M. G., & Ipock A. R. (2015). Physical activity breaks and student learning: A teacher-research project. *Education, 135*(3), 291–298. https://go.gale.com/ps/i.do?p=AONE&u=anon~3a4dbb5a&id=GALE%7CA406162560&v=2.1&it=r&sid=googleScholar&asid=dc7ebadc

Cappella, E., Kim, H. Y., Neal, J. W., & Jackson, D. R. (2013). Classroom peer relationships and behavioral engagement in elementary school: The role of social network equity. *American Journal of Community Psychology, 52*, 367-379. https://doi.org/10.1007/s10464-013-9603-5

Cardenas, A., Albert, W., Leger, M., Dion, C., & Cardoso, M. (2024). Effects of implementing an active sitting protocol compared to using a traditional office chair and standing workstation. *International Journal of Industrial Ergonomics, 101*, 103587. https://doi.org/10.1016/j.ergon.2024.103587

Cardoso, M. R., Cardenas, A. K., & Albert, W. J. (2021). A biomechanical analysis of active vs static office chair designs. *Applied Ergonomics*, *96*, 103481. https://doi.org/10.1016/j.apergo.2021.103481

Caromano, F. A., de Amorim, C. A. P., de Fátima Rebelo, C., Contesini, A. M., Fávero, F. M., Frutuoso, J. R. C., Kawai, M. M., & Voos, M. C. (2015). Prolonged sitting and physical discomfort in university students. *Acta Physiatrica, 22*(4), 176-180. https://doi.org/10.5935/0104-7795.20150034

Carrer, P., Wargocki, P., Fanetti, A., Bischof, W., Fernandes, E. D. O., Hartmann, T., Kephalopoulos, S., Palkonen, S., & Seppänen, O. (2015). What does the scientific literature tell us about the ventilation–health relationship in public and residential buildings? *Building and Environment, 94*, 273-286. https://doi.org/10.1016/j.buildenv.2015.08.011

Carriere, J. S., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology, 67*(1), 19. https://doi.org/10.1037/a0031438

Castro, M., Expósito-Casas, E., López-Martín, E., Lizasoain, L., Navarro-Asencio, E., & Gaviria, J. L. (2015). Parental involvement on student academic achievement: A meta-analysis. *Educational Research Review, 14*, 33-46. https://doi.org/10.1016/j.edurev.2015.01.002

Caviola, S., Visentin, C., Borella, E., Mammarella, I., & Prodi, N. (2021). Out of the noise: Effects of sound environment on maths performance in middle-school students. *Journal of Environmental Psychology, 73*, 101552. https://doi.org/10.1016/j.jenvp.2021.101552

Chambers, C. T., Dol, J., Tutelman, P. R., Langley, C. L., Parker, J. A., Cormier, B. T., Macfarlane, G. J., Jones, G. T., Chapman, D., Proudfoot, N., Grant, A., & Marianayagam, J. (2024). The prevalence of chronic pain in children and adolescents: a systematic review update and meta-analysis. *Pain*, *165*(10), 2215-2234. https://doi.org/10.1097/j.pain.0000000000003267

Chapman, B. N., Drevon, D. D., & Jasper, A. D. (2023). The impact of the quiet Classroom game on On-Task Behavior and Classroom noise level in three Middle School classrooms. *Journal of Behavioral Education, 32*(1), 109-126. https://doi.org/10.1007/s10864-021-09444-3

Cheryan, S., Ziegler, S. A., Plaut, V. C., & Meltzoff, A. N. (2014). Designing classrooms to maximize student achievement. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 4-12. https://doi.org/10.1177/2372732214548677

Chesnais, N., Cabagno, G., & Verret, C. (2023). The effects of classroom physical activity breaks on the behavioural and emotional self-regulation of students with behavioural difficulties. *Journal of Research in Special Educational Needs, 23*(2), 147-157. https://doi.org/10.1111/1471-3802.12587

Cho, H. (2017). The effects of summer heat on academic achievement: A cohort analysis. *Journal of Environmental Economics and Management, 83*, 185-196. https://doi.org/10.1016/j.jeem.2017.03.005

Cogswell, S., Carr, A., Abbott, N., & Monks, C. P. (2020). The development and validation of a teacher-reported low-level classroom disruption scale (LLCD-S). *Emotional and Behavioural Difficulties, 25*(3-4), 230-243. https://doi.org/10.1080/13632752.2020.1816651

Coley, D. A., Greeves, R., & Saxby, B. K. (2007). The effect of low ventilation rates on the cognitive function of a primary school class. *International Journal of Ventilation, 6*(2), 107-112. https://doi.org/10.1080/14733315.2007.11683770

Collins, T. A., Cook, C. R., Dart, E. H., Socie, D. G., Renshaw, T. L., & Long, A. C. (2016). Improving classroom engagement among high school students with disruptive behavior: Evaluation of the class pass intervention. *Psychology in the Schools, 53*(2), 204-219. https://doi.org/10.1002/pits.21893

Conklin, C. G., Kamps, D., & Wills, H. (2017). The effects of class-wide function-related intervention teams (CW-FIT) on students' prosocial classroom behaviors. *Journal of Behavioral Education, 26*(1), 75-100. https://doi.org/10.1007/s10864-016-9252-5

Cooper, J., Heron, T., & Heward, W. (2020). *Applied Behavior Analysis, Global Edition*. Pearson Education, Limited.

Costa, A., Moreira, D., Casanova, J., Azevedo, Â., Gonçalves, A., Oliveira, Í., Azevedo, R., & Dias, P. C. (2024). Determinants of academic achievement from the middle to secondary school education: A systematic review. *Social Psychology of Education, 27*(6), 3533-3572. https://doi.org/10.1007/s11218-024-09941-z

Crewdson, M., Richardson, R. D., Skinner, C. H., Fowler, K., & Wright, S. (2023). Tootling: A classwide peer-mediated intervention for decreasing antisocial and disruptive behavior and enhancing prosocial behaviors and academic engagement. *TEACHING Exceptional Children, 55*(3), 198-207. https://doi.org/10.1177/00400599221074268

De Sio, S., Traversini, V., Rinaldo, F., Colasanti, V., Buomprisco, G., Perri, R., Mormone, F., La Torre. G., & Guerra, F. (2018). Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella review. *PeerJ, 6*, e4154. https://doi.org/10.7717/peerj.4154

Dick, B. D., & Rashiq, S. (2007). Disruption of attention and working memory traces in individuals with chronic pain. *Anesthesia & Analgesia, 104*(5), 1223-1229. https://doi.org/10.1213/01.ane.0000263280.49786.f5

Doan, S., Steiner, E., & Pandey, R. (2024). *Teacher well-being and intentions to leave in 2024: Findings from the 2024 State of the American Teacher Survey. RAND*. https://doi.org/10.7249/RRA1108-12

Dobmeier, R., & Moran, J. (2008). Dealing with disruptive behavior of adult learners. *New Horizons in Adult Education and Human Resource Development, 22*(2), 29-54. https://doi.org/10.1002/nha3.10306

Dong, Y., Jiang, P., Jin, X., Jiang, N., Huang, W., Peng, Y., Shen, Y., He, I., Forsman, M., & Yang, L. (2022). Association between long-term static postures exposure and musculoskeletal disorders among university employees: A viewpoint of inflammatory pathways. *Frontiers in Public Health, 10*, 1055374. https://doi.org/10.3389/fpubh.2022.1055374

Donnelly, J. E., & Lambourne, K. (2011). Classroom-based physical activity, cognition, and academic achievement. *Preventive Medicine*, *52*, S36-S42. https://doi.org/10.1016/j.ypmed.2011.01.021

Douglas, J., Moyes, D., & Douglas, A. (2016). The Impact of Disruptive Behavior in the Classroom: the student perspective. *ST-6: Education Excellence, 5*(3), 143-151. https://www.researchgate.net/profile/Jacqueline-Douglas/publication/309390995_The_Impact_of_Disruptive_Behavior_in_the_Classroom_the_student_perspective/links/580dc56e08aea8ecfaf1de0d/The-Impact-of-Disruptive-Behavior-in-the-Classroom-the-student-perspective.pdf

Dulay, S., & Karadağ, E. (2017). The Effect of School Climate on Student Achievement. In E. Karadag (Eds), *The Factors Rffecting Student Schievement* (pp. 199-213). Sptinger, Cham. https://doi.org/10.1007/978-3-319-56083-0_12

Edgerton, J. D., Roberts, L. W., & von Below, S. (2012). Education and Quality of Life. In K. C. Land, A. C. Michalos, & M. J. Sirgy (Eds.), *Handbook of Social Indicators and Quality of Life Research* (pp. 265-296). Springer Netherlands. https://doi.org/10.1007/978-94-007-2421-1_12

Edgerton, E., & McKechnie, J. (2023). The relationship between student's perceptions of their school environment and academic achievement. *Frontiers in Psychology, 13*, 959259. https://doi.org/10.3389/fpsyg.2022.959259

Education Review Office. (2024). *Time to Focus: Behaviour in our Classrooms*. https://evidence.ero.govt.nz/documents/time-to-focus-behaviour-in-our-classrooms

Elango, M., & Manimozhi, G. (2021). Meta analysis of study habits and academic achievement. *Shanlax International Journal of Arts, Science and Humanities, 8*(4), 139-145. https://doi.org/10.34293/sijash.v8i4.3722

Ellegast, R. P., Kraft, K., Groenesteijn, L., Krause, F., Berger, H., & Vink, P. (2012). Comparison of four specific dynamic office chairs with a conventional office chair: impact upon muscle activation, physical activity and posture. *Applied Ergonomics, 43*(2), 296-307. https://doi.org/10.1016/j.apergo.2011.06.005

Engels, M. C., Colpin, H., Van Leeuwen, K., Bijttebier, P., Van Den Noortgate, W., Claes, S., Goossens, L., & Verschueren, K. (2016). Behavioral engagement, peer status, and teacher–student relationships in adolescence: A longitudinal study on reciprocal influences. *Journal of Youth and Adolescence, 45*, 1192-1207. https://doi.org/10.1007/s10964-016-0414-5

Erdem, C., & Kaya, M. (2024). The relationship between school and classroom climate, and academic achievement: A meta-analysis. *School Psychology International, 45*(4), 380-408. https://doi.org/10.1177/01430343231202923

Erwin, H. E., Fedewa, A., Ahn, S., & Thornton, M. (2016). Elementary students' physical activity levels and behavior when using stability balls. *The American Journal of Occupational Therapy, 70*(2), 700220010p1-700220010p7. https://doi.org/10.5014/ajot.2016.017079

Eryılmaz, A., & Kara, A. (2025). Reciprocal relations between self-esteem, class engagement, and career calling: evidence from a two-wave longitudinal study. *International Journal for Educational and Vocational Guidance*, 1-20. https://doi.org/10.1007/s10775-025-09738-2

Fan, Y., Cao, X., Zhang, J., Lai, D., & Pang, L. (2023). Short-term exposure to indoor carbon dioxide and cognitive task performance: A systematic review and meta-analysis. *Building and Environment, 237*, 110331. https://doi.org/10.1016/j.buildenv.2023.110331

Fedewa, A. L., & Erwin, H. E. (2011). Stability balls and students with attention and hyperactivity concerns: Implications for on-task and in-seat behavior. *The American Journal of Occupational Therapy*, *65*(4), 393-399. https://doi.org/10.5014/ajot.2011.000554

Fedewa, A., Davis, M. A., & Ahn, S. (2015). Effects of stability balls on children's on-task behavior, academic achievement, and discipline referrals: A randomized controlled trial*. The American Journal of Occupational Therapy, 69*(2), 6902220020p1-6902220020p9. https://doi.org/10.5014/ajot.2015.014829

Fedewa, A., Abel, M., & Erwin, H. E. (2017). The effects of using stationary bicycle desks in classrooms on adolescents' physical activity. *Journal of Occupational Therapy, Schools, & Early Intervention*, *10*(1), 78-89. https://doi.org/10.1080/19411243.2016.1266457

Fedewa, A. L., Erwin, H., Ahn, S., & Alawadi, S. (2024). The effects of desk cycles in elementary children's classroom physical activity: A feasibility study. *Journal of Occupational Therapy, Schools, & Early Intervention, 17*(4), 1026-1038. https://doi.org/10.1080/19411243.2021.1910608

Fenesi, B., Lucibello, K., Kim, J. A., & Heisz, J. J. (2018). Sweat so you don't forget: Exercise breaks during a University Lecture increase on-task attention and learning. *Journal of Applied*

Research in Memory and Cognition, 7(2), 261–269. https://doi.org/10.1016/j.jarmac.2018.01.012

Ferguson, J.L., & Cihon, J.H. (2021). Social Validity. In F. R. Volkmar (Eds), *Encyclopedia of Autism Spectrum Disorders* (pp. 4487–4490). Springer, Cham. https://doi.org/10.1007/978-3-319-91280-6_102237

Finn, J. D., Pannozzo, G. M., & Voelkl, K. E. (1995). Disruptive and Inattentive-Withdrawn Behavior and Achievement among Fourth Graders. *The Elementary School Journal, 95*(5), 421-434. https://doi.org/10.1086/461853

Flores-Mendoza, C., Widaman, K., Mansur-Alves, M., Bacelar, T. D., & Saldanha, R. (2013). Psychoticism and disruptive behavior can be also good predictors of school achievement. *The Spanish Journal of Psychology, 16*, 1-13. https://doi.org/10.1017/sjp.2013.3

Flower, A., McKenna, J. W., Bunuan, R. L., Muething, C. S., & Vega Jr, R. (2014). Effects of the Good Behavior Game on challenging behaviors in school settings. *Review of Educational Research, 84*(4), 546-571. https://doi.org/10.3102/0034654314536781

Forgeron, P. A., King, S., Stinson, J. N., McGrath, P. J., MacDonald, A. J., & Chambers, C. T. (2010). Social functioning and peer relationships in children and adolescents with chronic pain: A systematic review. *Pain Research and Management, 15*(1), 27-41. https://doi.org/10.1155/2010/820407

Francisco, R., Nunes, C. L., Breda, J., Jesus, F., Lukaski, H., Sardinha, L. B., & Silva, A. M. (2022). Breaking of Sitting Time Prevents Lower Leg Swelling—Comparison among Sit, Stand and Intermittent (Sit-to-Stand Transitions). *Conditions. Biology, 11*(6), 899. https://doi.org/10.3390/biology11060899

Frey, M., Barrett, M., & De Carvalho, D. (2021). Effect of a dynamic seat pan design on spine biomechanics, calf circumference and perceived pain during prolonged sitting. *Applied Ergonomics, 97*, 103546. https://doi.org/10.1016/j.apergo.2021.103546

Gaihre, S., Semple, S., Miller, J., Fielding, S., & Turner, S. (2014). Classroom carbon dioxide concentration, school attendance, and educational attainment. *Journal of School Health, 84*(9), 569-574. https://doi.org/10.1111/josh.12183

Garcia, J. M., Huang, T. T., Trowbridge, M., Weltman, A., & Sirard, J. R. (2016). Comparison of the effects of stable and dynamic furniture on physical activity and learning in children. *The Journal of Primary Prevention*, *37*, 555-560. https://doi.org/10.1007/s10935-016-0451-6

Ghanizadeh, A., & Jahedizadeh, S. (2015). Teacher burnout: A review of sources and ramifications. *British Journal of Education, Society & Behavioural Science, 6*(1), 24-39. https://doi.org/10.9734/BJESBS/2015/15162

Gilmore, L., Sullivan, K. A., & Hughes, B. (2024). Incorporating physical activities in teaching practice. *Australian Journal of Education, 68*(2), 145-156. https://doi.org/10.1177/00049441241244553

Godwin, K. E., Almeda, M. V., Seltman, H., Kai, S., Skerbetz, M. D., Baker, R. S., & Fisher, A. V. (2016). Off-task behavior in elementary school children. *Learning and Instruction, 44*, 128-143. https://doi.org/10.1016/j.learninstruc.2016.04.003

Goh, T. L., Fu, Y., Brusseau, T., & Hannon, J. (2018). On-task behavior of elementary students during movement integration. *Journal of Physical Education and Sport, 18*(1), 103-106. https://doi.org//10.7752/jpes.2018.01013

Gogoi, P., Bhattacharyya, N. C. & Saikia, K. C. (2024). The prevalence of musculoskeletal pain among school students and its association with physical fitness in Guwahati urban society: a cross sectional study. *Bulletin of Faculty of Physical Therapy, 29*(1), 49. https://doi.org/10.1186/s43161-024-00215-5

Goss, S. (1992). School Injuries. *Hazard, 10*. https://www.monash.edu/__data/assets/pdf_file/0003/218433/haz10.pdf

Goulas, S., Griselda, S., Megalokonomou, R., & Zenou, Y. (2024). *Disruptive Peers and Academic Performance: Short and Long-Term Outcomes* (CESifo Working Paper Series No. 11568) http://dx.doi.org/10.2139/ssrn.5073305

Grimby-Ekman, A., Åberg, M., Torén, K., Brisman, J., Hagberg, M., & Kim, J. L. (2018). Pain could negatively affect school grades-Swedish middle school students with low school grades most affected. *PloS ONE*, *13*(12), e0208435. https://doi.org/10.1371/journal.pone.0208435

Groenewald, C. B., Giles, M., & Palermo, T. M. (2019). School absence associated with childhood pain in the United States*. The Clinical Journal of Pain, 35*(6), 525-531. https://doi.org/10.1097/AJP.0000000000000701

Grooten, W. J., Äng, B. O., Hagströmer, M., Conradsson, D., Nero, H., & Franzén, E. (2017). Does a dynamic chair increase office workers' movements? – Results from a combined laboratory and field study. *Applied Ergonomics, 60*, 1-11. https://doi.org/10.1016/j.apergo.2016.10.006

Halverson, L. R., & Graham, C. R. (2019). Learner engagement in blended learning environments: A conceptual framework. *Online Learning, 23*(2), 145-178. https://doi.org/10.24059/olj.v23i2.1481

Hahn, R. A., & Chattopadhyay, S. K. (2019). Linking studies to assess the life expectancy associated with eighth grade school achievement. *Preventive Medicine Reports*, *16*, 100980. https://doi.org/https://doi.org/10.1016/j.pmedr.2019.100980

Heller-Sahlgren, G., & Jordahl, H. (2024). Test scores and economic growth: update and extension. *Applied Economics Letters*, *31*(11), 1024-1027. https://doi.org/10.1080/13504851.2023.2168604

Hanaysha, J. R., Shriedeh, F. B., & In'airat, M. (2023). Impact of classroom environment, teacher competency, information and communication technology resources, and university facilities on student engagement and academic performance. *International Journal of Information Management Data Insights, 3*(2), 100188. https://doi.org/10.1016/j.jjimei.2023.100188

Harithasan, D., Singh, D. K. A., Abd Razak, N. A. B., & Baharom, N. B. (2022). Personal, academic stressors and environmental factors contributing to musculoskeletal pain among undergraduates due to online learning: a mixed method study with data integration. *International Journal of Environmental Research and Public Health, 19*(21), 14513. https://doi.org/10.3390/ijerph192114513

Haverinen-Shaughnessy, U., Moschandreas, D. J., & Shaughnessy, R. J. (2011). Association between substandard classroom ventilation rates and students' academic achievement. *Indoor Air, 21*(2), 121-131. https://doi.org/10.1111/j.1600-0668.2010.00686.x

Haverinen-Shaughnessy, U., & Shaughnessy, R. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PloS ONE, 10*(8), e0136165. https://doi.org/10.1371/journal.pone.0136165

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting impacts on human performance in school. *Journal of the Illuminating Engineering Society*, *31*(2), 101-114. https://doi.org/10.1080/00994480.2002.10748396

Hopland, A. O., & Nyhus, O. H. (2015). Does student satisfaction with school facilities affect exam results? An empirical investigation. *Facilities*, *33*(13/14), 760-774. https://doi.org/10.1108/F-09-2014-0076

Hoque, S., & Weil, B. (2016). The relationship between comfort perceptions and academic performance in university classroom buildings. *Journal of Green Building, 11*(1), 108-117. https://doi.org/10.3992/jgb.11.1.108.1

Howie, E. K., Beets, M. W., & Pate, R. R. (2014). Acute classroom exercise breaks improve on-task behavior in 4th and 5th grade students: a dose–response. *Mental Health and Physical Activity, 7*(2), 65-71. https://doi.org/10.1016/j.mhpa.2014.05.002

Hulac, D. M., Mickelson, L. R., Briesch, A. M., Maroeca, H., Hartjes, C., Anderson, K., & Ederveen, K. (2020). Stability balls and student on-task behavior. *Journal of Behavioral Education*, 1-18. https://doi.org/10.1007/s10864-020-09412-3

Huntington, R. N., Badgett, N. M., Rosenberg, N. E., Greeny, K., Bravo, A., Bristol, R. M., Byun, Y. H., & Park, M. S. (2023). Social validity in behavioral research: A selective review. *Perspectives on Behavior Science, 46*(1), 201-215. https://doi.org/10.1007/s40614-022-00364-9

Hwang, M. H., Choi, H. C., Lee, A., Culver, J. D., & Hutchison, B. (2016). The relationship between self-efficacy and academic achievement: A 5-year panel analysis. *The Asia-Pacific Education Researcher, 25*(1), 89-98. https://doi.org/10.1007/s40299-015-0236-3

Hyeong, J. H., Roh, J. R., Park, S. B., Kim, S., & Chung, K. R. (2014). A trend analysis of dynamic chair and applied technology. *Journal of the Ergonomics Society of Korea, 33*(4), 267-279. http://dx.doi.org/10.5143/JESK.2014.33.4.267

Infantino, J., & Little, E. (2005). Students' perceptions of classroom behaviour problems and the effectiveness of different disciplinary methods. *Educational Psychology*, *25*(5), 491-508. https://doi.org/10.1080/01443410500046549

Imms, W., & Byers, T. (2017). Impact of classroom design on teacher pedagogy and student engagement and performance in mathematics. *Learning Environments Research, 20*, 139-152. https://doi.org/10.1007/s10984-016-9210-0

Jaakkola, K., Saukkoriipi, A., Jokelainen, J., Juvonen, R., Kauppila, J., Vainio, O., Ziegler, T., Rönkkö, E., Jaakkola, J. J., Ikäheimo, T. M., & KIAS-Study Group. (2014). Decline in temperature and humidity increases the occurrence of influenza in cold climate. *Environmental Health, 13*, 1-8. https://doi.org/10.1186/1476-069X-13-22

Jaffal, A. (2019). Reducing off-Task Behaviors Using an Action Research Method with One-Case Study. *Journal of Educational and Psychological Studies, 13*(4), 703-714. https://doi.org/10.53543/jeps.vol13iss4pp703-714

Joubert, L., Kilgas, M., Riley, A., Gautam, Y., Donath, L., & Drum, S. (2017). In-class cycling to augment college student academic performance and reduce physical inactivity: Results from an RCT. *International Journal of Environmental Research and Public Health*, *14*(11), 1343. https://doi.org/10.3390/ijerph14111343

Just, U., Oelkers, R., Bender, S., Parzer, P., Ebinger, F., Weisbrod, M., & Resch, F. (2003). Emotional and behavioural problems in children and adolescents with primary headache. *Cephalalgia, 23*(3), 206-213. https://doi.org/10.1046/j.1468-2982.2003.00486.x

Kandasamy, G., Almanasef, M., Almeleebia, T., Orayj, K., Shorog, E., Alshahrani, A. M., Prabahar, K., Veeramani, V. P., Amirthalingam, P., Alqifari, S. F., Alrashidi, F., Aldurum, M., Almutiri, F., Alzaidi, A., & Almutairi, F. (2024). Prevalence of musculoskeletal pain among undergraduate students. *Frontiers in Medicine*, *11*, 1403267. https://doi.org/10.3389/fmed.2024.1403267

Kaplan, A., Gheen, M., & Midgley, C. (2002). Classroom goal structure and student disruptive behaviour. *British Journal of Educational Psychology, 72*(2), 191-211. https://doi.org/10.1348/000709902158847

Kaplan, R. M., Spittel, M. L., & Zeno, T. L. (2014). Educational attainment and life expectancy. *Policy Insights from the Behavioral and Brain Sciences, 1*, 189-194. https://doi.org/10.1177/2372732214549754

Karababa, A. (2020). The reciprocal relationships between school engagement and self-esteem among Turkish early adolescents: a three-wave cross-lagged model. *Children and Youth Services Review, 116*, 105114. https://doi.org/10.1016/j.childyouth.2020.105114

Kerpan, S., Humbert, M. L., Rodgers, C. D., & Stoddart, A. L. (2019). Improving Kindergarten and Grade One Indigenous Students' On-Task Behavior with the Use of Movement Integration. *Journal of American Indian Education, 58*(1-2), 84-107. https://doi.org/10.5749/jamerindieduc.58.1-2.0084

Kirkpatrick, B. A., Wright, S., Daniels, S., Taylor, K. L., McCurdy, M., & Skinner, C. H. (2019). Tootling in an after-school setting: Decreasing antisocial interactions in at-risk students. *Journal of Positive Behavior Interventions, 21*(4), 228-237. https://doi.org/10.1177/1098300719851226

Knight, G., & Noyes, J. A. N. (1999). Children's behaviour and the design of school furniture. *Ergonomics, 42*(5), 747-760. https://doi.org/10.1080/001401399185423

Kollerová, L., Květon, P., Zábrodská, K., & Janošová, P. (2023). Teacher exhaustion: The effects of disruptive student behaviors, victimization by workplace bullying, and social support from colleagues. *Social Psychology of Education, 26*(4), 885-902. https://doi.org/10.1007/s11218-023-09779-x

Kosola, S., Mundy, L. K., Sawyer, S. M., Canterford, L., van der Windt, D. A., Dunn, K. M., & Patton, G. C. (2017). Pain and learning in primary school: a population-based study. *Pain*, *158*(9), 1825-1830. https://doi.org/10.1097/j.pain.0000000000000984

Kremer, K. P., Flower, A., Huang, J., & Vaughn, M. G. (2016). Behavior problems and children's academic achievement: A test of growth-curve models with gender and racial differences. *Children and Youth Services Review, 67*, 95-104. https://doi.org/10.1016/j.childyouth.2016.06.003

Kriegbaum, K., Becker, N., & Spinath, B. (2018). The relative importance of intelligence and motivation as predictors of school achievement: A meta-analysis. *Educational Research Review, 25*, 120-148. https://doi.org/10.1016/j.edurev.2018.10.001

Kristiansen, J., Persson, R., Lund, S. P., Shibuya, H., & Nielsen, P. M. (2013). Effects of classroom acoustics and self-reported noise exposure on teachers' well-being. *Environment and Behavior, 45*(2), 283-300. https://doi.org/10.1177/0013916511429700

Kristoffersen, J. H. G., Krægpøth, M. V., Nielsen, H. S., & Simonsen, M. (2015). Disruptive school peers and student outcomes. *Economics of Education Review, 45*, 1-13. https://doi.org/10.1016/j.econedurev.2015.01.004

Krombach, T., & Miltenberger, R. (2020). The effects of stability ball seating on the behavior of children with autism during instructional activities. *Journal of Autism and Developmental Disorders, 50*, 551-559. https://doi.org/10.1007/s10803-019-04283-8

Lala, B., & Hagishima, A. (2023). Impact of escalating heat waves on students' well-being and overall health: a survey of primary school teachers. *Climate, 11*(6), 126. https://doi.org/10.3390/cli11060126

Lallukka, T., Kerkelä, M., Ristikari, T., Merikukka, M., Hiilamo, H., Virtanen, M., Øverland, S., Gissler, M., & Halonen, J. I. (2019). Determinants of long-term unemployment in early adulthood: A Finnish birth cohort study. *SSM-Population Health, 8*, 100410. https://doi.org/10.1016/j.ssmph.2019.100410

Lamote, C., Speybroeck, S., Van Den Noortgate, W., & Van Damme, J. (2013). Different pathways towards dropout: The role of engagement in early school leaving. *Oxford Review of Education, 39*(6), 739-760. https://doi.org/10.1080/03054985.2013.854202

Lan, L., Tang, J., Wargocki, P., Wyon, D. P., & Lian, Z. (2022). Cognitive performance was reduced by higher air temperature even when thermal comfort was maintained over the 24–28 C range. *Indoor Air, 32*(1), e12916. https://doi.org/10.1111/ina.12916

Lankester, M., Coles, C., Trotter, A., Scott, S., Downs, J., Dickson, H., & Wickersham, A. (2025). The Association Between Academic Achievement and Subsequent Youth Offending: A Systematic Review and Meta-Analysis. *Journal of Developmental and Life-Course Criminology*, 1-24. https://doi.org/10.1007/s40865-025-00266-9

Léger, M. C., Cardoso, M. R., Dion, C., & Albert, W. J. (2022). Does active sitting provide more physiological changes than traditional sitting and standing workstations? *Applied Ergonomics, 102*, 103741. https://doi.org/10.1016/j.apergo.2022.103741

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal, 46*(3), 517-528. https://doi.org/10.2224/sbp.7054

Lê-Scherban, F., Roux, A. V. D., Li, Y., & Morgenstern, H. (2014). Does academic achievement during childhood and adolescence benefit later health?. *Annals of Epidemiology*, *24*(5), 344-355. https://doi.org/10.1016/j.annepidem.2014.02.008

Lettau, J. (2021). The Impact of Children’s Academic Competencies and School Grades on their Life Satisfaction: What Really Matters? *Child Indicators Research*, *14*(6), 2171-2195. https://doi.org/https://doi.org/10.1007/s12187-021-09830-3

Lindley, S. (2012). The effects of pain on behaviour and behavioural problems Part 3: Aggression and compulsion. *Companion Animal, 17*(2), 50-54. https://doi.org/10.1111/j.2044-3862.2012.00147.x

Liu, C., Zhang, Y., Sun, L., Gao, W., Jing, X., & Ye, W. (2021). Influence of indoor air temperature and relative humidity on learning performance of undergraduates. *Case Studies in Thermal Engineering, 28*, 101458. https://doi.org/10.1016/j.csite.2021.101458

Liu, J., Peng, P., Zhao, B., & Luo, L. (2022). Socioeconomic status and academic achievement in primary and secondary education: A meta-analytic review. *Educational Psychology Review, 34*(4), 2867-2896. https://doi.org/10.1007/s10648-022-09689-y

Liu, Y., Ma, S., & Chen, Y. (2024). The impacts of learning motivation, emotional engagement and psychological capital on academic performance in a blended learning university course. *Frontiers in Psychology, 15*, 1357936. https://doi.org/10.3389/fpsyg.2024.1357936

López, L. R., Dessì, P., Cabrera-Codony, A., Rocha-Melogno, L., Kraakman, B., Naddeo, V., Balaguer, M. D., & Puig, S. (2023). CO_2 in indoor environments: From environmental and health risk to potential renewable carbon source. *Science of the Total Environment, 856*, 159088. https://doi.org/10.1016/j.scitotenv.2022.159088

López-Martín, E., Gutiérrez-de-Rozas, B., González-Benito, A. M., & Expósito-Casas, E. (2023). Why do teachers matter? A meta-analytic review of how teacher characteristics and competencies affect students' academic achievement. *International Journal of Educational Research, 120*, 102199. https://doi.org/10.1016/j.ijer.2023.102199

Lozano-Blasco, R., Quílez-Robres, A., Usán, P., Salavera, C., & Casanovas-López, R. (2022). Types of intelligence and academic performance: A systematic review and meta-analysis. *Journal of Intelligence, 10*(4), 123. https://doi.org/10.3390/jintelligence10040123

Ludyga, S., Gerber, M., Brand, S., Möhring, W., & Pühse, U. (2022). Do different cognitive domains mediate the association between moderate-to-vigorous physical activity and adolescents' off-task behaviour in the classroom? *British Journal of Educational Psychology, 92*(1), e12445. https://doi.org/10.1111/bjep.12445

Ma, J. K., Mare, L. L., & Gurd, B. J. (2014). Classroom-based high-intensity interval activity improves off-task behaviour in primary school students. *Applied Physiology, Nutrition, and Metabolism, 39*(12), 1332-1337. https://doi.org/10.1139/apnm-2014-0125

Machin, S., Marie, O., & Vujić, S. (2011). The crime reducing effect of education. *The Economic Journal*, *121*(552), 463-484. https://doi.org/https://doi.org/10.1111/j.1468-0297.2011.02430.x

Mahar, M. T. (2011). Impact of short bouts of physical activity on attention-to-task in elementary school children*. Preventive Medicine, 52*, S60-S64. https://doi.org/10.1016/j.ypmed.2011.01.026

Mäkinen, T. M., Juvonen, R., Jokelainen, J., Harju, T. H., Peitso, A., Bloigu, A., Silvennoinen-Kassinen, S., Leinonen, M. & Hassi, J. (2009). Cold temperature and low humidity are associated with increased occurrence of respiratory tract infections. *Respiratory Medicine, 103*(3), 456-462. https://doi.org/10.1016/j.rmed.2008.09.011

Mammadov, S. (2022). Big Five personality traits and academic performance: A meta-analysis. *Journal of Personality, 90*(2), 222-255. https://doi.org/10.1111/jopy.12663

Mao, P., Cai, Z., He, J., Chen, X., & Fan, X. (2021). The relationship between attitude toward science and academic achievement in science: A three-level meta-analysis*. Frontiers in Psychology, 12*, 784068. https://doi.org/10.3389/fpsyg.2021.784068

Martin, I. (2021). *An experimental evaluation of the introduction of Bodyfurn chairs on on-task and disruptive behaviour in the classroom*. (Master's thesis, The University of Waikato). The University of Waikato Research Commons. https://hdl.handle.net/10289/14338

Martins, R. C., Gonçalves, H., Blumenberg, C., Könsgen, B., Houvèssou, G. M., Carone, C., Gill, J. D., Lautenschläger, P., Wehrmeister, F.C., Menezes, A. M. B., & Murray, J. (2022). School performance and young adult crime in a Brazilian birth cohort. *Journal of Developmental and Life-Course Criminology*, *8*(4), 647-668. https://doi.org/10.1007/s40865-022-00214-x

Matin Sadr, N., Haghgoo, H. A., Samadi, S. A., Rassafiani, M., Bakhshi, E., & Hassanabadi, H. (2017). The Impact of Dynamic Seating on Classroom Behavior of Students with Autism Spectrum Disorder. *Iranian Journal of Child Neurology, 11*(1), 29-36. https://doi.org/10.22037/ijcn.v11i1.11193

Mavilidi, M. F., Drew, R., Morgan, P. J., Lubans, D. R., Schmidt, M., & Riley, N. (2020). Effects of different types of classroom physical activity breaks on children's on-task behaviour, academic achievement and cognition. *Acta Paediatrica, 109*(1), 158-165. https://doi.org/10.1111/apa.14892

McGowan, A. L., Gerde, H. K., Pfeiffer, K. A., & Pontifex, M. B. (2021). Physically active learning in preschoolers: Improved self-regulation, comparable quantity estimation. *Trends in Neuroscience and Education, 22*, 100150. https://doi.org/10.1016/j.tine.2021.100150

Mead, T., Scibora, L., Gardner, J., & Dunn, S. (2016). The impact of stability balls, activity breaks, and a sedentary classroom on standardized math scores. *Physical Educator*, *73*(3), 433. https://doi.org/10.18666/TPE-2016-V73-I3-5303

Mealings, K. T., Buchholz, J. M., Demuth, K., & Dillon, H. (2015). Investigating the acoustics of a sample of open plan and enclosed Kindergarten classrooms in Australia. *Applied Acoustics, 100*, 95-105. https://doi.org/10.1016/j.apacoust.2015.07.009

Mealings, K., Maggs, L., & Buchholz, J. M. (2024). The effects of classroom acoustic conditions on teachers' health and well-being: A scoping review. *Journal of Speech, Language, and Hearing Research, 67*(1), 346-367. https://doi.org/10.1044/2023_JSLHR-23-00256

Mealings, K., & Buchholz, J. M. (2025). The effect of classroom acoustics and noise on preschool children's listening, learning, and wellbeing: A scoping review. *Building Acoustics, 32*(1), 109-121. https://doi.org/10.1177/1351010X241286267

Meany-Walen, K. K., Bratton, S. C., & Kottman, T. (2014). Effects of Adlerian play therapy on reducing students' disruptive behaviors. *Journal of Counseling & Development, 92*(1), 47-56. https://doi.org/10.1002/j.1556-6676.2014.00129.x

Mellor, N. (2005). Attention seeking: The paradoxes of an under-researched concept. *Educational and Child Psychology, 22*(4), 94-107. https://doi.org/10.53841/bpsecp.2005.22.4.94

Metsäpelto, R.-L., Zimmermann, F., Pakarinen, E., Poikkeus, A.-M., & Lerkkanen, M.-K. (2020). School grades as predictors of self-esteem and changes in internalizing problems: A longitudinal study from fourth through seventh grade. *Learning and Individual Differences*, *77*, 101807. https://doi.org/https://doi.org/10.1016/j.lindif.2019.101807

Metz, A. E., DeMarco, M., Khalsa, A., Kreuz, N., Stock, R., & Westfall, A. (2020). The effects of ball chair seating during an instructional period in first grade classrooms. *Journal of Occupational Therapy, Schools, & Early Intervention, 13*(4), 395-409. https://doi.org/10.1080/19411243.2020.1768999

Meyer, J., Jansen, T., Hübner, N., & Lüdtke, O. (2023). Disentangling the association between the Big Five personality traits and student achievement: Meta-analytic evidence on the role of domain specificity and achievement measures. *Educational Psychology Review, 35*(1), 12. https://doi.org/10.1007/s10648-023-09736-2

Miller, T. (2019). "Johnny Is just Disruptive": Changing Behaviours Within the Classroom. In: G. Gerg, P. Smith, P. Black, Y. Budd, L. Disney (Eds.), *Reflective Practice in Teaching* (pp 27–31). Springer. https://doi.org/10.1007/978-981-13-9475-1_4

Minghelli, B. (2020). Musculoskeletal spine pain in adolescents: Epidemiology of non-specific neck and low back pain and risk factors. *Journal of Orthopaedic Science*, *25*(5), 776-780. https://doi.org/10.1016/j.jos.2019.10.008

Ministry of Education. (2022). *Designing Quality Learning Spaces (DQLS) Indoor Air Quality and Thermal Comfort*. https://web-assets.education.govt.nz/s3fs-public/2024-10/Indoor-Air-

Quality-and-Thermal-Comfort-V2-v2.0-2022.pdf?VersionId=FWYjUT5Ej_GCPwenx3OqguCG8.phJHEy

Mogas-Recalde, J., & Palau, R. (2021). Classroom lighting and its effect on student learning and performance: Towards smarter conditions. In *Ludic, Co-Design and Tools Supporting Smart Learning Ecosystems and Smart Education: Proceedings of the 5th International Conference on Smart Learning Ecosystems and Regional Development* (pp. 3-12). Springer Singapore. https://doi.org/10.1007/978-981-15-7383-5_1

Moon, J., Webster, C. A., Herring, J., & Egan, C. A. (2022). Relationships between systematically observed movement integration and classroom management in elementary schools. *Journal of Positive Behavior Interventions, 24*(2), 122-132. https://doi.org/10.1177/1098300720947034

Moore, D. J., Keogh, E., & Eccleston, C. (2012). The interruptive effect of pain on attention. *Quarterly Journal of Experimental Psychology, 65*(3), 565-586. https://doi.org/10.1080/17470218.2011.626865

Moore, D. J., Meints, S. M., Lazaridou, A., Johnson, D., Franceschelli, O., Cornelius, M., Schreiber, K., & Edwards, R. R. (2019). The effect of induced and chronic pain on attention. *The Journal of Pain, 20*(11), 1353-1361. https://doi.org/10.1016/j.jpain.2019.05.004

Morishima, T., Restaino, R. M., Walsh, L. K., Kanaley, J. A., Fadel, P. J., & Padilla, J. (2016). Prolonged sitting-induced leg endothelial dysfunction is prevented by fidgeting. *American Journal of Physiology. Heart and Circulatory Physiology, 311*(1), H177-H182. https://doi.org/10.1152/ajpheart.00297.2016

Motlagh, S. E., Amrai, K., Yazdani, M. J., altaib Abderahim, H., & Souri, H. (2011). The relationship between self-efficacy and academic achievement in high school students. *Procedia-Social and Behavioral Sciences, 15*, 765-768. https://doi.org/10.1016/j.sbspro.2011.03.180

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S., & Visscher, C. (2015). Improving academic performance of school-age children by physical activity in the classroom: 1-year program evaluation*. Journal of School Health, 85*(6), 365-371. https://doi.org/10.1111/josh.12259

Ng, Z. J., Huebner, S. E., & Hills, K. J. (2015). Life satisfaction and academic performance in early adolescents: Evidence for reciprocal association. *Journal of School Psychology, 53*(6), 479-491. https://doi.org/10.1016/j.jsp.2015.09.004

Nordlander, E., Stensöta, H. O. (2014). Grades – for Better or Worse? The Interplay of School Performance and Subjective Well-Being Among Boys and Girls. *Child Indicators Research, 7*, 861–879. https://doi.org/10.1007/s12187-014-9233-y

Nüesch, C., Kreppke, J. N., Mündermann, A., & Donath, L. (2018). Effects of a dynamic chair on chair seat motion and trunk muscle activity during office tasks and task transitions. *International Journal of Environmental Research and Public Health, 15*(12), 2723. https://doi.org/10.3390/ijerph15122723

Nunes, C., Oliveira, T., Santini, F. D. O., Castelli, M., & Cruz-Jesus, F. (2022). A weight and meta-analysis on the academic achievement of high school students. *Education Sciences, 12*(5), 287. https://doi.org/10.3390/educsci12050287

Nyström, A. S., Jackson, C., & Salminen Karlsson, M. (2019). What counts as success? Constructions of achievement in prestigious higher education programmes. *Research Papers in Education, 34*(4), 465-482. https://doi.org/10.1080/02671522.2018.1452964

Ødegård, M., & Solberg, S. (2024). Identifying teachers' reactive strategies towards disruptive behavior in classrooms. *Teaching and Teacher Education, 145*, 104627. https://doi.org/10.1016/j.tate.2024.104627

OECD. (2024). *OECD Economic Surveys: New Zealand 2024*. OECD Publishing, Paris, https://doi.org/10.1787/603809f2-en.

Ofsted (2014). *Below the Radar: Low-Level Disruption in Classrooms*. London: Ofsted. https://www.gov.uk/government/publications/below-the-radar-low-level-disruption-in-the-countrys-classrooms

Ogunlana, M. O., Govender, P., & Oyewole, O. O. (2021). Prevalence and patterns of musculoskeletal pain among undergraduate students of occupational therapy and physiotherapy in a South African university. *Hong Kong Physiotherapy Journal*, *41*(01), 35-43. https://doi.org/10.1142/S1013702521500037

O'Keeffe, M., Dankaerts, W., O'Sullivan, P., O'Sullivan, L., & O'Sullivan, K. (2013). Specific flexion-related low back pain and sitting: comparison of seated discomfort on two different chairs. *Ergonomics, 56*(4), 650-658. https://doi.org/10.1080/00140139.2012.762462

Okeke, C., Thomas, A., & Botha, A. (2023). The impact of learners' disruptive behaviour on teachers' well-being: a qualitative approach. *International Journal of Research in Business and Social Science, 12*(8), 504-511. https://doi.org/10.20525/ijrbs.v12i8.2917

Okino, K., Aoki, M., Yamane, M., Kataoka, Y., Nitta, A., & Kohmura, C. (2022). Prolonged sitting causes leg discomfort in middle aged adults: evaluation of shear wave velocity, calf circumference, and discomfort questionaries. *Journal of Clinical Medicine, 11*(14), 4024. https://doi.org/10.3390/jcm11144024

Olota, P. O. (2022). Effect of Class Rules on Noisemaking and Interruption Behaviour of Pupils in Uruan Local Government Area. *South Asian Research Journal of Humanities and Social Sciences, 4*(3), 201-206. https://doi.org/10.36346/sarjhss.2022.v04i03.010

Oosterman, J. M., Derksen, L. C., van Wijck, A. J., Kessels, R. P., & Veldhuijzen, D. S. (2012). Executive and attentional functions in chronic pain: does performance decrease with increasing task load*? Pain Research and Management, 17*(3), 159-165. https://doi.org/10.1155/2012/962786

Opio, G., Ofoyuru, D. T., Hoppers, C. A. O., Odama, S., Ogwang, T. H., & Monk, D. (2024). The Relationship Between Physical Learning Environment and Academic Achievement of Learners in Inclusion: Across-Sectional Survey with Secondary School Students in Uganda. *Advances in Social Sciences and Management*, *2*(1), 62–72. https://hspublishing.org/ASSM/article/view/347

Otani, M. (2020). Parental involvement and academic achievement among elementary and middle school students. *Asia Pacific Education Review, 21*(1), 1-25. https://doi.org/10.1007/s12564-019-09614-z

Otero-López, J. M., Castro, C., Villardefrancos, E., & Santiago, M. J. (2009). Job dissatisfaction and burnout in secondary school teachers: Students' disruptive behaviour and conflict management examined. *European Journal of Education and Psychology, 2*(2), 99–111. https://doi.org/10.30552/ejep.v2i2.25

Owiredua, C., Flink, I., & Boersma, K. (2023). Prevalence and risk factors for pain-specific school absenteeism in adolescents with recurrent pain: A prospective population-based design. *European Journal of Pain, 27*(3), 390-400. https://doi.org/10.1002/ejp.2065

Ozdemir, S. (2008). The effectiveness of social stories on decreasing disruptive behaviors of children with autism: Three case studies*. Journal of Autism and Developmental Disorders, 38*(9), 1689-1696. https://doi.org/10.1007/s10803-008-0551-0

Patterson, S. T. (2009). The effects of teacher-student small talk on out-of-seat behavior. *Education and Treatment of Children, 32*(1), 167-174. https://doi.org/10.1353/etc.0.0048

Perrykkad, K., & Hohwy, J. (2020). Fidgeting as self-evidencing: A predictive processing account of non-goal-directed action. *New Ideas in Psychology, 56*, 100750. https://doi.org/10.1016/j.newideapsych.2019.100750

Petrigna, L., Thomas, E., Brusa, J., Rizzo, F., Scardina, A., Galassi, C., Lo Verde, D., Caramazza, G., & Bellafiore, M. (2022). Does learning through movement improve academic performance in primary schoolchildren? A systematic review. *Frontiers in Pediatrics*, *10*, 841582. https://doi.org/10.3389/fped.2022.841582

Pettit-Mee, R. J., Ready, S. T., Padilla, J., & Kanaley, J. A. (2021). Leg Fidgeting During Prolonged Sitting Improves Postprandial Glycemic Control in People with Obesity. *Obesity, 29*(7), 1146-1154. https://doi.org/10.1002/oby.23173

Philp, J., & Duchesne, S. (2016). Exploring engagement in tasks in the language classroom. *Annual Review of Applied Linguistics, 36*, 50-72. https://doi.org/10.1017/S0267190515000094

Qiu, Y., Wei, K., Zhu, L., Wu, D., & Jiao, C. (2021). The Association of Meteorological Factors with Cognitive Function in Older Adults. *International Journal of Environmental Research and Public Health, 18*(11), 5981. https://doi.org/10.3390/ijerph18115981

Radwan, A., Barnes, L., DeResh, R., Englund, C., & Gribanoff, S. (2022). Effects of active microbreaks on the physical and mental well-being of office workers: A systematic review. *Cogent Engineering, 9*(1), 2026206. https://doi.org/10.1080/23311916.2022.2026206

Raghupathi, V., & Raghupathi, W. (2020). The influence of education on health: An empirical assessment of OECD countries for the period 1995–2015. *Archives of Public Health*, *78*(1), 1-18. https://doi.org/https://doi.org/10.1186/s13690-020-00402-5

Ragnarsson, S., Johansson, K., Bergström, E., Sjöberg, G., Hurtig, A. K., & Petersen, S. (2022). Recurrent pain in school-aged children: a longitudinal study focusing on the relation to academic achievement. *Pain*, *163*(11), 2245-2253. https://doi.org/10.1097/j.pain.0000000000002625

Rantala, L. M., Hakala, S., Holmqvist, S., & Sala, E. (2015). Classroom noise and teachers' voice production. *Journal of Speech, Language, and Hearing Research, 58*(5), 1397-1406. https://doi.org/10.1044/2015_JSLHR-S-14-0248

Reeve, J., Cheon, S. H., & Jang, H. (2020). How and why students make academic progress: Reconceptualizing the student engagement construct to increase its explanatory power. *Contemporary Educational Psychology, 62*, 101899. https://doi.org/10.1016/j.cedpsych.2020.101899

Reeve, J., Basarkod, G., Jang, H. R., Gargurevich, R., Jang, H., & Cheon, S. H. (2025). Specialized Purpose of Each Type of Student Engagement: A Meta-Analysis. *Educational Psychology Review, 37*(1), 1-38. https://doi.org/10.1007/s10648-025-09989-z

Reinke, W. M., Herman, K. C., Stormont, M., & Ghasemi, F. (2025). Teacher Stress, Coping, Burnout, and Plans to Leave the Field: A Post-Pandemic Survey. *School Mental Health*, 1-13. https://doi.org/10.1007/s12310-024-09738-7

Rollo, S., Crutchlow, L., Nagpal, T. S., Sui, W., & Prapavessis, H. (2019). The effects of classroom-based dynamic seating interventions on academic outcomes in youth: A systematic review. *Learning Environments Research, 22*(2), 153-171. https://doi.org/10.1007/s10984-018-9271-3

Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., & Spinath, F. M. (2015). Intelligence and school grades: A meta-analysis*. Intelligence, 53*, 118-137. https://doi.org/10.1016/j.intell.2015.09.002

Salar, M., Ragandang, E. F., Orpilla, M. Q., Pagara, P. G., Cabana, S., Paderna, L. J., & Quiño-Justol, J. (2024). Oplan Baklas: Examining the Impact of Classroom Design on the Academic Performance of Grade 3 Learners. *Universal International Journal of Research and Technology*, *5*(8), 108-116. https://uijrt.com/paper/oplan-baklas-examining-impact-classroom-design-academic-performance-grade-3-learners

Salminen, S., Kurenniemi, M., Råback, M., Markkula, J., & Lounamaa, A. (2014). School environment and school injuries. *Frontiers in Public Health, 1*, 76. https://doi.org/10.3389/fpubh.2013.00076

Sarbu, I., & Pacurar, C. (2015). Experimental and numerical research to assess indoor environment quality and schoolwork performance in university classrooms. *Building and Environment, 93*, 141-154. https://doi.org/10.1016/j.buildenv.2015.06.022

Sarver, D. E., Rapport, M. D., Kofler, M. J., Raiker, J. S., & Friedman, L. M. (2015). Hyperactivity in attention-deficit/hyperactivity disorder (ADHD): Impairing deficit or compensatory behavior? *Journal of Abnormal Child Psychology, 43*(7), 1219-1232. https://doi.org/10.1007/s10802-015-0011-1

Scattone, D., Wilczynski, S. M., Edwards, R. P., & Rabian, B. (2002). Decreasing disruptive behaviors of children with autism using social stories. *Journal of Autism and Developmental Disorders, 32*, 535-543. https://doi.org/10.1023/A:1021250813367

Schilling, D. L., Washington, K., Billingsley, F. F., & Deitz, J. (2003). Classroom seating for children with attention deficit hyperactivity disorder: Therapy balls versus chairs*. The American Journal of Occupational Therapy, 57*(5), 534-541. https://doi.org/10.5014/ajot.57.5.534

Schilling, D. L., & Schwartz, I. S. (2004). Alternative seating for young children with autism spectrum disorder: Effects on classroom behavior*. Journal of Autism and Developmental Disorders, 34*(4), 423-432. https://doi.org/10.1023/B:JADD.0000037418.48587.f4

Schmidt, B. M., Elies, A., Plank, J., & Schabmann, A. (2025). The relationship of students' classroom behaviour and word reading—The role of on-task behaviour as a mediator. *Journal of Research in Special Educational Needs*. Advance online publication https://doi.org/10.1111/1471-3802.70013

Scott-Webber, L., Konyndyk, R., French, R., & French, J. (2018). Significant results. Space makes a difference increasing student academic engagement levels. *European Scientific Journal, 14*(16), 1857-7881. https://doi.org/10.19044/esj.2018.v14n16p61

See, C. (2012). The use of music and movement therapy to modify behaviour of children with autism. *Pertanika Journal of Social Sciences & Humanities, 20*(4), 1103-1116. http://psasir.upm.edu.my/id/eprint/57742/1/JSSH%20Vol.%2020%20%284%29%20Dec.%202012%20%28View%20Full%20Journal%29.pdf#page=167

Selvitopu, A., & Kaya, M. (2023). A meta-analytic review of the effect of socioeconomic status on academic performance. *Journal of Education, 203*(4), 768-780. https://doi.org/10.1177/00220574211031978

Serbic, D., Friedrich, C., & Murray, R. (2023). Psychological, social and academic functioning in university students with chronic pain: a systematic review. *Journal of American College Health, 71*(9), 2894-2908. https://doi.org/10.1080/07448481.2021.2006199

Settimo, G., Indinnimeo, L., Inglessis, M., De Felice, M., Morlino, R., di Coste, A., Carriera. P., Di Fiore, C., & Avino, P. (2024). CO_2 Levels in Classrooms: What Actions to Take to Improve the Quality of Environments and Spaces. *Sustainability, 16*(19), 8619. https://doi.org/10.3390/su16198619

Shield, B. M., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *The Journal of the Acoustical Society of America, 123*(1), 133-144. https://doi.org/10.1121/1.2812596

Shoval, E., Sharir, T., Arnon, M., & Tenenbaum, G. (2018). The effect of integrating movement into the learning environment of kindergarten children on their academic achievements. *Early Childhood Education Journal*, *46*, 355-364. https://doi.org/10.1007/s10643-017-0870-x

Sidorin, D. I. (2015). Dynamics of carbon dioxide concentrations in the air and its effect on the cognitive ability of school students. *Izvestiya, Atmospheric and Oceanic Physics, 51*, 871-879. https://doi.org/10.1134/S000143381508006X

Slavin, R. E. (2020). How evidence-based reform will transform research and practice in education. *Educational Psychologist, 55*(1), 21-31. https://doi.org/10.1080/00461520.2019.1611432

Smith, T. E., Thompson, A. M., & Maynard, B. R. (2022). Self-management interventions for reducing challenging behaviors among school-age students: A systematic review. *Campbell Systematic Reviews, 18*(1), e1223. https://doi.org/10.1002/cl2.1223

Sölpük, N. (2017). The Effect of Attitude on Student Achievement. In L. Karadag (Eds), *The Factors Effecting Student Achievement* (pp. 57-73). Springer, Cham. https://doi.org/10.1007/978-3-319-56083-0_4

Stanić, V., Žnidarič, T., Repovš, G., & Geršak, G. (2022). Dynamic Seat Assessment for Enabled Restlessness of Children with Learning Difficulties. *Sensors, 22*(9), 3170. https://doi.org/10.3390/s22093170

Starr, A., Haider, Z. F., & von Stumm, S. (2024). Do school grades matter for growing up? Testing the predictive validity of school performance for outcomes in emerging adulthood. *Developmental Psychology, 60*(4), 665–679. https://doi.org/10.1037/dev0001548

Steinmayr, R., Meiṅer, A., Weideinger, A. F., & Wirthwein, L. (2014). *Academic Achievement*. Oxford Bibliographies. https://doi.org/10.1093/obo/9780199756810-0108

Stranden, E. (2000). Dynamic leg volume changes when sitting in a locked and free floating tilt office chair. *Ergonomics, 43*(3), 421-433. https://doi.org/10.1080/001401300184503

Sun, R. C., & Shek, D. T. (2012). Student classroom misbehavior: An exploratory study based on teachers' perceptions. *The Scientific World Journal, 2012*(1), 208907. https://doi.org/10.1100/2012/208907

Swinson, J., & Knight, R. (2007). Teacher verbal feedback directed towards secondary pupils with challenging behaviour and its relationship to their behaviour. *Educational Psychology in Practice, 23*(3), 241-255. https://doi.org/10.1080/02667360701507327

Synnott, A., Dankaerts, W., Seghers, J., Purtill, H., & O'Sullivan, K. (2017). The effect of a dynamic chair on seated energy expenditure. *Ergonomics, 60*(10), 1384-1392. https://doi.org/10.1080/00140139.2017.1324114

Szabó, L., Zsolnai, A., & Fehérvári, A. (2024). The relationship between student engagement and dropout risk in early adolescence. *International Journal of Educational Research Open, 6*, 100328. https://doi.org/10.1016/j.ijedro.2024.100328

Tamiya, H., Hotta, K., Hoshiai, M., Kurosawa, Y., Hamaoka, T., & Tsubaki, A. (2024). Leg fidgeting alleviates reduced oxygen extraction in the gastrocnemius muscle caused by prolonged sitting: a randomized crossover trial. *European Journal of Applied Physiology*, 1-13. https://doi.org/10.1007/s00421-024-05613-0

Tanoue, H., Mitsuhashi, T., Sako, S., Goto, R., Nakai, T., & Inaba, R. (2016). Effects of a dynamic chair on pelvic mobility, fatigue, and work efficiency during work performed while sitting: a comparison of dynamic sitting and static sitting. *Journal of Physical Therapy Science, 28*(6), 1759-1763. https://doi.org/10.1589/jpts.28.1759

Tao, Y., Meng, Y., Gao, Z., & Yang, X. (2022). Perceived teacher support, student engagement, and academic achievement: A meta-analysis. *Educational Psychology, 42*(4), 401-420. https://doi.org/10.1080/01443410.2022.2033168

Taylor, F. C., Pinto, A. J., Maniar, N., Dunstan, D. W., & Green, D. J. (2022). The Acute Effects of Prolonged Uninterrupted Sitting on Vascular Function: A Systematic Review and Meta-analysis. *Medicine and Science in Sports and Exercise, 54*(1), 67-76. https://doi.org/10.1249/MSS.0000000000002763

Tian, X., Fang, Z., & Liu, W. (2021). Decreased humidity improves cognitive performance at extreme high indoor temperature. *Indoor Air, 31*(3), 608-627. https://doi.org/10.1111/ina.12755

Torbeyns, T., de Geus, B., Bailey, S., Decroix, L., Van Cutsem, J., De Pauw, K., & Meeusen, R. (2017). Bike desks in the classroom: energy expenditure, physical health, cognitive performance, brain functioning, and academic performance. *Journal of Physical Activity and Health*, *14*(6), 429-439. https://doi.org/10.1123/jpah.2016-0224

Toyran, M., Yagmur, I. T., Guvenir, H., Haci, I. A., Bahceci, S., Batmaz, S. B., Topal, O. Y., Celik, I. K., Karaatmaca, B., Misirlioglu, E. D., Civelak, E., Can, D., & Kocabas, C. N. (2020). Asthma control affects school absence, achievement and quality of school life: a multicenter study. *Allergologia et Immunopathologia, 48*(6), 545-552. https://doi.org/10.1016/j.aller.2020.05.005

Triglav, J., Howe, E., Cheema, J., Dube, B., Fenske, M. J., Strzalkowski, N., & Bent, L. (2019). Physiological and cognitive measures during prolonged sitting: Comparisons between a standard and multi-axial office chair. *Applied Ergonomics, 78*, 176-183. https://doi.org/10.1016/j.apergo.2019.03.002

Tu, Z., Li, Y., Geng, S., Zhou, K., Wang, R., & Dong, X. (2021). Human responses to high levels of carbon dioxide and air temperature. *Indoor Air, 31*(3), 872-886. https://doi.org/10.1111/ina.12769

Turner, L., & Chaloupka, F. J. (2017). Reach and implementation of physical activity breaks and active lessons in elementary school classrooms*. Health Education & Behavior, 44*(3), 370-375. https://doi.org/10.1177/1090198116667714

Turtura, J. E., Anderson, C. M., & Boyd, R. J. (2014). Addressing task avoidance in middle school students: Academic behavior check-in/check-out. *Journal of Positive Behavior Interventions, 16*(3), 159-167. https://doi.org/10.1177/1098300713484063

Udo, H., Fujimura, M., & Yoshinaga, F. (1999). The effect of a tilting seat on back, lower back and legs during sitting work. *Industrial Health, 37*(4), 369-381. https://doi.org/10.2486/indhealth.37.369

van den Brink, F., Vollmann, M., & Tick, N. T. (2025). Disruptive Student Behavior and Emotional Exhaustion in Dutch Primary Special Education Teachers: The Mediating Role of Teachers' Competence Beliefs. *Psychology in the Schools, 62*(3), 920-930. https://doi.org/10.1002/pits.23365

van Dyne, P. R. (2010). School District Injuries, Injury Rates and Loss Source Controls. *In ASSE Professional Development Conference and Exposition. .* https://onepetro.org/ASSPPDCE/proceedings-abstract/ASSE10/All-ASSE10/76762

Vidić, T., Đuranović, M., & Klasnić, I. (2021). Student misbehaviour, teacher self-efficacy, burnout and job satisfaction: Evidence from Croatia. *Problems of Education in the 21st Century, 79*(4), 657. http://dx.doi.org/10.33225/pec/21.79.657

Voerman, J. S., de Klerk, C., Vander Heyden, K. M., Passchier, J., Idema, W., Timman, R., & Jolles, J. (2017). Pain is associated with poorer grades, reduced emotional well-being, and attention problems in adolescents. *The Clinical Journal of Pain*, *33*(1), 44-50. https://doi.org/10.1097/AJP.0000000000000367

Walck-Shannon, E. M., Rowell, S. F., & Frey, R. F. (2021). To what extent do study habits relate to performance?. *CBE—Life Sciences Education, 20*(1), 1-15. https://doi.org/10.1187/cbe.20-05-0091

Wang, M. T., & Fredricks, J. A. (2014). The reciprocal links between school engagement, youth problem behaviors, and school dropout during adolescence. *Child Development, 85*(2), 722-737. https://doi.org/10.1111/cdev.12138

Waongenngarm, P., Rajaratnam, B. S., & Janwantanakul, P. (2015). Perceived body discomfort and trunk muscle activity in three prolonged sitting postures. *Journal of Physical Therapy Science, 27*(7), 2183-2187. https://doi.org/10.1589/jpts.27.2183

Waongenngarm, P., van der Beek, A. J., Akkarakittichoke, N., & Janwantanakul, P. (2021). Effects of an active break and postural shift intervention on preventing neck and low-back pain among high-risk office workers: a 3-arm cluster-randomized controlled trial. *Scandinavian Journal of Work, Environment & Health, 47*(4), 306. https://doi.org/10.5271/sjweh.3949

Wargocki, P., Porras-Salazar, J. A., & Contreras-Espinoza, S. (2019). The relationship between classroom temperature and children's performance in school. *Building and Environment, 157*, 197-204. https://doi.org/10.1016/j.buildenv.2019.04.046

Wargocki, P., Porras-Salazar, J. A., Contreras-Espinoza, S., & Bahnfleth, W. (2020). The relationships between classroom air quality and children's performance in school. *Building and Environment, 173*, 106749. https://doi.org/10.1016/j.buildenv.2020.106749

Wargocki, P. (2022). Effects of Classroom Air Quality on Learning in Schools. In Y. Zhang, P. K. Hopke, & C. Mandin (Eds), *Handbook of Indoor Air Quality* (pp. 1447-1459). Springer. https://doi.org/10.1007/978-981-16-7680-2_65

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*, 1-24. https://doi.org/10.1186/s12966-017-0569-9

Webster, E. K., Wadsworth, D. D., & Robinson, L. E. (2015). Preschoolers' time on-task and physical activity during a classroom activity break. *Pediatric Exercise Science, 27*(1), 160-167. https://doi.org/10.1123/pes.2014-0006

Wells, S. L. (2012). Moving through the curriculum: The effect of movement on student learning, behavior, and attitude. *Rising Tide, 5*, 1-17. http://mat2012wells.pbworks.com/w/file/fetch/54431635/Wells,%20MRP.pdf

Woessmann, L. (2016). The economic case for education. *Education Economics*, *24*(1), 3-32. https://doi.org/https://doi.org/10.1080/09645292.2015.1059801

Wong, Z. Y., Liem, G. A. D., Chan, M., & Datu, J. A. D. (2024). Student engagement and its association with academic achievement and subjective well-being: A systematic review and meta-analysis. *Journal of Educational Psychology, 116*, 48. https://psycnet.apa.org/doi/10.1037/edu0000833

Woo, J., Rajagopalan, P., & Andamon, M. M. (2022). An evaluation of measured indoor conditions and student performance using d2 Test of Attention. *Building and Environment, 214*, 108940. https://doi.org/10.1016/j.buildenv.2022.108940

Yeganeh, A. J., Reichard, G., McCoy, A. P., Bulbul, T., & Jazizadeh, F. (2018). Correlation of ambient air temperature and cognitive performance: A systematic review and meta-analysis. *Building and Environment, 143*, 701-716. https://doi.org/10.1016/j.buildenv.2018.07.002

Zemp, R., Fliesser, M., Wippert, P. M., Taylor, W. R., & Lorenzetti, S. (2016). Occupational sitting behaviour and its relationship with back pain–A pilot study. *Applied Ergonomics, 56*, 84-91. https://doi.org/10.1016/j.apergo.2016.03.007

Zhao, L., & Zhao, Z. (2021). Disruptive peers in the classroom and students' academic outcomes: Evidence and mechanisms. *Labour Economics, 68*, 101954. https://doi.org/10.1016/j.labeco.2020.101954

Zhu, X., Tian, L., Zhou, J., & Huebner, E. S. (2019). The developmental trajectory of behavioral school engagement and its reciprocal relations with subjective well-being in school among Chinese elementary school students. *Children and Youth Services Review, 99*, 286-295. https://doi.org/10.1016/j.ecresq.2009.03.002

Zuniga, A. N., & Cividini-Motta, C. (2022). Using Class Pass Intervention to Decrease Disruptive Behavior in Young Children. *Journal of Behavioral Education*, *31*(3), 524-542. https://doi.org/10.1007/s10864-020-09411-4

Appendices

Co-Authorship Forms