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THE IMPACT OF CLASSROOM FURNITURE

ON THIRD GRADE CHILDREN'S OCCUPATIONAL PERFORMANCE

by

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ABSTRACT

The Impact of Classroom Furniture on

Third Grade Children's Occupational Performance

Jennifer K. Wingrat

Being a student is a primary occupation for children. Theoretical principles of the Person-Environment-Occupation Model suggest that interactions between people, environments, and the occupations they perform affect occupational performance. Studies show that classroom furniture is often too large for schoolchildren; there is little study of the impact on classroom occupational performance. This study used a repeated measure correlated groups design to assess relationships among furniture fit, sitting behaviors, on-task behaviors, math scores, and comfort in 31 third grade children, and handwriting legibility in a subset of 15 children while sitting in large standard classroom furniture and smaller standard and ergonomic furniture. The students demonstrated significantly better sitting and on-task behaviors and higher math test scores in the smaller, better fitting furniture. Students sat significantly better in the ergonomic chairs; better sitting behaviors were correlated with better handwriting legibility. The study supports the significance of environmental features for children's occupational performance.

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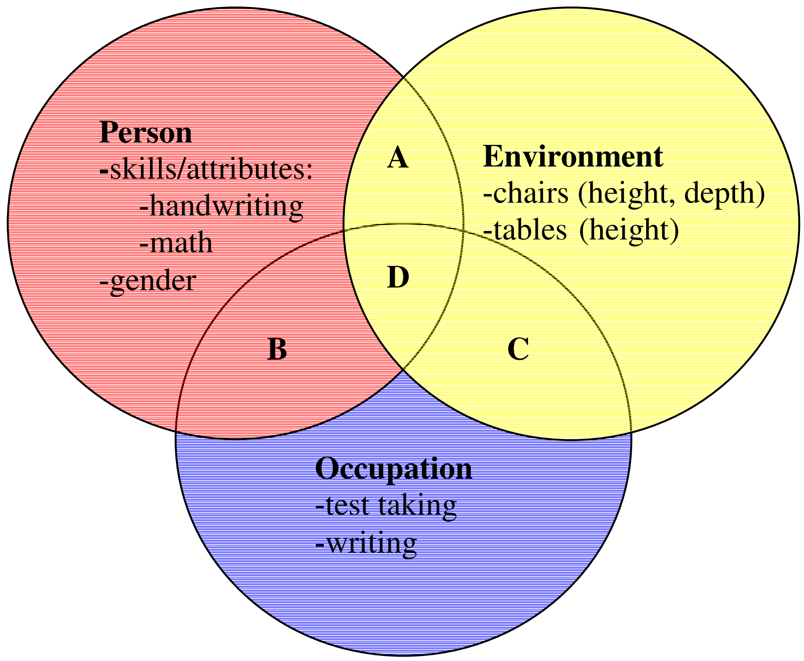
1. Occupational performance – an interaction between the student, the classroom environment, and the classroom task, e.g., performance on math test or handwriting legibility/productivity.
2. Task/classroom task – purposeful activities/occupations in which students engage, including sitting, attending to task, writing, reading, listening, taking tests.
3. Standard classroom chair – plastic, four-legged, bucket-type chairs with curved seat bottom used in many public school classrooms (see Figure 2).
4. Standard classroom table – 30” high round and rectangular tables used in the third grade classroom in the school in which the study will be conducted.
5. Appropriately-sized furniture – 15” high chairs and adjustable height tables, approximately 24-25” high.
6. Ergonomic chairs – 15” high plastic *IQ*™ chairs by Virco Inc., with flexible convex back support to support forward working and backward leaning positions (see Figure 3).

Chapter I

Problem Statement

Occupational scientists examine the many aspects that make up everyday occupations in their study of the form, function, and meaning of occupations in people's lives (Larson, Wood, & Clark, 2003; Zemke & Clark, 1996). According to occupational scientists, humans are most true to themselves when they are able to successfully engage in meaningful occupations (Wicks, 2001). The occupations of children involve performance in activities of daily living, play, and education. Since most children spend as much as 30% of their day in school (Linton, Hellsing, Halme, & Akerstedt, 1994), the education context is a key location for children's engagement in occupations, which include "activities needed for being a student and participating in a learning environment" (American Occupational Therapy Association [AOTA], 2002a, p. 620). Some of the activities needed for being a student and participating in the learning environment include tasks such as sitting in one's seat, engaging in writing activities, attending to tasks, and taking tests. Understanding how factors within school contexts affect children's participation in and performance of these school tasks is important for promoting success among all students.

The Person-Environment-Occupation (PEO) model (Law et al., 1996) proposes that environments that best support the demands of a given task or occupation help to facilitate successful performance of the tasks or occupations within it. According to this model, people, their environments, and the occupations in which they engage are interrelated (Figure 1).



Key:
A- person-environment interaction: fit in furniture, sitting behavior, comfort in furniture
B – person-occupation interaction: on-task behavior
C – environment-occupation interaction: ergonomic chairs; furniture matched to occupation
D – person-environment-occupation interaction: test performance, handwriting legibility

Figure 1. Person-Environment-Occupation Model (PEO).

Note. Figure adapted from Reitz, Scaffa, & Pizzi (in press), from a figure developed in *Measuring Occupational Performance: Supporting Best Practice in Occupational Therapy* (p. 41), by M. Law, C. Baum & W. Dunn, 2001, Thorofare, New Jersey: SLACK. Copyright 2001 by SLACK.

Specifically, the PEO model defines the *person* as a dynamic being with numerous roles who is in constant interaction with the environment (Law et al.), as highlighted in segment A of Figure 1. The person's behaviors are influenced by his or her unique attributes and life experiences, as well as by cultural and social factors. The *environment*, which is the context in which occupational performance occurs, includes cultural, social, socio-economic, institutional, and physical elements, all of which also influence a person's actions (Law et al.). *Occupations*, in the PEO model, are "groups of self-directed activities in which a person engages over the lifespan" (Law et al., p. 16). Engagement in these purposeful, self-directed activities serves to meet each person's intrinsic needs related to his or her roles. *Occupational performance* occurs when the person interacts with the environment through engagement in a purposeful occupation. Occupational performance (segment D, Figure 1) is influenced by the person's attributes and skills, by features of the environment, and by features of the occupation.

According to the PEO model, occupational performance is supported by a good fit between the person and/or the environment, and/or the occupation (Law et al.). For example, occupational performance is enhanced by maximizing the fit between a person's skills, abilities, and interests with the demands of the occupation, which is considered the person-occupation interaction (segment B, Figure 1). Being on-task in school is an example if a successful person-occupation interaction. Occupational performance is also enhanced when elements of the environment support successful engagement in an occupation via a good fit between the environment and the occupation or the environment-occupation interaction (segment C, Figure 1), such as by using ergonomic chairs that are designed to support seated tasks. However, according to Law et al., when there is a poor fit between a person, the environment and/or the occupation, it is often easier to alter or adapt features of an environment than to alter or adapt a person or an occupation. Therefore, the most effective way to facilitate occupational performance is to structure the environment to fit the person's needs, such as by providing a comfortable sitting position, thus targeting the person-environment interaction (segment A, Figure 1).

Lawton's (1980) Theory of Environmental Docility similarly proposes that successful interactions with the environment are facilitated by environments that are structured to meet a person's needs. According to Lawton, those with poorer skill levels are more likely to be negatively affected by environmental constraints or demands (1980). Lawton's principles are used to explain the effect of environmental demands on the elderly in order to create environments that meet the needs of those with varying skill levels. For example, an elderly person in good physical and cognitive health would likely be successful living independently in the community, because he or she would have the necessary skills to navigate the environment, prepare meals safely, take medication as directed, and so forth (Lawton, 1980). Conversely, another elderly person of the same age and gender but with compromised physical and cognitive health might trip over furniture, forget to turn off the stove, and/or take medication incorrectly, and would therefore be more successful in a supportive environment.

While Lawton's theory is traditionally used to assess the impact of the environment on successful aging, his principles can also be applied to address the impact of the environment on success in other areas such as the classroom. Based on Lawton's principles, environmental demands in a classroom may be more difficult for some students than for others, because of person factors such as varying skill levels or student size, or environment factors such as furniture size. Therefore, classroom environments should be designed to maximize all students' abilities to meet the environmental demands in order to support successful student performance in school. Occupational therapists and occupational scientists can use principles from Lawton's theory and PEO to structure classroom environments that support an optimal fit between students, the environment, and the occupations to be performed.

The *Occupational Therapy Practice Framework: Domain and Process* (AOTA, 2002a) defines school-based occupations as academic tasks such as math and reading, as well as non-academic and extracurricular tasks such as recess and sports. While success in non-academic and extracurricular tasks is important, schoolteachers, administrators, and federal legislators are primarily concerned about schoolchildren's success in academic tasks including standardized testing. The *No Child Left Behind* (NCLB) federal education law mandates accountability for academic success in public schools (United States Department of Education [USDE], n.d. a). The NCLB law also mandates the use of proven methods (USDE, n.d. a) to enhance academic success and to meet state standards. Because of the NCLB, schoolteachers and administrators are concerned about pass rates and overall student performance on standardized tests, which are used as the primary indicator of individual student achievement and determine how well a school is performing. Schools with students who have poor standardized test scores or generally poor performance rates risk losing students to other schools and also risk losing federal funding (Rennell, 2004). Therefore, school administrators and school systems are concerned about using methods that result in students achieving high standardized test scores and ensuring academic success for all students.

While the NCLB addresses issues related to academic success for all students, public law 108-446, the Individuals with Disabilities Education Improvement Act (IDEA), addresses issues related to academic success for students with disabilities. Specifically, the IDEA mandates that all children are entitled access to full participation in an educational setting that offers the least restrictive environment (National Education Administration [NEA], n.d.; USDE, n.d. b). Therefore, children with varying levels of physical, emotional, and behavioral disabilities often attend regular public schools with the provision of additional services including occupational therapy (Swinth, 2003). Furthermore, the NCLB includes expectations for children with disabilities to participate in standardized testing. Under the provisions of the IDEA, school-based occupational therapists typically provide direct and indirect services that focus on contextual factors to promote successful participation in the school environment. Therefore, school-based occupational therapists may be involved in recommending accommodations for standardized testing.

In addition to their role in enhancing success for students with disabilities, occupational therapists and occupational scientists can also help to enhance the success for all students within a classroom or school. For example, occupational therapists and occupational scientists can assess the impact of elements of a classroom environment on student performance. One element of classroom environments that can support or interfere with successful performance in school is the classroom furniture. In most classrooms, students sit at a desk or table while they attend to and engage in class work.

McHale and Cermak (1992) found that overall, elementary-aged children in a school in the United States spend 30% to 55% of the day engaged in fine motor tasks while seated and working on tabletop activities such as writing letters or words, or writing and solving math problems. Storr-Paulsen and Aagaard-Hensen (1994) found that students in a school in Denmark spend as much as 60 minutes at a time seated in a chair at their table or desk, with equal time spent leaning forward to engage in tasks and leaning back to listen to the teacher or other students. Cardon, De Clercq, Bourdeauduhij, and Breithecker (2004) reported that students in a school in Belgium spent 97% of the time sitting during math and language arts classes, with 70% of the time spent leaning forward. Based on these studies' findings, classroom furniture should appropriately support prolonged sitting and students' ability to perform tabletop work in both forward leaning and back-leaning sitting positions.

Despite the time students spend in classroom furniture, typical classroom furniture does not always meet the needs of the students who use it. According to recommendations in an education-based trade journal, school administrators should select classroom furniture based on factors such as price, quality, durability, the reputation of the furniture company, and availability of warranties (Fowler, Johnson, Maggett, & Muci, 2004), not on how well the furniture supports students of different sizes engaging in different tasks. Furthermore, furniture is typically designed to fit functional needs such as being easy to move or stack in a classroom rather than to facilitate learning or meet users' needs for comfort and function (Cornell, 2002). As a result, most classroom furniture is not designed to support students for prolonged periods of sitting in varying positions such as leaning forward or back (Cornell, 2002; Mandal, 1981, 1982; Yeats, 1997). Furniture that does not provide support for prolonged sitting may elicit poor sitting postures including dangling legs, hunched shoulders, and rounded backs, that lead to musculoskeletal discomfort (Cornell, 2002; Linton, Hellsing, Halme, & Akerstedt, 1994; Murphy, Buckle, & Stubbs, 2004). Cornell, Linton, et al., and Murphy et al. all hypothesize that poor sitting postures and musculoskeletal discomfort may compromise students' performance of classroom tasks.

The hypothesis that poor sitting postures may negatively affect students' occupational performance in school is based on principles from biomechanical and motor control models, which suggest the importance of positioning in supporting optimal performance. A primary principle of the biomechanical model typically applied to adults is that proximal stability is necessary for distal mobility, such as functional hand use (Trombly & Radomski, 2002). Proximal stability, including trunk control, and stability in the hip, pelvis, and shoulder, can be enhanced through supportive positioning (Trombly & Radomski). This principle can be applied to children by providing chairs whose height, seat length and depth, and back support fit a child's size. Classroom chairs that are too high off the ground or whose seats are too deep may compromise students' proximal support needed to facilitate successful distal skills. Smith-Zuzovsky and Exner (2004) found that 6- and 7-year-old children who sat in appropriately-sized furniture performed better on a test of hand skills than did children who sat in furniture that was too large. Sents and Marks (1989) found that preschool aged children scored significantly higher on an IQ test that involved manipulatives when seated in appropriately-sized furniture compared to when they sat in furniture that was too large.

These findings suggest that a lack of proximal support may lead to difficulty performing tasks involving distal hand skills.

While the biomechanical model emphasizes the importance of proximal support for success with distal skills, motor control theories focus on the integration of the central nervous system, the musculoskeletal system, and the environment, as integral to the ability to use the body effectively while engaging in a task (Kielhofner, 2004; Shumway-Cook & Woolacott, 2001). The integration of the central nervous system, the musculoskeletal system, and the environment represents an interaction between a person, the task, and the context (Shumway-Cook & Woolacott, 2001), similar to the person-environment-occupation interaction depicted in segment D of Figure 1. The ability to maintain a sitting position during listening tasks requires a successful interaction between the student, and the environment including the furniture. Postural control, which is one form of proximal stability required during writing tasks, requires a successful interaction between the student, and the classroom environment including the furniture. Therefore, if the furniture within a classroom environment does not facilitate a successful interaction between the students and the environment, then the ability to perform classroom tasks is negatively affected. Based on this principle, it is possible that sitting in chairs that are too high or too deep or at tables that are too high, may decrease a child's ability to interact successfully in the classroom as evidenced by poor attention to tasks, use of poor sitting postures, poor handwriting skills, or low test scores.

The principles of the biomechanical and motor control approaches are reflected in ergonomic principles that are often recommended for adult workers. For example, in order to reduce musculoskeletal strain, adult workers may be advised to sit in height-adjustable chairs with reclining backrests to provide for rests and posture changes, foot supports either on the chair or on the floor, and adjustable arm supports for adults of different sizes (AOTA, 2002b). However, children who sit for long periods in school five days per week do not have access to furniture that allows for the application of these principles. In fact, not only do schoolchildren not have furniture that allows for varying sitting positions, they usually do not have furniture that is the correct size for their height. As a result, many children may assume and maintain unnatural and uncomfortable sitting positions, such as sitting with less than half of the buttocks in contact with the seat, sitting with a twisted trunk, sitting on knees, and sitting with a posterior pelvic tilt. When students are uncomfortable, the subsequent interaction between the person and the environment may compromise optimal occupational performance.

Research on the impact of poorly sized school furniture is limited by methodological weaknesses. Studies that have assessed the relationship between children's sizes and their classroom furniture (Cotton et al., 2002; Parcells et al., 1999; Yeats, 1997) have not assessed the impact of subsequent comfort or discomfort on occupational performance. Other studies have found that when seated in furniture that fits, children generally perform better on classroom tasks such as writing (Burkhart, 1999; Parush, Pindak, Hahn-Markowitz, & Mazor-Karsenty, 1998; Parush, Levanon-Erez, & Weintraub, 1998; Schilling, Washington, Billingsley, & Deitz, 2003), attending to task (Knight & Noyes, 1999; Wheldall & Lam, 1987; Wingrat & Exner, 2005), and tests of hand skills (Smith-Zuzovsky & Exner, 2004). However, small sample sizes, use of simulated tasks, specially designed ergonomic furniture, and one-on-one testing to assess the relationship between areas of performance relative to children's fit in their classroom furniture, limit the generalizability of many of the previous studies to their particular samples, and do not allow for generalization to actual classroom environments. Additional research is needed to assess the impact of classroom furniture size and type, as well as sitting comfort on the occupational performance of schoolchildren within their natural classroom environment and while engaged in real-life classroom tasks such as attending to task, sitting behaviors, handwriting legibility, and test scores.

Purpose of the Study

The purpose of this study is to assess the person-environment-occupation interaction by examining the effects of classroom furniture size and type on selected aspects of children's occupational performance in the classroom, and to determine whether the environment most significantly affects those with lower skill levels compared to those with typical or high average skill levels. Areas of occupational performance that will be studied are third grade students' sitting behaviors, attention to task, classroom test scores, and handwriting. A secondary purpose is to assess the relationship between measures of student reports of seated comfort and children's occupational performance, in order to determine whether there is a link between sitting comfort, type of chair, size of chair, and improved occupational performance.

Significance and Need for the Study

The findings of this study are likely to have implications for schoolchildren, school administrators, occupational therapists and occupational scientists, theoretical models of PEO and Lawton, and policies affecting testing and accommodations in schools. If this study shows that simply providing children with furniture that more closely fits their size enhances children's occupational performance in the classroom, then other elementary schools may be more likely to use furniture that is more proportional to the sizes of the students. If occupational performance is more significantly enhanced while students sit in ergonomic chairs compared to standard chairs, then schools may choose to equip their classrooms with ergonomic chairs. Occupational therapists and occupational scientists may use the findings of this study to help create classroom environments that best support students' needs by modifying existing furniture or helping to plan for new classroom furniture. School administrators may pay greater attention to the role of different types of classroom furniture in enhancing student performance. This study also has the potential to support the application of PEO and Lawton's Theory of Environmental Docility to enhancing educational contexts. Finally, education-based policies may decide to include provisions for consideration of contextual factors such as classroom furniture as a method for optimizing learning environments.

Impact on Children

This study may impact school-aged children in several ways if it shows that children who sit in classroom furniture that fits them better are more successful in meeting the demands of their classroom environments. First, if the children in this study demonstrate better sitting postures, more on-task behaviors, better handwriting, and/or better test scores when sitting in the better fitting classroom furniture, then these children will have directly benefited from the environmental intervention. According to the PEO model (Law et al., 1996), experiences of successful interactions with the environment provide for a sense of achievement, mastery, and competence. Conversely, unsuccessful environmental interactions such as difficulty performing the tasks associated with one's occupational roles is likely to lead to frustration and a sense of incompetence (Law et al.). When schoolchildren sit in classroom furniture that does not fit their size and/or does not provide support for their task demands, then they may spend less time on classroom tasks due to their discomfort or frustration. Spending less time on classroom tasks may then result in poorer performance, poorer grades, and a poorer self-efficacy. Therefore, enhancing the fit between children and their environment by providing appropriately sized furniture is expected to optimize their ability to perform classroom tasks successfully.

The furniture may positively affect children's comfort while seated in school. If the children in the study are more comfortable when seated in the smaller, appropriately sized classroom furniture, they may be better able to attend to their teacher and be more engaged in their classroom tasks. Increased attention and task engagement may lead to better comprehension, better test scores, and better grades for the participants. Furthermore, if the children in the study are more comfortable in the smaller, appropriately sized or ergonomic furniture, thus making fewer position changes or using fewer nonstandard sitting behaviors such as sitting on the edge of the seat, sitting on their knees, or standing, they may receive more positive attention from their teacher.

In addition to the potential impact on the children in the study, this study has the potential to affect other schoolchildren as well. If some or all of the outcomes listed above are found and disseminated, then other schools may decide to use classroom furniture that is better suited to the sizes of their students, which in turn may help to improve those students' occupational performance in the classroom as well. Equipping more schools with appropriately sized furniture has the potential to enable more students to meet classroom demands successfully, which may help to enhance the self-efficacy, self-competence, and role satisfaction of schoolchildren in general. If the hypotheses are not supported, then parents may feel reassured about the furniture that is available in their children's schools despite its size or design.

Impact on School Administrators

In addition to the impact on schoolchildren, this study has the potential to impact school administrators by providing evidence for a method to enhance student performance overall, without major expense or time from teachers. Improvements in any or all of the study's outcome measures are desirable to school administrators because each provides evidence of a well-performing school. Therefore, school administrators may use the findings of this study to consider the potential role that classroom furniture plays in the academic success of their students, and furnish their classrooms with ergonomically designed and/or better-sized furniture. School administrators may also use this study to address furniture issues in their own schools as a method of enhancing student success.

Impact on Occupational Therapists and Occupational Scientists

This study has the potential to impact occupational therapists and occupational scientists by expanding occupational therapists' roles in school-based practice and creating a role for occupational scientists in schools. Currently, the primary role for school-based occupational therapists involves provision of services to children with disabilities, often by providing direct intervention. There is no specifically defined role for occupational scientists in the classroom, as occupational scientists are not health care providers. Therefore, this study may support a consultative role for both occupational therapists and occupational scientists to work with students, parents, teachers, school administrators, and furniture manufacturers to facilitate optimal performance of classroom tasks and enhance the overall well-being of all students within the school community. Occupational therapists and scientists can work with school personnel by adjusting or modifying existing classroom furniture or providing inservices to teachers and principals. Additionally, occupational therapists and occupational scientists can consult with furniture manufacturers about optimal design and height of school furniture to support healthy sitting postures and successful engagement in school-based tasks.

Impact on Theoretical Models

The results of this study will potentially support occupation-based models and occupational scientists' understanding of the significance of the environment on the occupations of schoolchildren. This study has the potential to provide evidence to support principles of the PEO (Law et al., 1996) which state that environmental demands can enhance or inhibit occupational performance and that occupational performance is enhanced by maximizing the *fit* between the person, the environment, and the occupation. Specifically, this study seeks to improve children's occupational performance by maximizing the fit between children and their classroom environment, via providing classroom furniture that is better suited to the students' sizes and/or offers ergonomic support. This intervention therefore targets the person and environment elements of the model (see Figure 1). If children in the study demonstrate better sitting postures, more on-task behaviors, better handwriting, and/or better test scores, when sitting in better fitting or ergonomically designed furniture, then application of the principles of the PEO to improve occupational performance will be supported. That is, this study has the potential to support the principle that changing elements of an environment to fit the attributes of the person(s) within it serves to enhance occupational performance.

This study also has the potential to specifically support the principle that the changing elements of the environment is an effective way to promote successful occupational performance, and may support occupational therapists' and occupational scientists' use of this principle in a group situation. Changing an element of the classroom environment by enhancing the fit between the students and their furniture allows one change to affect most or all of the students at once, which is likely easier than making changes in each individual person or individual occupations. Occupational therapists and scientists may then be able to use the evidence from this study to help design classroom furniture and help to set-up classrooms to best support students' occupational performance.

In addition to the impact on the PEO, the findings of this study may also support Lawton's (1980) Theory of Environmental Docility, specifically the principle that the environment most significantly affects those with lower skill levels. Lawton's theory is traditionally applied to elderly populations, and has been used to structure environments to support successful aging. If this study shows that children's occupational performance in the classroom is enhanced by facilitative changes in the environment then there will be some initial evidence that Lawton's theory could be expanded to apply to schoolchildren. Furthermore, this study may provide support for Lawton's principle if the students with the poorest baseline handwriting and weakest math skills as evidenced by their placement in the lowest level math class are shown to be the most significantly affected by changing their classroom furniture. The results of this study may lead to further research on Lawton's principles with children as well as the elderly, in order to lend additional support for the application of his principles to enhancing environments to optimize occupational performance for other populations, such as children in schools.

Impact on Policy

Finally, the findings of this study have the potential to impact policies related to classrooms and schools. The NCLB seeks to reform public education through stronger accountability and use of proven education methods to meet specified state standards, particularly regarding standardized testing (USDE, n.d. a). If this study demonstrates that students' attention to task, handwriting, and test scores improve when they sit in classroom furniture that fits their sizes better or is ergonomically designed, then these findings provide evidence for a method to improve student performance. Therefore, the results of this study may serve as a basis for other studies that lead public schools to pay closer attention to the size of the furniture used in their classrooms. Occupational therapists and occupational scientists can apply principles from the PEO and Lawton's Theory of Environmental Docility to address the furniture needs in public schools.

In addition to the implications for the NCLB law, this study also has the potential to impact children's access to education and occupational therapy services provided under the IDEA (USDE, n.d. b). According to Swinth (2003), one role of school-based occupational therapists under the provisions of the IDEA is to focus on those contextual factors that promote participation in the school environment. While school-based occupational therapists typically provide direct and indirect services to children with disabilities, the findings of this study may serve as a basis for supporting occupational therapists' and occupational scientists' role in creating classroom environments that support all students' needs, not only those with special needs. Specifically, the findings of this study may support the application of principles of the PEO and Lawton's theory to providing all students with classroom furniture that best supports their ability for successful occupational performance in the classroom.

Chapter II

Literature Review

The purpose of this literature review is to examine theoretical models, education-based policies, the role of occupational therapists and occupational scientists in schools, as well as previous research and current ideas related to the influence of classroom furniture on occupational performance in the classroom. First, the PEO model and Lawton's theory of environmental docility provide the theoretical background for this study. Next, two education-based policies, *No Child Left Behind* and the *Individuals with Disabilities Education Act* are reviewed. The role of occupational therapists in classroom environments is discussed, and a role for occupational scientists in classrooms is proposed. A review of research on the evidence of a mismatch between schoolchildren and classroom furniture is presented along with the implications of the mismatch on children's sitting postures and musculoskeletal systems. Finally, research on the impact of furniture size, type, and arrangement on school-based occupational forms including handwriting, attention, and testing is reviewed.

Theoretical Background: Significance of Environment

Occupation-Based Conceptual Model

Since its early days, the profession of occupational therapy has recognized the significant role of the environment on humans' occupational performance and overall well-being. In his address to the fifth annual meeting of the National Society for the Promotion of Occupational Therapy (now AOTA), Meyer (1922/1977) stated the importance of being able to respond successfully to environmental demands in his description of psychiatric problems as "problems of adaptation" (p. 639). Meyer also described the role of occupational therapists as "giving opportunities rather than prescriptions" (p. 641), by creating an environment with meaningful demands that fit with patients' needs. While Meyer's focus was on people with psychiatric illness, his ideas about the importance of creating environments to support occupational performance are relevant to all populations.

Current occupational therapy theorists have proposed that environments significantly influence occupational performance and well-being. Specifically, the PEO (Law et al., 1996) proposes that the environment can enhance or constrain occupational performance. In this model the person is viewed holistically and is comprised of performance components, life experiences, personal competencies, and skills, while the environment is defined broadly to include physical elements such as the physical objects found within it, along with other elements such as cultural, socio-economic, institutional, and social (Law et al.). Therefore, the classroom environment includes the room itself and the chairs, tables, and desks, among numerous other objects, along with factors such as social norms, rules, and expectations of students, teachers, and administrators. Occupations, according to the PEO, are defined as "self-directed, functional tasks and activities in which a person engages over the lifespan" (Law et al., p. 16), while occupational performance is the interaction between the person, the environment, and the occupation, such as performance on a test or quality of handwriting on a written task.

The PEO model proposes that the greater the fit between a person, the environment, and the occupations, the more successful his or her occupational performance will be (Law et al.). According to Strong et al. (1999), occupational therapists can use the PEO to assess the fit between a person, his or her environment, and the occupations by identifying factors that enable or constrain the "PEO fit." Once the enabling or constraining variables are identified, occupational therapists can develop intervention strategies that target the person, environment, and/or occupations. The efficacy of the intervention is determined by assessing subsequent changes in a person's occupational performance.

The PEO model argues that it is easier to implement an intervention in which changes are made to the environment instead of making changes to the person (Law et al.). Therefore, an effective method for applying the PEO model to enhance occupational performance is by modifying the features of a person's environment (Law et al.). Because the environment has a significant impact on occupational performance, it is important to provide people with environments that best support their ability to perform the demands within the environment. Therefore, the interaction between a student and his or her occupations and classroom environment may be enhanced by structuring the environment to best support the student's ability to engage in and perform classroom tasks successfully. Thus, if occupational therapists and occupational scientists use their knowledge of environments, adaptation, and activity analysis in working with teachers and school administrators, they may be able to recommend classroom furniture that best supports classroom demands.

Non-Occupation-Based Conceptual Model

In addition to the PEO model, other theories also address the significant role of the environment on performance and well-being. In the 1950s, Lewin (as cited in Lawton, 1980) developed a formula to describe the relationship between people and environments that stated, "behavior is a function of both the person and the environment"

(Lewin, as cited in Lawton, 1980, p. 11). Lawton expanded on this idea in his theory of Environmental Docility by proposing that the impact of an environment on any given person is affected by elements of the environment and characteristics of the person (Lawton, 1980). That is, according to Lawton, a person's level of competence affects his or her ability to adapt to the demands of the environment, such that "the less competent the individual, the greater the impact of environmental factors on the individual" (Lawton, 1980, p. 14). In this model therefore, environmental demands or constraints have less effect on a person with moderate to high levels of competence than on a person with lower competence. Furthermore, seemingly slight environmental demands can negatively affect the performance of a person with low competence, while having little to no effect on those with higher levels of competence (Lawton).

Lawton's model traditionally has been used to explain the impact of the environment on successful aging, and has contributed to the growth of retirement communities and assisted living facilities. For example, Lawton's principle that those with lower skill levels are more significantly affected by environmental constraints is applied to creating living arrangements with varying levels of environmental support for elderly people of different skill levels, such as retirement communities for highly competent individuals, assisted living for those with moderate competencies, and nursing homes for the most impaired. Lawton's model can also be used to explain how elements of a classroom environment may affect children's successful performance of classroom tasks. Based on Lawton's hypothesis that "the less competent the individual, the greater the impact of environmental factors on the individual" (Lawton, 1980, p. 14), most typically developing children with average or above average skill levels may be able to adapt to the constraints of furniture that is too large for their size. However, children with low or below average skills may have greater difficulty adapting to the same environmental constraints, resulting in even greater difficulties performing classroom tasks. In addition, even children with average/high average skills may be affected by environmental constraints when their skills, or person variables, are stressed by factors such as fatigue, illness, or injury. Therefore, based on Lawton's principles, providing appropriately sized classroom furniture is likely to benefit all students' occupational performance.

Summary

In summary, the PEO model (Law et al., 1996; Strong et al., 1999) and the theory of environmental docility (Lawton, 1980) both propose that successful occupational performance depends on a supportive environment. The PEO model can be used to identify environmental supports and constraints that affect the fit between a person, the environment, and the occupations. According to the PEO model, altering the features of an environment is an effective way to enhance this fit and thus promote greater success in occupational performance. Lawton proposes that environmental constraints have a greater impact on people with poorer skills, so environments should support the needs of people with different skill levels. Overall, both approaches address the importance of providing people with environments that best support their ability to meet the demands within the environment for successful occupational performance. Occupational therapists and occupational scientists can use PEO and Lawton's principles to facilitate the development of optimal learning environments in schools.

Education-Based Policy and Services

No Child Left Behind

The *No Child Left Behind Act* (NCLB) of 2001 was developed to increase standards and accountability of public schools in order to improve student achievement (Bloomfield & Cooper, 2003; UDSE, n.d. a). The NCLB law is based on four main principles: increased accountability for results, greater flexibility and local control of resources, use of proven education methods, and increased choice for parents (Boswell, 2004; USDEa). Under the requirements of the NCLB, all students in the third through eighth grades, including students with disabilities, are required to take yearly-standardized achievement tests in math and reading (Bloomfield & Cooper; Boswell). The results of these tests are used to track each school's adequate yearly progress (AYP) in meeting state standards (Bloomfield & Cooper; Boswell). Schools that fail to demonstrate AYP for two years in a row risk losing students, who are subsequently allowed to transfer to other schools, and must offer tutoring and other additional services to remaining students (Bloomfield & Cooper; Boswell; USDEa).

Because of the mandates of the NCLB, the results of standardized testing hold great importance as evidence of a school's accountability (Charp, 2003). Standardized test results are used to compare schools and school districts against each other to identify high and low performing schools (USDEa). As a result, many teachers spend much of their time "teaching to the test" as often standardized tests address different curricula than the typical state curricula (Bloomfield & Cooper; Charp). Overall, the impact of the NCLB in many public schools is an increased emphasis on student performance on standardized math and reading tests, and a need to use proven methods that are supported by research to increase student performance.

Individuals with Disabilities Education Improvement Act

The Individuals with Disabilities Education Improvement Act (IDEA) is a federal law that mandates that all children are entitled access to full participation in an educational setting within the least restrictive environment (NEA, n. d.; USDE, n.d. b). Under the IDEA, the goal for children with disabilities is to be included in regular classrooms with non-disabled peers, with supplementary services as needed (Case-Smith & Rogers, 2005; NEA). All children with disabilities receive an Individualized Education Program (IEP) to address individual learning needs and goals, and to specify the provision of supplementary services. Some of the supplementary services may include support from a full-time classroom aide, direct or consultative rehabilitation services including occupational therapy, and/or adaptations and accommodations such as adapted seating systems, slant-boards for writing, keyboards, or other environmental modifications. Children who need additional support may be placed in special education classes or special education schools, but according to Case-Smith and Rogers, most children with disabilities spend some part of the day in regular classrooms.

As a result of their inclusion in regular education classrooms, children with disabilities participate in yearly standardized testing as mandated by the NCLB (Boswell, 2004; Charp, 2003). These children's participation in standardized testing may be problematic for schools and students because while the tests are designed to measure grade level standards, IEPs are designed to measure functional level standards (Boswell). Therefore, students with disabilities who are regularly achieving functional goals may be unable to achieve grade level goals as measured on standardized tests, which can result in poor AYP measures for the school.

Occupational Therapy and Occupational Science in the Classroom. The principles of the IDEA guide occupational therapy services in schools (Swinth, 2003). The IDEA defines occupational therapy's role as including: improving, developing, or restoring function, improving independent task performance, and preventing initial or additional loss of function (NEA, n.d.). In each of these three roles, school-based occupational therapists address students' ability to participate in tasks within the educational environment (Swinth). School-based occupational therapists are typically members of the IEP team, and are responsible for developing a plan to help students reach functional goals. Occupational therapists provide direct or indirect services to address person, environment, and occupation factors including motor performance, sensory responsiveness, perceptual processing, psychosocial and cognitive abilities, and environmental factors (Case-Smith & Rogers, 2005).

Occupational scientists study the form, function, and meaning of occupations in people's lives. While occupational scientists have not traditionally played a role in educational settings, their knowledge in understanding and analyzing the factors that affect task performance can help to enhance the fit between environmental variables with person and occupation variables. Similar to occupational therapists, occupational scientists can make recommendations to alter or adapt environmental factors to enhance rather than constrain schoolchildren's task performance. For example, occupational scientists can assist in the design and selection of classroom furniture that supports prolonged sitting and enhances the performance of classroom tasks such as paying attention, handwriting, and taking tests. Occupational scientists can therefore use their expertise to assist in developing optimal environmental support for schoolchildren.

Summary

The NCLB legislation has led to greater accountability for students' academic performance in schools, particularly on standardized tests of math and reading. Children with disabilities are typically included in general standardized testing regardless of their ability to achieve grade-level competencies. Under the provisions of the IDEA, school based occupational therapists provide direct and indirect services to enhance children with disabilities' participation in school-based tasks, including standardized testing (AOTA, 2002a; Swinth, 2003). Occupational therapists and occupational scientists can focus on factors within the environment, such as issues related to a child's seating, to promote successful occupational performance as indicated by success in school-based tasks. Because of their focus on the form, function, and meaning of occupations, occupational scientists have a unique approach to understanding how environmental variables affect a person's task performance. Therefore, occupational scientists can use their knowledge in understanding and analyzing the factors that affect task performance to explore the relationships between environmental variables such as classroom furniture, person variables such as size, skills, and abilities, and occupational performance variables including on-task behaviors, sitting behaviors, handwriting legibility, and test performance.

Impact of Classroom Furniture on Occupational Performance

Children are required to engage in a number of classroom tasks while in school. Some of these tasks include sitting at a table or desk, writing, attending to tasks, and taking tests. The size and design of the classroom furniture has the potential to affect how well students are able to perform each of these tasks, so classroom furniture should be appropriately sized for the children who use it. In addition, the design of classroom furniture should promote good sitting posture. A mismatch between children's sizes and the size of their classroom furniture may cause musculoskeletal injuries including back and neck pain, and repetitive strain injuries such as tendonitis or nerve compression syndromes.

Posture and Positioning

Size mismatch. A number of studies have found that classroom furniture often is the wrong size for the majority of the students in all grades (Cotton et al., 2002; Panagiotopoulou, Christoulas, Papanckolaou, & Mandroukas, 2004; Parcells et al., 1999). Parcells et al. (1999) compared anthropometric measurements of 74 middle-school aged students with measurements of their classroom furniture, and found that fewer than 20% of the students fit into their desks and chairs, even though there were three sizes of chairs and two sizes of desks available. They reported that in the school district in which they collected their data, most of the chairs were too high and too deep (14.9-67.6%) compared to students' leg lengths, and most of the desks were too high (40-91%) compared to students' height. Older students, especially boys, were more likely to find an appropriately sized desk-chair combination than were younger students or girls who were typically smaller than the boys. Based on their findings, the authors suggest that students' ability and potential to learn may be affected by musculoskeletal discomfort caused by the mismatch. However, incidence of discomfort and actual impact on learning were not assessed.

Cotton et al. (2002) also collected anthropometric measurements from a sample of 211 middle school students, and compared them with measurements of chair seat height, depth, and slope, and desk height, clearance, and slope. Similar to the study by Parcells et al., Cotton et al. also found that the desks and chairs were too high for most of the students, based on anthropometric measurements of their legs. In fact, 99% of their participants did not fit the seat depth or desk height of their classroom furniture. The authors concluded that this discrepancy between student size and furniture size might lead to a generation of students with musculoskeletal problems in their backs and necks. However, they did not collect data to assess the presence of musculoskeletal symptoms, so their conclusion is only speculative.

In a similar study, Panagiotopoulou et al. (2004) compared anthropometric measurements with classroom furniture measurements and found that younger children were more likely to be mismatched to their furniture than were older children. Measurements of 180 children in grades two, four, and six revealed that none of the 2nd or 4th graders, and fewer than 12% of the sixth graders fit into the chair-desk combinations in their classrooms, typically due to chairs and desks being too high for the students' legs. Panagiotopoulou et al. cautioned that sitting in chairs that are too high elicits poor sitting postures, usually demonstrated by a tendency to sit on the edge of the seat without back support. They believe that this type of sitting may lead to a kyphotic posture and cause strain on the spinal muscles (Panagiotopoulou et al.). Additional strain on the neck and shoulders may occur because of the desk surface being too high as well.

While the studies reviewed above found the furniture to be too large for the majority of students, a study conducted in Australia found the opposite. Milanese and

Grimmer (2004) collected anthropometric measurements of 1269 high school students ages 12-18 and compared these measurements with the dimensions of their classroom furniture. The results indicated that only the smaller students (approximately 25%) were able to find a good fit with classroom furniture, and that taller students were more likely to report back and neck pain. Based on these findings, Milanese and Grimmer recommend that all schools should use higher furniture. However, because no data were provided for the height of the furniture or of the children, these results may not be generalizable to students in the United States or other countries.

Musculoskeletal impact. While the studies reviewed above focused on the relationship between student size and furniture size, some also looked at the musculoskeletal impact of a size mismatch. In their study, Panagiotopoulou et al. (2004) found that while the furniture was too high for the majority of the students, fewer than 25% of them reported musculoskeletal complaints. However, Panagiotopoulou et al. noted that levels of discomfort were higher among the older children, and suggested that a lack of complaints among younger children was due to their inability to associate muscle pain with their sitting posture. It is possible that the younger children actually did not feel discomfort despite sitting in furniture that was too large for them.

Despite the findings of Panagiotopoulou et al., two other studies (Murphy et al., 2004; Linton et al., 1994) found that sitting position did affect children's self-reported back and neck pain. Murphy et al. (2004) observed the sitting postures of 66 children ages 11-14 while seated in their classrooms in school. The students also completed self-report questionnaires for presence of musculoskeletal pain during the last month and the last week. In response to pain in the last month, 29 of the 66 participants reported low back pain, 23 reported upper back pain, and 34 reported neck pain. Thirteen of the students reported pain in all three areas. Fewer students reported problems with pain occurring during the last week. Overall, six of the 66 students sought treatment for their pain but only four of the students ever missed school because of their pain.

Based on comparisons of the self-reports of pain with observations of sitting posture, Murphy et al. concluded that there is a positive relationship between using both flexed or forward leaning postures and static or fixed postures in the neck and trunk, and reports of back and neck pain. However, the findings are limited because only students who sat in the back of the room were observed as the researchers had easiest access to these students. The students who sat in the back of the room may have used more awkward postures than the students who sat in other areas in order to hear and see the teacher in the front of the room. In addition, the questionnaire asked about the occurrence of musculoskeletal pain in general, but did not ask specifically about pain experienced while sitting in class. Therefore, it is possible that factors other than those measured on the questionnaire, such as sports injuries, may have caused the students' musculoskeletal pain.

In a study by Linton et al., two groups of fourth-graders were observed while seated in their standard classroom furniture (n=21) or in ergonomically designed furniture (n=46) with a tilted desktop and foot supports on higher chairs. Each student was observed for five 10-second intervals for the presence of positive or negative sitting behaviors. Positive sit behaviors included arms resting on the desk when sitting in a forward working position, back in contact with the backrest when sitting in the listening position, use of footrest, buttocks in contact with seat of chair, and head and trunk in neutral positions (Linton et al.). The students also completed questionnaires about their posture and satisfaction with their furniture.

While the sitting positions of the students were similar in both groups, 23 of the 46 students who used the ergonomically designed furniture reported musculoskeletal complaints (50%) while approximately 12 of the 21 students in the standard furniture complained of musculoskeletal pain (57%). Furthermore, the musculoskeletal complaints of students who sat in the ergonomically designed furniture decreased to 38% (approximately 17 students) during the six-month period of the study. Students who sat in the ergonomic furniture also rated the comfort of their furniture more favorably on a four-point questionnaire, with a mean rating of three, while students who sat in the standard furniture had a mean comfort rating of two. The difference in musculoskeletal complaints is interesting because the students in the ergonomic furniture did not use better sitting postures than the other students did. Therefore, it is possible that the ergonomic design of the furniture contributed to more supportive working positions. Also, the authors did not state whether the students who sat in the ergonomic furniture knew what its intended function was, so it is unclear how those students' responses may have been affected.

In a longitudinal study, Troussier, et al. (1999) followed 263 students ages 8-11 who used one of two types of classroom furniture over four years. Half of the students only sat in standard classroom furniture while the other half only sat in ergonomically designed furniture, with a forward inclined seat and tilted desktop. The students completed self-report questionnaires to rate how much they liked their furniture and to report incidence of back and neck pain, and were given physical examinations for evidence of scoliosis, kyphosis, hamstring stiffness, and lower back stiffness. Overall, more students preferred the comfort and height of the ergonomic furniture, especially when engaging in writing tasks. No differences were found between the groups on musculoskeletal complaints or physical examination. The researchers concluded that back pain was not affected by sitting position, although writing was (Troussier et al., 1999). However, this conclusion is questionable because writing performance was not assessed.

Summary

Many studies have shown that classroom furniture often does not fit the schoolchildren who use it. Typically, the furniture is too big for students in elementary and middle schools (Cotton et al., 2002; Panagiotopoulou et al., 2004; Parcells et al., 1999), although in some middle and high school classrooms the furniture may be too small (Milanese & Grimmer, 2004). Furthermore, when classrooms use only one size of furniture, it is likely that at least some students will not fit into the furniture because of the variability in the height of children in a similar age range (Cotton et al., 2002; Panagiotopoulou et al., 2004; Parcells et al., 1999). The variability in children's sizes makes it challenging to fit all of the children within a given class or grade into a set of classroom furniture. Therefore, adjustable furniture might be useful for helping to maximize the number of students who are able to fit appropriately into their classroom furniture.

While some researchers (Milanese & Grimmer, 2004; Murphy et al., 2004) note that sitting in poorly fitting furniture may affect childrens' musculoskeletal systems by causing back, neck, and shoulder pain and injuries, few children actually report complaints of musculoskeletal pain while in school. The low incidence of findings may be attributed to children's difficulty associating muscular pain to their sitting postures (Panagiotopoulou et al., 2004), or because questionnaires did not ask children to identify if they felt pain while sitting in school (e.g., Murphy et al., 2004). It is also possible that children do not experience pain from prolonged sitting. Future studies should ask children to report on incidence of musculoskeletal pain specifically while sitting in their classroom furniture. Longitudinal studies would also be useful in tracking musculoskeletal pain and strain in school-aged children.

Positioning and Performance

Given that many students are sitting in classroom furniture that is not the optimal size for them, schoolchildren may lack adequate postural support and therefore be poorly positioned and uncomfortable while doing seated class work. According to Triano and Engle's (2001) research on ergonomics in adults, there is a relationship between perceptions of discomfort and the ability of adult workers to attend to tasks, which is often demonstrated by frequent position changes. These position changes, which Triano and Engle refer to as the "squirm factor" (p. 138), may indicate that a person is distracted from his or her task. While position changes are necessary when sustaining a posture such as prolonged sitting, Triano and Engle believe that a person who is sitting comfortably in a healthy posture should only require one position change every two minutes. Knight and Noyes (1999) reported that a group of 9- and 10-year-old children made fewer position changes as indicated by a decreased frequency of observed non-standard sitting positions when sitting in supportive ergonomic furniture compared to when they sat in furniture that was too big. It is possible children who are uncomfortable in their classroom furniture may make frequent position changes and therefore may also have difficulty attending to and performing classroom tasks.

Positioning and attention. In order to assess the impact of school furniture on schoolchildren's attention to classroom tasks, several studies have used a minimum time sampling (MTS) procedure to record task and sitting behaviors. The MTS procedure involves systematically observing students within a classroom for a specified duration, typically 4 or 5 seconds (Merritt & Wheldall, 1986). Observations may include type of sitting posture used, whether a child's feet are flat on the floor, or whether a child is on or off-task during each interval. Knight and Noyes (1999) used a MTS procedure in a repeated measures correlated groups design to compare the on-task and sitting behaviors of 21 students ages 9- and 10-years-old, while seated first in their regular classroom furniture and then while seated in ergonomically designed chairs with a slightly backward sloping seat and convex back support. The students' task and sitting behaviors were observed over a two-week period for each condition. Knight and Noyes found that when seated in the ergonomic furniture, the students were more likely to be on-task and to use more standard sitting positions with fewer observed position changes recorded than when seated in their standard classroom furniture. Specifically, Knight and Noyes found a significant difference between on-task behaviors at $p<0.001$ as 85.5% of students were on task when seated in the traditional chairs while 87.3% were on task when seated in the ergonomic chairs. The difference between frequency of non-standard sitting behaviors was also significant at $p<0.001$ with a mean of 12.3% non-standard sitting behaviors recorded in ergonomic chairs versus a mean of 24.6% non-standard sitting behaviors in the traditional chairs.

Knight and Noyes believe that the students would have benefited from instruction in how to sit in the ergonomic chair, which was different in design from a traditional chair. The study is limited by a lack of operational definitions for on-task behaviors and because the authors did not state how much time elapsed between data collection periods. Therefore, it is possible that the increased on-task behaviors were due to a novelty effect, particularly if the observations occurred immediately after the new furniture was introduced. Another limitation is the potential that the results were due to maturation, as the baseline condition was not repeated. However, due to the improvements noted, returning the students to their baseline furniture may have negatively affected their school performance. Finally, the study is also limited because the authors did not describe methods for recording position changes, and it is unclear whether the students knew the purpose of the study.

Wheldall and Lam (1987) also used MTS to measure the on-task behaviors of 34 12- to 15-year-old students with behavior problems while seated in two different classroom configurations: clusters of tables and tables arranged into rows. An ABAB reversal design was used with each condition lasting for two weeks. Wheldall and Lam hypothesized that students would attend better when seated in rows so that all of the students would be facing the front of the class, and none would have to assume unnatural or uncomfortable postures in order to see the teacher or task. The results supported their hypothesis as the students were more on-task as measured by researcher observations when seated in rows instead of at groups of tables. The students also demonstrated fewer disruptive behaviors when seated in rows instead of tables. The researchers concluded that sitting comfort resulting from use of more natural, forward-facing sitting postures might play a role in students' abilities to attend to classroom tasks. However, the findings are limited by the use of a small sample and because the students were aware of the study's objectives. Additional research with larger samples that are blind to the study's purpose is needed to determine how different sizes and types of classroom furniture affect children's ability to attend to tasks in the classroom.

Wheldall and Lam's study was partially replicated by Wingrat and Exner (2005), in their study that used MTS to observe the on-task and sitting behaviors of 63 fourth graders while the students sat in two different sizes of furniture. Wingrat and Exner used a repeated measures correlated groups design to assess task and sitting behaviors while students sat in their traditional classroom furniture consisting of round and rectangular tables arranged in clusters, and while seated at desks arranged first in clusters and then in rows. The traditional tables and chairs were observed to be too large for the majority of the students while the desks and accompanying chairs were smaller and appropriately sized for the study participants, with desks at the students' elbow heights and chairs that allowed the students' feet to reach the floor. Wingrat and Exner found significant differences in sitting and on-task behaviors when the children sat in the smaller furniture, and found that girls had better sitting and task behaviors than boys in all three conditions. Unlike Wheldall and Lam's study, Wingrat and Exner did not find a difference in task and sitting behaviors when students were seated in rows instead of clusters, possibly due to a ceiling effect, as sitting and on-task behaviors improved so much once the students were seated in the smaller-sized furniture, that there was little room left for additional improvement. One limitation of this study was that because the smaller chair was a different design than the traditional chair, it is unclear whether the results were due to differences in the chairs' designs or sizes. Also, because data were collected for four days over a two-week period for each condition, the observations of sitting and on-task behaviors may have reflected a change over time as the students became more acclimated to the furniture changes. The four-day data collection periods also resulted in missing data for students who were absent on one or more of the data collection days. However, the findings of both Wingrat and Exner's and Wheldall and Lam's studies indicate a positive relationship between classroom furniture with being on task and using appropriate sitting positions.

Positioning and handwriting. Handwriting is an important motor skill that may contribute to children's success in school. Studies have reported a relationship between handwriting legibility and grades received on written assignments. In one study, 50 teachers from five different elementary and middle schools were asked to rank and grade ten essays, each of which were written in different handwriting styles (Briggs, 1970). The results indicated that handwriting legibility had a significant effect on how the teachers ranked and graded the essays, as the neater, more legible handwriting samples received higher ranks and grades. In another study by Briggs (1980), 28 teachers each graded five essays written by 11-year-old children, in five different writing styles. The teachers were told to grade the essays for quality, structure, word choices, and errors. The results indicated a significant difference in grades for the same writing sample based on legibility of the handwriting. Specifically, the neatest samples with the best legibility received higher grades than did the same essay when written with poor handwriting legibility. These studies suggest that handwriting legibility may be an important factor in schoolchildren's grades.

The ability to write legibly and efficiently requires adequate motor skills and supportive environments (Rosengren & Braswell, 2003). Preschool and elementary school-aged children often demonstrate a range of skill levels in drawing and writing abilities (Blote & Van Der Heijden, 1988; Blote, Zielstra, & Zoetewey, 1987; Rosengren & Braswell, 2003). According to Rosengren and Braswell, the variability in performance often results from both differences in physiological and musculoskeletal structures, as well as factors such as environmental and task constraints. Rosengren and Braswell further state that environmental constraints including type of work surface can affect children's ability to write letters or words. Rosengren and Braswell also believe that task constraints such as the orientation of a writing surface in relation to gravity can also affect writing outputs (Rosengren & Braswell). Based on this hypothesis, providing children with optimal writing surfaces may be a method to support efficient and proficient writing skills. One way in which to provide an optimal writing surface is to position a desk or tabletop at the correct height and angle for a given child's size.

In order to assess the impact of sitting positioning on handwriting performance, Burkhart (1999) compared the handwriting legibility of forty 6- and 7-year-old children while the children were seated in appropriately sized and poorly fitting furniture. While no significant differences were found overall, Burkhart did find that those students who had lower scores on visual motor integration skills as measured by Beery's *Developmental Test of Visual Motor Integration* (VMI), produced better word legibility and speed on the Evaluation Tool of Children's Handwriting when properly positioned compared to those with lower VMI scores who were poorly positioned. Burkhart concluded that children on the lower range of normal for visual motor skills are more likely to be affected by furniture size and resultant positioning than students who have proficient skills. The ability to generalize the findings would be strengthened by comparing children's writing legibility on actual classroom writing tasks rather than on a simulated task, and by comparing writing samples for the same group of students in different types of positioning.

Schilling, Washington, Billingsley, and Deitz (2003) compared handwriting legibility on actual classroom writing tasks in their study that assessed the impact of seating on handwriting legibility of children with attention deficit hyperactivity disorder (ADHD). Specifically, Schilling et al. compared the handwriting legibility of three fourth-graders with diagnosed ADHD when the students sat in traditional classroom chairs and while seated on therapy balls. The participants attended school in a regular classroom and all of the fourth-graders sat on therapy balls during that phase of the study. Schilling et al. hypothesized that sitting on therapy balls would provide sufficient sensory stimulation to help the students with ADHD to modulate their arousal levels, thus enhancing their performance skills. The primary investigator measured handwriting legibility using a window card to rate one word at a time from randomly selected writing samples, with 94% interrater agreement between the primary investigator and a blind evaluator. The results showed better legibility for all three subjects when seated on the therapy balls. Furthermore, the subjects were also more likely to remain in their seats when using the therapy balls, which, according to Triano and Engle (2001), may be an indication of greater sitting comfort.

Schilling et al. concluded that the improvements in handwriting legibility were due to the students' abilities to maintain optimal arousal states due to the sensory input they received from sitting on the balls. While the study was limited by a small sample size of only three participants, the teacher and the majority of the fourth-graders reported preferring the balls for comfort, writing, and ability to attend to task, as indicated by written comments about their preferences. These finding are notable because the students with ADHD were not instructed to use the balls for sensory stimulation, but may have done so automatically. As a result, the students were able to self-regulate their arousal states without disrupting the class. Therefore, classroom furniture that provides sensory stimulation may be beneficial to students with ADHD as well as students in general. Additional research on other seating alternatives with sensory modulation properties is warranted.

While the previously cited studies addressed the relationship of sitting positioning on handwriting performance, two other studies addressed the relationship between positioning and postural fatigue, and the subsequent impact on handwriting. In a study of the effect of fatigue on handwriting, Parush, Pindak, Hahn-Markowitz, and Mazor-Karsenty (1998) induced fatigue on 157 third-grade students in Israel. Specifically, 61 students with good handwriting and 99 with poor handwriting engaged in a prolonged writing task involving copying from a textbook for 10 minutes while properly seated with good postures in furniture that fit each student's size. The researchers noted that the longer students spent writing, the more fatigued they became as evidenced by worsening sitting postures. Parush et al. noted that as sitting posture worsened, all of the students demonstrated poorer letter formation and slower writing speed, with the impact being greatest among the students classified with poor handwriting. Therefore, it is possible that poor sitting postures have a negative impact on children's handwriting legibility and speed. While other factors besides posture may have contributed to the changes in handwriting, this study provides evidence for the need to assess the impact of classroom furniture on handwriting legibility.

In a similar study, Parush, Levanon-Erez, and Weintraub (1998) observed a group of 209 elementary school-aged students, 106 with good handwriting and 103 with poor handwriting, in Israel while completing a writing task from the Hebrew Handwriting Evaluation, which evaluates handwriting speed, legibility, and spatial arrangement. This study found small but significant positive correlations for the whole sample between body positioning with handwriting speed ($r = .24$), legibility ($r = .17$), and spatial arrangement ($r = .14$). The researchers observed that the students with better handwriting tended to use upright postures while the students with poor handwriting tended to use slouched postures. Overall, they concluded that ergonomic factors such as sitting posture and body positioning are important elements of handwriting performance. However, because the reported correlation coefficients were so low, it is likely that other factors also contributed to the findings. Furthermore, in both studies, the students were positioned in appropriately- sized furniture so no comparisons were made of the students' handwriting in poorly fitting furniture. Additional studies are needed to address the relationship between sitting positions, furniture size, and handwriting legibility.

Positioning and testing. Only two studies that address the impact of positioning on performance on standardized tests and no studies that addressed the impact of positioning on students' performance of educationally based achievement tests were uncovered in a comprehensive search of the literature. Sents and Marks (1989) tested the intelligence quotients (IQs) of 14 typically developing preschoolers twice; once while properly positioned in furniture that fit the childrens' sizes, and once while poorly positioned in furniture that was too large. The two standardized tests occurred within 7 and 9 days for each participant, and the order in which they were tested, properly positioned or poorly positioned, was randomly assigned. Sents and Marks found that IQ scores were significantly higher when the participants were properly positioned, indicating that a child's position can significantly affect his or her test performance. The increase in scores may have occurred because the postural and proximal support provided by the proper positioning may have assisted the children's performance of test items involving hand skills. It is also possible that the children were better able to attend to the test while properly positioned, thus resulting in higher scores.

Sents and Marks' findings are limited due to a small sample size, and because the participants were given an IQ test that is standardized for deaf children. Despite these limitations, Sents and Marks caution that poor positioning of children during screenings and evaluations may lead to erroneous referrals for special services. As indicated in Burkhart's (1999) study, children with lower skill levels may be more susceptible to poor positioning. As a result, the need to provide optimal positioning during testing may be critical for such children.

In a recent study, Smith-Zuzovsky and Exner (2004) compared scores on the In-Hand Manipulation Test (IMT) for children who were positioned optimally in appropriately sized furniture and poorly in furniture that was too large. Two groups of 20 children ages 6 and 7 were given the IMT; one group while optimally positioned in furniture that fit their sizes and one group while poorly positioned in their standard classroom furniture that was too large. Smith-Zuzovsky and Exner found that the group of optimally positioned children scored significantly higher than the group of poorly positioned children. The effect was greater for more complex in-hand manipulation skills compared to easier skills that were less challenging on the childrens' postural control. Smith-Zuzovsky and Exner concluded that poor positioning may lead to inaccurate perceptions about a given child's object manipulation skills, and that proper positioning may have an important effect on children's test scores when hand skills are required. They also noted that the optimally positioned children appeared to make fewer position changes than the poorly positioned children did, indicating that the latter group may have had more difficulty attending to the task. Wingrat and Exner (2005) observed a similar phenomenon in their study that compared the on-task and sitting behaviors of children while properly and poorly positioned. However, in both of these studies, the observations of position changes were not formally documented or studied.

Summary

Though the availability of research is limited in each of the areas reviewed relative to sitting positioning of children, a review of the literature suggests that overall, children's performance of classroom-related tasks can be significantly affected by their positioning. Attention to task was found to be positively affected by providing students with appropriately sized and ergonomically designed chairs (Knight & Noyes, 1999; Wingrat & Exner, 2005) and by arranging the classroom furniture to allow all students to face forward, which in turn may decrease discomfort and strain on students' musculoskeletal systems (Hastings and Schwieso, 1995; Wheldall & Lam, 1987). Positioning may affect handwriting quality in children who are fatigued by engaging in a sustained task (Parush et al, 1998; Parush, Levanon-Erez, & Weintraub, 1998) or who have low average skills compared to their peers (Burkhart, 1999). Furthermore, seating options that provide sensory stimulation and facilitate self-modulation such as therapy balls seem to improve handwriting and attention in children with ADHD (Schilling et al., 2003). Finally, scores on standardized assessments that rely on hand skills may be better when students are properly positioned than when they are not (Sents & Marks, 1989; Smith-Zuzovsky & Exner, 2004).

While the studies reviewed for this literature review have yielded significant findings regarding the relationship between classroom furniture and children's occupational performance in the classroom, further research is still needed. Many of the studies reviewed had significant design flaws that limit their findings. For example, in one of only three studies that looked at the relationship between furniture size and attention to task, the student participants were aware of the study's purpose (Wheldall & Lam, 1987). In Knight and Noyes' study on furniture size and attention, there were no operational definitions described for on-task behaviors, and it is unclear whether the students were given time to adjust to their new furniture before data collection began. In Wingrat and Exner's (2005) study, the chairs used during the baseline condition were both larger and different in design than those used in the treatment conditions, so it is possible that differences in on-task behaviors were a function of differences in chair type instead of chair size.

Few studies that addressed the impact of positioning on handwriting legibility were uncovered in a comprehensive review of the literature, and all of them had considerable limitations. No studies examined the impact of positioning on writing productivity or number of letters and words written. In the unpublished master's thesis by Burkhart (1999), students were individually given a short writing task, so their resulting handwriting legibility may not accurately represent an actual in-class writing task. The study by Schilling et al. (2003) yielded a significant relationship between sitting on therapy balls and improved handwriting legibility, but therapy balls may not be a realistic seating alternative for most classrooms. Finally, the designs of the studies by Parush et al. (1998) and Parush, Levanon-Erez, and Weintraub (1998) were so weak in terms of the methods of assessing factors related to handwriting legibility that their conclusions are questionable.

The findings of the two studies that assessed the relationship between furniture size and performance on tests involving hand skills are also limited. In the study by Sents and Marks (1989), participants were given an IQ test and did not engage in classroom-based tests or tasks. The IQ test was standardized for deaf children although none of the participants were actually hearing impaired, so the validity of the scores is questionable. Furthermore, only 14 children participated in the study. The study by Smith-Zuzovsky and Exner involved individually testing children on specific hand skills, instead of looking at children's performance on functional hand skills in a classroom setting.

Overall, a significant problem with the previous studies is that many of them used simulated tasks and/or simulated settings to assess the impact of positioning on children's performance of tasks such as handwriting, standardized testing, and sitting behaviors. Therefore, the findings of these studies may not be generalizable to real-life classroom settings. Other studies that used specially designed ergonomic furniture were limited because the furniture was so different from typical classroom chairs that the students did not always sit in it correctly. In addition, the findings associated with students' use of unique ergonomic chairs may not apply to students who use more traditional chairs or traditional chairs with ergonomic features. Finally, no studies have tested theoretical principles or models. Therefore, research that tests theoretical principles and models is needed to further understand the impact of furniture size and type on occupational performance within actual classrooms while schoolchildren engage in real-life classroom tasks.

Conclusion

Theoretical principles including those from PEO, Lawton's Theory of Environmental Docility, motor control theory, and biomechanical theory all suggest that classroom furniture has the potential to affect children's performance of classroom tasks. Specifically, sitting in furniture that is too large may compromise a person's skilled task performance due to a lack of adequate postural support. Because children spend so much of the day seated while in school, their classroom furniture should be designed to fit their size and to enhance their ability to meet classroom demands. However, furniture manufacturers and school administrators often design and select classroom furniture based on its durability and price, instead of its ability to support students in prolonged sitting and task engagement (Cornell, 2002; Fowler et al., 2004; Mandal, 1981, 1982; Yeats, 1997).

While theoretical principles suggest that furniture size and design can have an impact on occupational performance, few studies have examined the impact of classroom furniture on children's performance of classroom tasks. Furthermore, while some studies found a mismatch between schoolchildren and their classroom furniture (Cotton et al, 2002; Panagiotopoulou et al., 2004; Parcells et al., 1999), these studies did not assess the impact of the mismatch on task performance. Two studies found fewer reports of musculoskeletal pain in students who sat in ergonomic chairs (Linton et al., 1994; Murphy et al., 2004), but neither of these studies looked at the impact of sitting in ergonomic chairs on classroom occupational performance.

Other studies have attempted to assess the relationship between classroom furniture size and design on occupational performance. Studies by Parush et al. (1998) and Parush, Levanon-Erez, and Weintraub (1998) reported a relationship between poor sitting positioning and postural fatigue with decreased handwriting legibility in elementary school children, but these studies were limited by weak designs that did not demonstrate a strong link between the variables that were studied. Two studies reported a relationship between classroom furniture size and on-task behaviors in 9- and 10-year-old children (Knight & Noyes, 1999; Wingrat & Exner, 2005), but in both studies the students sat in chairs that were different in design and size, so it is unclear whether improvements in on-task behaviors occurred due to differences in the furniture size and/or the furniture design. Two other studies found a relationship between furniture size and performance on tests requiring hand skills in preschoolers and first graders (Sents & Marks, 1989; Smith-Zuzovsky & Exner, 2004), but the testing occurred outside of a classroom environment in both studies, and neither involved assessment of actual classroom tasks. Finally, no studies have looked at the relationship between classroom furniture and task performance in third graders, or children aged 8- and 9-years-old.

Despite the limitations of previous studies, this literature review suggests that sitting in furniture that fits and supports has important implications for schoolchildren and their performance of classroom tasks. Children who sit in furniture that does not fit their body size may be at risk for musculoskeletal pain and discomfort, difficulty attending to tasks, and poorer performance of skills involving hand use. Because young children naturally vary in range of skills and abilities, some might be more affected than other children due to an increased need for environmental/contextual support. Furthermore, because sitting in sustained uncomfortable positions can negatively affect a person's ability to attend to tasks, providing children with comfortable furniture that fits their size and supports performance of school tasks is likely to improve students' overall occupational performance in the classroom.

Improving students' overall occupational performance in the classroom is congruent with the goals of education-based policies such as NCLB, which focuses on use of proven educational methods to increase accountability as assessed by standardized testing of math and reading, and IDEA, which mandates access for all children to full participation in an educational setting within the least restrictive environment. Because NCLB emphasizes standardized test performance, additional studies are needed to explore the interaction between the person and environment on children's occupational performance as measured on in-class math tests, which are important indicators of success used in public schools. This literature review shows that while mandates of policies such as NCLB and IDEA may support use of appropriately-sized and/or ergonomically designed furniture, many classrooms use furniture that is the wrong size for the majority of students (Cotton et al, 2002; Panagiotopoulou et al., 2004; Parcells et al., 1999), without relying on research about the furniture's ability to support academic success (e.g., Fowler et al., 2004). The literature review also suggests that sitting in appropriately sized furniture may promote use of more natural sitting postures instead of awkward, uncomfortable, and unsupportive postures, and therefore improve students' attention to task and handwriting legibility, both of which are important for successful occupational performance in school.

Additional studies are needed to explore the interaction between the person and the environment on occupational performance by examining how furniture size affects students' attention to task, test performance and performance of tasks involving hand skills such as handwriting. For example, studies should address whether manipulating the environment by providing children with furniture that fits their size yields improved occupational performance of classroom tasks such as attending to tasks, better handwriting legibility, better writing productivity such as number of letters and words written, and improved performance on math tests. Furthermore, if manipulating the environment by providing better fitting furniture is found to improve children's occupational performance, then the reason for such improvements needs to be determined. Important research questions include asking whether improvements in occupational performance result because children are more comfortable when their furniture is appropriately sized or because the postural support of the appropriately sized furniture leads to greater comfort, which then allows for greater attention to task, better handwriting legibility, and more letters and words written. Finally, studies need to determine if children perform better on classroom tests when sitting in appropriately sized furniture, and if better test performance occurs because the children are more comfortable and therefore better able to attend to task.

Hypotheses

This study includes two experiments, each with its own set of hypotheses:

Experiment 1 – Math class.

1. There will be a significant Person-Environment Interaction as demonstrated by:
    a. a significant relationship between fit potential and increased frequency of positive sitting behaviors.
    b. better sitting behaviors (see Appendix B) when children sit in appropriately-sized chairs and tables than when seated in larger standard chairs and tables.
    c. higher self-reported ratings of comfort when children are seated in appropriately-sized chairs and tables than when seated in larger standard chairs and tables.
    d. students in the lowest math class will demonstrate greater improvements in math fluency scores compared to students in the highest math class.
2. There will be a significant Person-Occupation Interaction as demonstrated by:
    a. increased attention to classroom tasks demonstrated by increased on-task behaviors when children sit in appropriately-sized chairs and tables than when seated in larger standard classroom chairs and tables
    b. higher math test scores when children are seated in appropriately-sized chairs and tables than when seated in larger standard classroom chairs and tables as reflected by higher scores on the Woodcock-Johnson III math fluency test.

c. a significant relationship between student self-report of comfort and increased frequency of positive on-task behaviors

3. There will be a significant Environment-Occupation Interaction as demonstrated by better sitting behaviors, on-task behaviors, higher math fluency scores, and higher self-reported ratings of comfort when children are seated in appropriately sized ergonomic chairs than when sitting in appropriately sized standard chairs in their math class.
4. There will be a significant Person-Environment-Occupation Interaction as demonstrated by
    a. a significant relationship between furniture size and type with sitting behaviors, on-task behaviors, math fluency scores, and self-report of comfort.
    b. a significant relationship between higher fit potential and increased frequency of positive sitting behaviors, on-task behaviors, and increased math fluency scores.

Experiment 2 – Language arts class.

1. There will be a significant Person-Environment Interaction as demonstrated by:
    a. a significant relationship between fit potential and increased frequency of positive sitting behaviors.
    b. better sitting behaviors when children sit in appropriately-sized chairs and tables than when seated in larger standard chairs and tables.

c. higher self-reported ratings of comfort when children are seated in appropriately-sized chairs and tables than when seated in larger standard chairs and tables.

d. students with lowest baseline handwriting legibility will demonstrate greater improvements in handwriting legibility scores compared to students with highest baseline legibility as reflected by higher ratings of legibility on a handwriting sample.

2. There will be a significant Person-Occupation Interaction as demonstrated by:

   a. increased attention to classroom tasks demonstrated by increased on-task behaviors when children sit in appropriately-sized chairs and tables than when seated in larger standard classroom chairs and tables

   b. higher handwriting legibility scores when children are seated in appropriately sized chairs and tables than when seated in larger standard classroom chairs and tables

   c. a significant relationship between student self-report of comfort and increased frequency of positive on-task behaviors

3. There will be a significant Environment-Occupation Interaction as demonstrated by better sitting behaviors, on-task behaviors, higher handwriting legibility scores, and higher self-reported ratings of comfort when children are seated in appropriately sized ergonomic chairs than when sitting in appropriately sized standard chairs.

4. There will be a significant Person-Environment-Occupation Interaction as demonstrated by:

a. a significant relationship between furniture size and type with sitting behaviors, on-task behaviors, handwriting legibility scores, and self-report of comfort.
b. a significant relationship between higher fit potential and increased frequency of positive sitting behaviors, on-task behaviors, and increased handwriting legibility scores.

Objectives

1. To assess the impact of chair type and chair size on the person-environment interaction as demonstrated by sitting behaviors of children.
2. To assess the impact of table and chair size and chair type on the person-environment interaction as demonstrated by children's comfort while seated in the classroom.
3. To assess the impact of chair size and type on the person-occupation interaction as demonstrated by the on-task behavior of children in the classroom.
4. To assess the impact of chair type and size on the person-environment-occupation interaction as demonstrated by math fluency scores.
5. To assess the impact of chair type and size on the person-environment-occupation interaction as demonstrated by handwriting legibility.
6. To assess the impact of chair type and size on the person-environment interaction as demonstrated by number of sitting position changes.
7. To assess the relationship between furniture fit potential and sitting behaviors, on-task behaviors, math test scores, handwriting legibility, and student comfort.
8. To assess the environment-occupation interaction by comparing schoolchildren's performance of classroom tasks while seated in ergonomic chairs and standard classroom chairs.
9. To assess the relationship between the person-environment interaction as demonstrated by student comfort and sitting behaviors and the person-occupation interaction as demonstrated by on-task behaviors on children's occupational performance as demonstrated by math fluency scores, and handwriting legibility.

10. To assess the relationship between the person-environment interaction as demonstrated by sitting behaviors and the person-occupation interaction as demonstrated by on-task behaviors, on occupational performance as demonstrated by math fluency scores, and handwriting legibility.
11. To assess the impact of the environment on the occupational performance of children with lowest versus highest baseline skills.

Assumptions

The research hypotheses and objectives are based on the following assumptions:

1. Children who use nonstandard sitting postures are demonstrating evidence of discomfort which may distract them from their school task.
2. Children who are engaging in behaviors other than those required by the teacher and or the task (e.g., doodling, talking, looking at non-related papers), are demonstrating evidence of inattention to task.
3. Children's behaviors will not be affected by the presence of a researcher in their classroom.
4. Providing 8-10 days of adjustment to each type of classroom furniture before each data collection period is a sufficient amount of time to reduce the impact of the furniture's novelty effect on children's behaviors.
5. Two days of observations in the classroom will represent typical classroom functioning.
6. Children who are comfortable in their classroom furniture will demonstrate better sitting behaviors.
7. Children who are comfortable in their classroom furniture will demonstrate fewer position changes.

Chapter III

Methods and Materials

Study Design

This study included two experiments using repeated measures correlated groups designs to compare a group of third grade students in three different conditions, a baseline condition and two experimental conditions. Specifically, this study assessed whether third grade students at a public elementary school demonstrated increased on-task behaviors, sitting behaviors, and math scores, better handwriting legibility, and increased comfort when seated in appropriately sized chairs and tables, and in appropriately sized ergonomically designed chairs compared to the same behaviors in their standard classroom chairs and tables. The study also assessed person-environment-occupation interactions by analyzing the relationships among the variables listed above. The repeated measures correlated groups design allows for comparisons of scores when the same group is measured over different conditions (Tabachnick & Fidell, 2001). That is, when the same group of participants is measured on different occasions, the repeated measures correlated group design allows for comparing the participants' mean scores against each other for each different condition. In this method, the participants serve as their own control group thus allowing any differences between means to be attributed to differences imposed by test conditions.

Experiment 1 included assessment of third grade students' sitting behaviors, on-task behaviors, math test scores, and self-reported comfort during their math class. Experiment 2 assessed sitting behaviors, on-task behaviors, handwriting legibility, and self-reported comfort, of 3rd grade students in their language arts class. In both experiments, the third grade students were observed using multiple time sampling (MTS) in each of three conditions. For the first phase of the study, a baseline condition was established with data collected while students sat in their standard classroom furniture. The standard furniture used in the baseline condition included six 30” high tables - four 42” round and two 36” x 72” rectangular - with 18½” chairs. In the first condition, the standard furniture was replaced with new tables and chairs that were appropriate for the majority of the childrens’ sizes, arranged in the same configuration as the standard furniture. The new tables also included four 42” round tables and two 36”x72” rectangular tables, but they were adjusted to a lower height of 25” to accommodate the majority of the students’ sizes. The new chairs included both ergonomic and standard chairs. During the first condition, half of the students sat in ergonomic chairs and the other half sat in the smaller sized traditional classroom chairs. In the second condition, type of chair was reversed so that each student was observed in each type of chair.

Initially, it was planned that two sizes of chairs, 13” and 15” high, would be used during the two experimental conditions to accommodate children of different sizes. However, for the purpose of the study only the 15” high chairs were used because the 13” chairs were so low that it was not possible to adjust the table height to fit both size chairs at the same table. It was not feasible to group smaller children at lower tables and larger children at higher tables because children of different sizes sat at the same table during the baseline phase, and it was important to keep each participant in the same seat for each of the study conditions. In addition, the majority of the third grade students did not like the small appearance of the 13” chairs and did not want to sit in them regardless of the quality of the fit.

Children in the Study

The participants were students in the third grade at a public elementary school in Baltimore County whose parents provided consent to participate. Parental consent forms (see Appendix A) were sent to families of all of the 70 students in the third grade at the school, which is comprised of children from a diverse mix of racial and ethnic groups. Two follow-up/reminder letters were sent home as well in an attempt to recruit as many participants as possible. The sample for Experiment 1 included 31 children (15 boys and 16 girls) ages 8 and 9 years-old. Experiment 2 was a subset of 15 children from Experiment 1 who were observed in their language arts class. This sample included 8 boys and 7 girls. It was assumed that none of the children in the total sample had any diagnosis that would preclude their inclusion in a regular classroom.

Furniture

Two types and sizes of chairs and two sizes of tables were used in the study. The standard chairs and tables in the school's third grade classroom were used during the baseline condition and are referred to as "baseline chairs." These chairs are plastic and have seats that measure 18 ½" from the floor. The seat is 21 ½" deep and 18 ¾" wide (see Figure 2). The tabletops of the standard tables were 30" high.

Figure 2. Standard classroom chair.

Virco Inc., a classroom furniture company in California, provided the experimental furniture to the school for the purpose of this study. Two types of chairs were used in the experimental conditions. The first chair is described by its manufacturer as ergonomic with a 15 ½" seat height from the floor, and is referred to as the "ergonomic chair." This chair has a seat depth of 19" and is 18 ¾" wide. The ergonomic chair features a flexible convex back support that fits and supports a child's lumbar curve and moves slightly when a student pushes back on it, a concave seat, and overall wider design (see Figure 3).

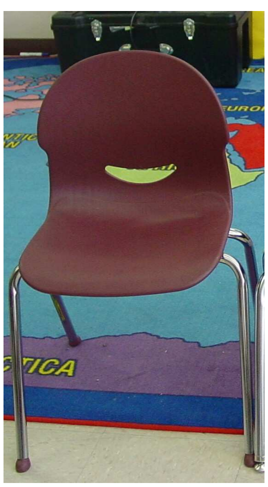


Figure 3. Ergonomic chair.

The flexible back allows for some degree of rocking in the chair without movement of the bottom of the chair and has been described as a "preferred" design for supporting prolonged sitting (Cornell, 2002). The sizes of the chairs were chosen based on a review of the literature and recommendation of the furniture manufacturer. As described previously, initially two sizes of chairs were to be used during the experimental conditions in order to accommodate children of various sizes, but it was not practical to do so. The second experimental chair was the same design as the baseline chair shown in Figure 2, but was 15" high with a 19 ½ " depth and 16 ¾" width. For the purpose of this study, this chair is referred to as the "standard chair."

The experimental tables included four 42" round tables and two 36"x72" rectangular tables. These tables are height-adjustable, so the primary investigator adjusted the height of the tables based on a best fit for typical classroom use at 25" high, which ft the approximate elbow height for the majority of students. The experimental tables were arranged to match the layout of the classroom during the baseline condition. Despite research that indicates that sitting at rows of desks may contribute to improved sitting and on-task behaviors, tables were used in this study because the classroom teacher who participated in this study prefers tables for cooperative work among students. Furthermore, according to Cornell (2004), the contemporary paradigm of teaching and learning supports cooperative learning, so tables may be more prevalent than desks in classrooms. Using smaller tables that matched the baseline arrangement of the classroom also allowed for consistency in the classroom environment, thus reducing the risk of a novelty effect associated with having desks.

Instruments

Observation checklist. On-task and sitting behaviors were assessed using a checklist (see Appendix B) and observation form adapted from Merritt and Wheldall's

(1986) *Observing Pupils and Teachers in Classrooms (OPTIC)* instrument, a multiple time sample (MTS) procedure. The OPTIC was developed and tested by the primary authors over a ten-year period, during which it underwent various psychometric studies. Merritt and Wheldall report that the OPTIC has strong face validity based on a review of the literature on applied behavior analysis in education, and strong concurrent, content, and construct validity. In an unpublished dissertation by Ng (as cited in Merritt & Wheldall), concurrent validity was reported to be very strong, with a correlation coefficient between the OPTIC and another measure of on-task behavior of $r = .99$. In other unpublished experimental studies which assessed the content and construct validity of the OPTIC as a measure of on-task behaviors, researchers demonstrated that on-task behaviors as recorded by the OPTIC were positively associated with a higher quantity and better quality of class work (Anderson, as cited in Merritt & Wheldall; Rosenshine & Berliner, as cited in Merritt & Wheldall).

Merritt and Wheldall (1986) reported on two reliability studies in which two trained and experienced examiners observing and recording students' on-task behaviors over a minimum of 26 observations. These studies yielded a minimum of 93% agreement on individual data collection trials and an overall rate of 97% interrater agreement for all trials combined. Based on the result of these studies, the authors report that their instrument is reliable for measuring students' on-task behaviors in the classroom (Merritt & Wheldall).

A previous study by Wingrat and Exner (2005) used a procedure based on the OPTIC to assess sitting and on-task behaviors with fourth-grade students. In this study, the primary investigator developed a MTS procedure based upon other researchers' models (e.g., Hastings and Schwieso, 1995; Knight and Noyes, 1999; Merritt and Wheldall, 1986; Wheldall & Lam, 1987) and pilot tested an observation system for observing and recording on-task and sitting behaviors. During the pilot testing, the primary investigator practiced by observing fourth grade students at the school. Two additional researchers then trained to use the same observation and recording techniques, and each attained a minimum of 80% inter-rater agreement with the primary investigator. The observation and recording method was used in a formal pilot study in the fall of 2002 during which inter-rater agreement remained at least at 80% for ratings of sitting behaviors, on-task behaviors, and overall.

The current study used the same observation and recording method described above. Observations were recorded on an observation form that depicts the layout of the tables in the classroom, with tables numbered from 1 to 6, and each seat numbered to correspond to each student participant, and the order in which they were observed (see Figure 4). Appendix B includes operational definitions for positive and negative sitting and on-task behaviors. These definitions guided observations of positive and negative sitting behaviors, and on- and off-task behaviors, which were recorded on the observation form. The definitions were also used to assess each participant's fit potential, or how well a child could fit into his or her chair if sitting properly.

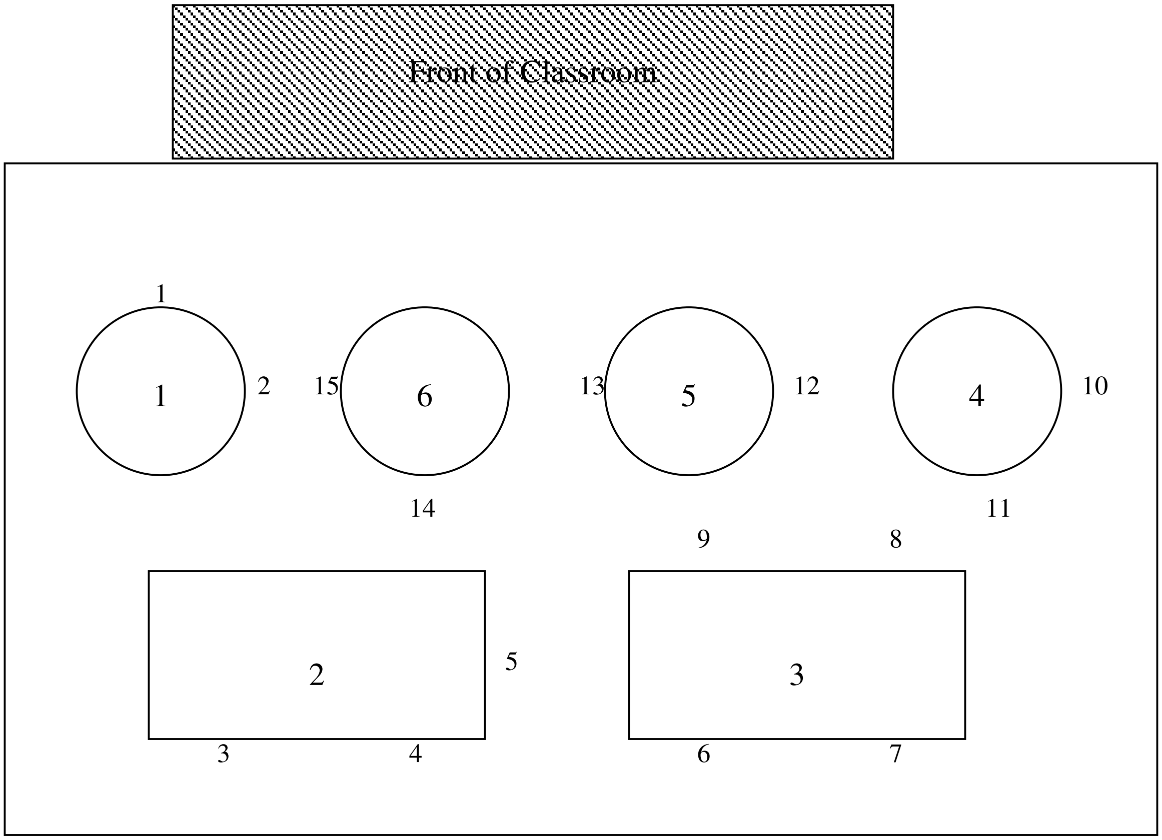


Figure 4. Sample observation form.

Fit potential was assessed on a 3-point scale, based on the criteria for positive sitting specified in Appendix B. A score of 0 was assigned if the child fit poorly in his or her chair such that he or she was unable to place feet flat on the floor while sitting upright. A score of 1 was assigned if the child's fit in his or her chair was fair, such that the child's toes reached the floor, but his or her feet did not rest flat on the floor when sitting upright against the back. A score of 2 was used if a child's fit in his or her chair was good such that he or she was able to sit upright against the back of the chair with feet flat on the floor. Interrater agreement for fit potential was 100% for all conditions.

Observations of sitting behaviors were recorded directly on the observation form after each of the 5-second observations. A plus sign (+) was used to record positive sitting behaviors and a minus sign (-) was used to record negative sitting behaviors. Positive sitting included having the elbows or forearms resting on the desk in a forward working position, having the feet flat on the floor or legs crossed at knees or ankles, having the buttocks in contact with at least half of the chair, and having contact with backrest when in a listening position. Negative sitting included the upper body laying on the table top, less than half of the buttocks in contact with chair, sitting on knees, standing (unless directed by teacher), sitting with the trunk twisted, or other awkward positioning. Each child was observed four times per day, per condition, with a total overall score potential of 0-8 per condition for sitting behaviors. Number of position changes were recorded with tally marks for each observation.

Observations of on-task behaviors were also recorded directly on the observation form after each 5-second observation, with a plus sign for positive on-task behaviors and a minus sign for off-task behaviors, and a total possible on-task score range of 0-8 per condition. Positive on-task behaviors included attending to teacher or task with one's body and gaze oriented to appropriate materials (i.e., reading, facing blackboard, etc.), manipulating learning aids as indicated, eye-contact with the teacher or task, following instructions, raising one's hand, answering a question, or offering relevant information. A lack of these behaviors, including engaging in non-related behaviors such as doodling or talking was considered off-task.

Student questionnaire. Student comfort was measured via student self-report on a questionnaire developed for this study (see Appendix C). The use of student self-report of furniture preference and musculoskeletal discomfort in similarly aged students was reported in studies by Panagiotopoulou et al. (2004) and Troussier et al. (1999). The questionnaire in the current study was adapted from the previous study by Wingrat and Exner (2005) and was originally adapted from other studies in which elementary school children rated their comfort and furniture preference (e.g., Panagiotopoulou et al., 2004; Troussier et al., 1999).

The current questionnaire was pilot tested with a group of 16 third grade students, ages 8- and 9-years-old, in their classroom at a local private school in September 2005. In its pilot format, questions 2 and 3 asked the students to write three or more words to describe what they like and dislike about their chairs. During the pilot test, many students were concerned about not being able to identify three reasons that they liked or disliked their chairs. Therefore, for the purpose of the current study, questions 2 and 3 asked the students to describe what they like and dislike about their chairs, without a minimum or maximum guideline.

The student self-report questionnaire includes forced choice, open ended, and Likert-scale items. It asks the children to state if they like their chair, to describe what they like and dislike about their chair, and to rate frequency of musculoskeletal discomfort. These self-report forms were distributed to the participants at the end of each of the three conditions.

Handwriting. Assessment of children's handwriting quality was evaluated using the Woodcock-Johnson III (WJ III) legibility scale (Woodcock, McGrew, & Mather, 2001), which is part of a standardized academic achievement test. The WJ III is normed and standardized for children over two years of age. Norms for school-age children were collected from a stratified random sample of 4783 participants across the United States (McGrew & Woodcock, 2001). The *Technical Manual* for the WJ III reports strong content, construct, and concurrent validity (McGrew & Woodcock). Results of interrater reliability studies for six raters who independently scored handwriting samples of third graders ranged from .78-.99 (McGrew & Woodcock). Test-retest reliability for 8 to 10-year-olds was .69 after one year (McGrew & Woodcock).

The WJ III handwriting legibility scale is used to measure legibility and general appearance of handwriting from any handwriting sample. Subjects' handwriting samples are compared to normed samples and rated on a 0-100 point scale in 10-point increments, with specific criteria described for 0, 10, 30, 50, 70, 90, and 100 points (see Appendix D). The comparison samples include both manuscript and cursive so the subjects' writing samples can be of either style. A score of 0 is assigned to illegible writing or writing that is extremely difficult to read. Ten points are assigned for poor handwriting with inconsistent or irregular slant, spacing, size, and horizontal alignment, incorrect letter formations, and/or writing that is too dark or too light. Thirty points are assigned for fair handwriting, and 50 points are assigned for satisfactory handwriting with some inconsistencies in slant, spacing and sizing. Handwriting that is judged to be very good is assigned 70 points, and 90 points are assigned for excellent handwriting with uniform, consistent slant, spacing, sizing, letter formation, and horizontal alignment. Finally, 100 points are assigned for artistic writing such as calligraphy (Mather & Woodcock, 2001). For the purpose of this study, writing samples were collected from the participants' language arts class during each condition.

In addition to rating handwriting legibility, the proposed study included a plan to compare number of letters and words written in a two-minute period for each condition. Specifically, while working on an in-class writing task, students were to be instructed to circle the last letter written after a two-minute timed period, and the primary investigator would record the number of letters and words written by each participant. While the classroom teacher had agreed to this plan before the study began, on the second day of baseline data collection the teacher indicated that it would be too difficult to follow through with this part of the research plan due to a variety of logistical issues. Because students started their written work at different times based on when they finished reading and/or when they received a handout being passed around the classroom, it was not possible to use an alternative method to collect these data. Therefore, data on number of words written in a given period were not collected.

Math fluency. *C*hildren's math test performance was assessed using the WJ III math fluency test (Woodcock, McGrew, & Mather, 2001), a standardized academic achievement test (see Appendix E). The WJ III is a normed and standardized achievement test, and norms for school-age children were collected from a stratified random sample of 4783 participants across the United States (McGrew & Woodcock, 2001). The *Technical Manual* for the WJ III reports strong content, construct, and concurrent validity (McGrew & Woodcock). Test-retest reliability for the math fluency test among 7-11 year-olds during standardization procedures was high at .95 overall, and a median of .89 when the children were re-tested the next day (Mather & Woodcock, 2001; McGrew & Woodcock). Test-retest reliability for 8-10 year-olds was also high at .86 after one year (McGrew & Woodcock). These reliability statistics support the repeated use of this measure throughout the three phases of the current study.

The WJ III math fluency test assesses students' ability to quickly calculate simple single-digit math equations including addition, subtraction, and multiplication (Mather &

Woodcock). Students have 3 minutes in which to complete the series of equations. The test measures both math skills and automaticity. Each response is scored 1 point if correct and zero points if incorrect. Total scores are used to determine grade equivalents, age equivalents, percentile ranks, and standard scores.

Interrater Reliability

Data included ratings of sitting and task behaviors based on classroom observations, scores on the Woodcock-Johnson III (WJ III) math fluency test (Woodcock, McGrew, & Mather, 2001), ratings of handwriting legibility using the WJ III handwriting legibility scale (Woodcock, McGrew, & Mather), and student self-report of furniture preference and the presence or absence of musculoskeletal discomfort. Estimates of inter-rater reliability were established prior to and during data collection by the primary investigator and a trained research assistant, who was an occupational therapist with three years of experience in pediatrics including school-based practice.

The primary investigator trained the research assistant by practicing observing students' task behaviors, sitting behaviors, and fit potential prior to beginning data collection, and scoring handwriting legibility on writing samples collected during a pilot phase of the study. Both raters observed the sit and task behaviors of two sections of 25 third grade students. The raters then compared their ratings for each observation of each student, to compute the percentage of time that they both gave the same rating. Initial estimates of agreement between raters were 95% for observations of sit behaviors, 80% for observations of task behaviors, and 87% when sit and task behavior observations were combined overall. Agreement on fit potential was 100%. After the initial training and practice with the observation technique, both the primary investigator and research assistant agreed that it was difficult at times to determine whether a child was on task, especially when not obviously engaged in a hands-on activity such as writing or solving a math problem. Therefore, it was decided that when in doubt, the task observation would be scored as positive.

Agreement for handwriting legibility scores using 15 writing samples from another group of third graders used during a pilot phase was 85% after two practice scorings. The raters independently compared the samples to models that were rated in 10-point increments from 0-100, and assigned a point score to each sample. Initial interrater agreement during this practice/training phase was 67%. Of the 15 samples scored, both raters gave the same score on 10 samples; the raters' initial scoring differed by 10 points on 3 of the 15 samples and by 20 points on 2 of the 15 samples. The two raters then met to discuss their scoring decisions, and independently re-scored the samples, achieving agreement on 13 of the 15 samples, thus reaching 87% agreement (see Table 1).

Table 1

Interrater agreement on practice handwriting samples

	Score		
Sample	Rater 1	Rater 2	Difference
1	10	10	0
2	70	70	0
3	30	10	20
4	10	10	0
5	30	30	0
6	50	30	0
7	70	70	0
8	50	50	0
9	50	50	0
10	70	70	0
11	10	10	0
12	10	10	0
13	70	70	0
14	50	50	0
15	50	30	20

Procedures

An application was submitted to the Towson University Institutional Review Board (IRB) for study approval in December 2005. Upon receipt of IRB approval in January, 2006 (see Appendix F), an application for permission to conduct research was then submitted to the Baltimore County School Board of Education's Office of Accountability, Research, and Testing, which granted approval for the study in January, 2006. The elementary school principal and classroom teacher from the school in which the study took place had previously verbally approved the study. The third grade teachers distributed letters to parents of all third graders at the school describing the study and requesting participation. The letters included consent forms and requested demographic information including gender and chronological age. Parents were asked to voluntarily identify their child's race for the purpose of describing the sample of children, but were not required to do so. No parents provided this information on their returned consent forms.

A research assistant was trained by the primary investigator in the observation and scoring method for sitting behaviors, task behaviors, and fit potential in order to allow for assessment of inter-rater reliability. The research assistant was an occupational therapist enrolled in a master's degree program at Towson University. The primary investigator and the research assistant practiced rating on-task and sitting behaviors during a language arts class in the classroom in which the study was to take place. Twenty-four third graders were observed with a total of 86 observations recorded for sitting behaviors and for on-task behaviors. The two raters agreed on 82 of the 86 sitting behavior ratings yielding an inter-rater agreement percentage of 95%, and 100% agreement for fit potential. Inter-rater agreement percentage for on-task behaviors was 80% (68/86). Overall, the two raters agreed on 150 of 172 total observations, yielding 87% agreement. It was previously decided that data collection would begin after the primary investigator and research assistant achieved a minimum of 85% overall agreement.

During the study, each participant was observed four times per day during each condition by the primary researcher, yielding a maximum of 8 observations per child per condition, and a maximum 24 total observations per child for on-task behavior and for sitting behavior. The research assistant was present for five of the six data collection days, which resulted in her being present for 14 of the 24 total classes observed. Table 2 shows interrater agreement for sitting behaviors and on-task behaviors for each class observed and for all observations combined.

In addition to collecting observational data for interrater reliability, both researchers independently scored all of the writing samples. Prior to the start of the study, both researchers independently practiced scoring handwriting legibility using 15 writing samples collected from a third grade class during a pilot phase. Initial interrater agreement for this sample was 67%, with 10 of 15 samples assigned the same score, and a maximum point score difference of 20 points. The two raters met to review their scoring and the scoring criteria, then rescored the 15 samples again, achieving an 87% agreement with 13 of the 15 samples receiving the same score. The maximum point score difference between the two raters for the second scoring practice was 20 points.

Table 2

Interrater agreement for sitting behaviors and on-task behaviors

Date		Sitting Behavior	On-Task Behavior
1/27			
	Math 2	100%	86%
	Math 3	100%	88%
	Language Arts	100%	87%
2/22			
	Math 1	70%	78%
	Math 2	86%	100%
	Math 3	85%	90%
2/24			
	Math 3	95%	95%
	Language Arts	75%	94%
3/6			
	Math 1	100%	90%
	Math 2	95%	95%
	Math 3	88%	85%
3/8			
	Math 1	96%	88%
	Math 2	77%	95%
	Language Arts	86%	93%

Overall Agreement Per Class		
Math 1	89%	85%
Math 2	90%	94%
Math 3	92%	90%
Overall Math	90%	90%
Language Arts	87%	91%

During the study, interrater agreement for handwriting legibility was 86% for the samples collected while students sat in the baseline chair, 87% for the samples collected while students sat in the ergonomic chair and 100% for the samples collected while students sat in the smaller standard chair. The two raters agreed on 13 of 15 scores for samples collected in the baseline condition, 12 of 14 scores for samples collected while students sat in the ergonomic chairs, and all 11 of the samples collected when students sat in the smaller standard chair. The greatest point difference between the raters' scores did not exceed 20 points (Table 3).

Table 3

Interrater agreement on handwriting sample scores

		Chair Type	
	Baseline	Ergonomic	Standard
Subject			
1	30/50	50/50	20/20
2	30/50	40/40	20/20
3	30/30	10/10	30/30
4	50/50	70/60	60/60
5	50/50	50/50	40/40
6	50/50	50/50	-
7	50/50	60/60	70/70
8	20/20	30/30	-
9	40/40	50/50	-
10	10/10	30/30	20/20
11	30/30	20/20	20/20
12	20/20	20/30	30/30
13	20/20	-	30/30
14	40/40	20/20	30/30
15	50/50	50/50	-

Note. Scores are reported with primary investigators score first, research assistant's score second. Dashes indicate that no score was available.

Data collection began in late January 2006. For experiment 1, the primary researcher and research assistant observed students in their standard furniture during math class in order to record on-task and sitting behaviors during two 55-minute class periods, over a non-consecutive two-day period, for each condition. Participants took the WJ III math fluency test during the second observation day in each condition. For Experiment 2, students in one language arts class were observed for two days per condition as well. Copies of the written work produced during the observation period were collected in each condition for scoring handwriting legibility. During the baseline condition and the second furniture switch, writing samples for the students in the language arts class were collected from a two-page handout on which the students wrote answers to questions about an in-class reading assignment. The handouts included lined spaces for the students to write their responses. In the first furniture switch, the majority of the writing samples were collected from a one-page handout on which students wrote one word responses to fill in lined blanks in a story, while two students also completed handouts similar to those described for the baseline and second switch. The writing samples for the students from the math classes who gave consent to be included in the handwriting legibility study were collected from their responses on the student surveys and from an in-class handout with lined spaces to write explanations for how they solved math problems.

Prior to the start of the study, each student was assigned to a specific seat by the classroom teacher and remained in that seat for the duration of the study. In order to maintain anonymity of the students, each student was assigned a number to correspond to his or her seat in the classroom and as depicted on the observation/data collection form. In both Experiment 1 and Experiment 2, each participant was observed four times per day for a 5-second interval in each observation. After each 5-second observation, the researcher marked her observation form to indicate whether the student was on- or off-task, and whether the student's sitting position met the criteria for positive or negative sitting. The researcher and assistant also rated each students' fit potential in their chair, noted general behavioral observations regarding sitting postures, and recorded number of position changes per observation.

At the end of the baseline data collection period, the standard classroom furniture was replaced with the new chairs and height-adjustable tables, which matched the same configuration as the original furniture. The primary investigator and research assistant rated each child's fit potential in each type of chair again. Ergonomic and standard chairs were evenly distributed throughout the classroom thus allowing experimental manipulation to be counterbalanced. Specifically, in the first furniture change after baseline, 15 students in Experiment 1 sat in ergonomic chairs while the additional 16 sat in the standard chairs, and in Experiment 2, 8 students sat in the ergonomic chairs and 7 students sat in the standard chairs.

Observations resumed two weeks after the new furniture was placed in the classroom, allowing the students time to adjust to the new furniture. During the next observation phase, or condition 1, the researchers collected four sets of observations on each of two days for both Experiment 1 and 2. Twenty-nine of the 31 participants in Experiment 1 took the WJ III math fluency test on the second data collection day (2 students were absent). Also during this phase of the study, one corresponding handwriting sample was collected in Experiment 2. At the end of condition 1, the chairs at each table were switched so that each student had the opportunity to sit in and be observed and tested in each type of chair. Data collection resumed six school days later following the same procedures for both Experiment 1 and 2 as in both of the previous conditions.

At the end of each observation period, each of the student participants completed a questionnaire about their classroom furniture. For each condition, the students reported what they liked and disliked about their chairs and the degree to which they liked or disliked their chairs. The students also rated frequency of discomfort for a total comfort rating.

When all data were analyzed, follow-up letters were sent to parents and to the school. The letters thanked the parents, teachers, and administrators for their participation and provided a summary of the study's results. All data will be secured in a locked filing cabinet in the office of the primary investigator for at least three years following the study's completion.

Data Analysis

All of the data were analyzed with SPSS version 12. First, descriptive statistics were computed to determine mean, median, standard deviation, and range for fit potential, sitting behaviors, on-task behaviors, math fluency scores, handwriting legibility scores, number of position changes, and sum of student self-report of comfort scores in each of the three types of chairs and each condition. Differences in sitting and on-task behaviors for students in the two regular math classes and the one higher math class, and those with the lowest baseline handwriting legibility versus highest baseline handwriting legibility were also compared, in order to assess Lawton's principle of environmental docility. In order to assess the person-environment-occupation interactions, correlations were computed to examine the relationships between chair size and type with each of the outcome measures, and between fit potential score with each outcome measure. Because chair type was a qualitative variable, it was impossible to compute a conventional Pearson product moment correlation between chair type and the dependent measures. Therefore, in order to estimate correlations the relationship was described by a Partial Eta Squared statistic (PES) which is the percent of variance in the dependent measure that was controlled by the chair manipulation, or type of chair. A multivariate general linear model was used because it is bounded by fewer assumptions, for example, homogeneity of treatment difference variance, relative to the univariate repeated measures analysis of variance model (Harris, 1975). For correlations between variables that were continuous measures such as sitting behaviors, on-task behaviors, handwriting legibility, math test scores and self-reported comfort ratings, standard Pearson correlation coefficients were used. Point-biserial correlations were used to assess the relationship between gender, a dichotomous variable, with other outcome variables.

In cases where no significant relationships were found, multivaiate analyses of variance (ANOVA) were computed to assess for differences among the outcome measures for each type of chair. These analyses were used to determine any significant differences in sitting behaviors, on-task behaviors, math scores, handwriting legibility, number of position changes, and furniture comfort, across the three conditions, for baseline versus smaller standard chairs, and for smaller standard chairs versus smaller ergonomic chairs. The same analyses were computed to compare outcomes for math class (lower versus higher) and for lowest versus highest baseline handwriting legibility. Each outcome measure, i.e., mean sitting behavior score, mean on-task behaviors score, mean math fluency score, mean handwriting legibility scores, mean position changes, and mean furniture comfort scores, were compared for chair size and type in order to test the impact of each chair on occupational performance (see Figure 1, part D; Appendix G).

The student self-reports of comfort were assessed using a combination of quantitative and qualitative methods. First, correlation coefficients were computed to determine relationships between chair preference, self-reports of comfort, and musculoskeletal complaints. Additionally, qualitative methods were used to identify common themes among responses. The comments from each survey were transcribed and sorted into categories, based on similarities among the comments, in order to identify primary themes among the responses.

Chapter IV

Results

This chapter describes the results of the data analyses and hypotheses testing. It includes descriptions of the sample and descriptive data for each of the variables: fit potential, sitting behaviors, on-task behaviors, handwriting legibility, math test scores, self-reported comfort, and position changes. In addition, results of a priori and post hoc correlational analyses and analyses of variance are discussed.

Sample

The sample included 31 third grade students ages 8- and 9-years-old at a public elementary school in Baltimore County. Thirty-one children participated in experiment 1 (15 boys and 16 girls). However, because of students' absences during the course of the study, the number of students who were present on data collection days ranged from 25 to 31. A subset of 15 students from Experiment 1 (8 boys and 7 girls) participated in Experiment 2. Because of students' absences among this group, the number of students present on data collection days ranged from 10 to 15.

Despite the relatively small sample size in this study, post-hoc power analyses indicated an overall acceptable level of power in both experiments. Power is defined as the probability of detecting a statistical relationship when it exists (Cohen, 1988). Estimates of power range from 0 to 1.0. Power estimates are not perfectly correlated with effect size or significant levels, such that a small effect size can still be significant regardless of the power of the test while a large effect size can be nonsignificant. Both of these outcomes depend on sample size, and while it is important to have an adequate sample size to ensure a valid statistical test, it is also true that literally any effect will be significant with a large enough sample size (Cohen). Therefore, a well-planned study should have enough participants to ensure detection of a true effect, but not so many participants such that the enormity of the sample ensures a significant effect with small effect sizes. For Experiment 1, the power was .788 for sitting behaviors and .904 for on-task behaviors. Power for the math test scores data was .807. For experiment 2, the power was .746 for sitting behaviors data, .173 for on-task behaviors, and .637 for handwriting legibility. Although the on-task effect was not significant, it accounted for only a small percent of the variance. It is therefore unlikely that increasing the sample size would have substantially increased the size of the effect, or the likelihood of finding statistically significant results. The other two effects, sitting behaviors and handwriting legibility, were statistically significant at the .05 alpha level. Overall, these data suggest that although the samples were small, the power, or the probability of detecting true effects, was not compromised.

Fit Potential

Fit potential was assessed on a 3-point scale during each of the three conditions. Each student was observed while seated in his or her chair during each condition. Fit potential scores were based on the criteria for positive sitting specified in Appendix B, and ranged from 0-2. Although the smaller standard chairs and the ergonomic chairs were the same height, fit potential scores varied between these chairs. This variance may have occurred due to differences in the seat depths of the different chairs, and/or due to the differences in the seatbacks as the ergonomic chair had a convex back compared to the concave back of the smaller standard chair. Overall, the majority of the students' fit potential was rated "fair" or "good" when seated in the smaller chairs, while no students had a “good” fit in the baseline chair. Table 4 shows the number of children rated in each fit potential category in each chair type, along with the corresponding average sitting behavior score.

Table 4

Mean Sitting Behavior Score by Fit Potential Category and Chair Type

	Fit Potential Category					
Chair Type	Poor	Mean Sit Score	Fair	Mean Sit Score	Good	Mean Sit Score
Baseline Chair	14	.00	16	.04	0	n/a
Small Standard Chair	3	.00	9	.10	15	.14
Ergonomic Chair	1	.00	10	.34	18	.51

Note. Sitting behavior scores have a minimum of .00 and a maximum of 1.0.

Table 4 shows that mean sitting behavior scores were very low for students who were poorly fitted in their chairs, in each chair type. Table 4 also shows highest sitting scores for students seated in the ergonomic chairs when their fit was fair or good. Students seated in the ergonomic chairs with a fair fit had higher sitting behavior scores compared to the smaller standard chairs even when the fit in these chairs was good.

Sitting Behavior Scores

In experiments one and two, the experimental design included a maximum of eight observations of sitting behaviors, per child, per condition. Sitting behavior scores for each child are reported in Table 5 as the proportion of time in each condition that a child received a positive sit score during the observations. Therefore, for each condition, any child had a possible sitting behavior score of 0-1. Table 5 shows descriptive statistics for sitting behaviors score observations for each type of chair.

Table 5

Mean Sitting Behavior Scores by Chair Type

(min = 0; max = 1)

Group	Mean	Min/Max	SD
Experiment One – Math Classes (N=31)			
Baseline Chair (n=30)	.02	.00/.38	.07
Smaller Standard Chair (n=28)	.09	.00/.75	.19
Ergonomic Chair (n=28)	.41	.00/1.0	.28
Experiment Two – Language Arts Class (N=15)			
Baseline Chair (n=13)	.02	.00/.13	.05
Smaller Standard Chair (n=13)	.04	.00/.38	.10
Ergonomic Chair (n=15)	.47	.00/.75	.24

After the baseline furniture was replaced, half of the students sat in the smaller standard chairs and half sat in the ergonomic chairs. Table 6 shows descriptive statistics for sitting behaviors during the first furniture switch and during the second furniture switch with both types of chairs combined.

Table 6

Mean Sitting Behavior Scores by Condition and Furniture Switch

(min = 0; max = 1)

Group	Mean	SD
Experiment One – Math Classes (N=31)		
Baseline Condition (n=30)	.02	.07
First Switch (n=28)	.21	.28
Second Switch (n=28)	.29	.29
Experiment Two – Language Arts Class (N=15)		
Baseline Condition (n=10)	.02	.05
Switch 1 (n=13)	.30	.28
Switch 2 (n=11)	.29	.16

In order to evaluate differences in sitting behavior among the various chairs, a 3 x 2 correlated groups Multivariate Analysis of Variance (MANOVA) was used to evaluate sitting behavior in each chair across the two observation days, with the sitting behavior score as the dependent variable. The analysis also evaluated the percent of variance that chair type determined in the dependent measure of sitting behavior, by computing the Partial Eta Square (PES) statistics on the independent variable (chair type) and the dependent variable (sitting behavior). Results indicated significant relationships between chair type and sitting behavior in both experiments. In Experiment 1, the PES = .525, Wilks' Lambda = .475, $F(2,11) = 6.079$, $p < .05$, estimated power = .778. In Experiment 2 the PES was .708, Wilks' Lambda = .996, $F(2,6) = 7.286$, $p < .05$, estimated power =

.746. Figures 5 and 6 show a significant difference in sitting behaviors when students sat in the ergonomic chairs compared to the smaller standard chairs and baseline chairs.

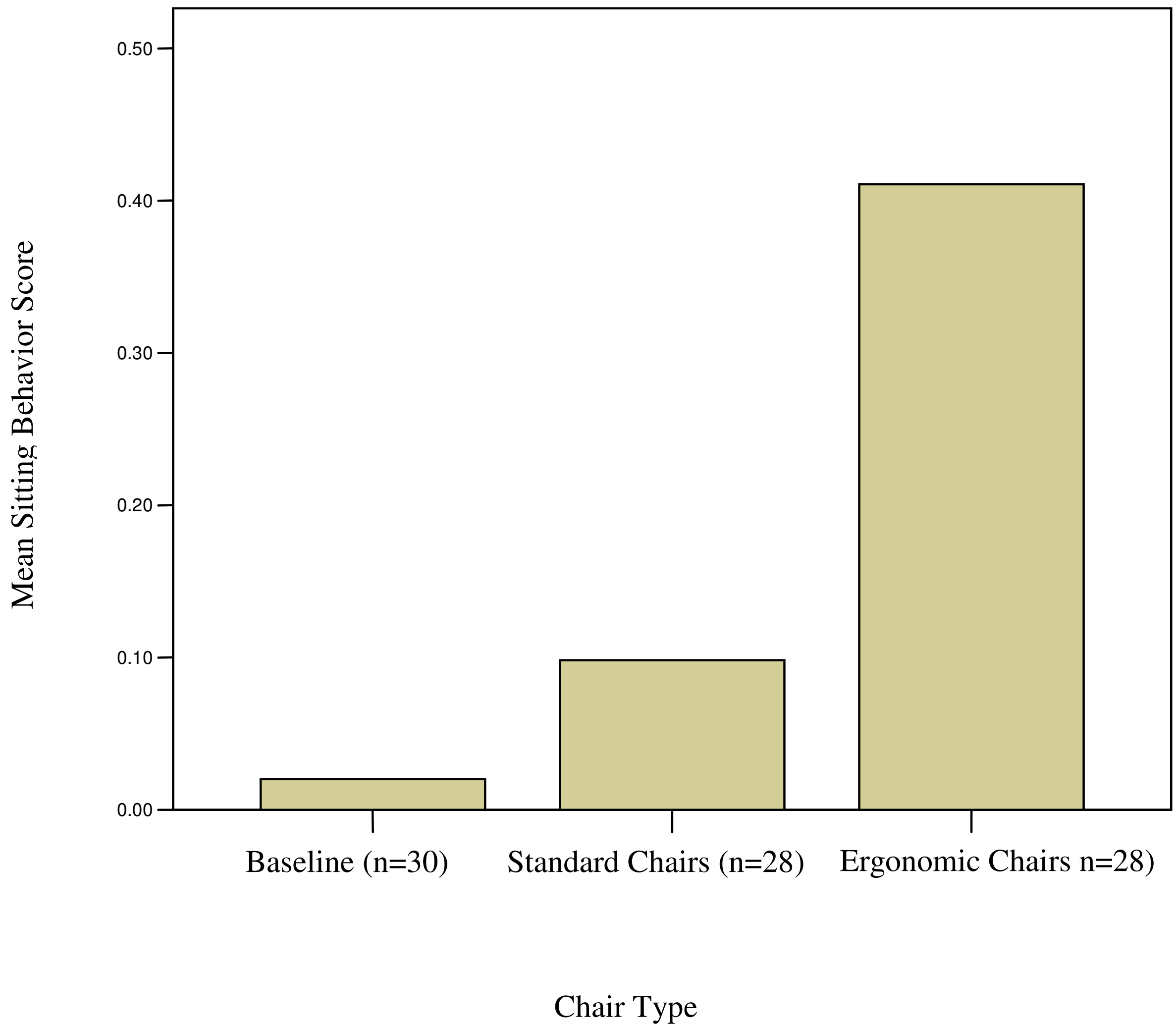


Figure 5. Mean Sitting Behavior Score by Chair Type for Experiment 1 – Math Classes.

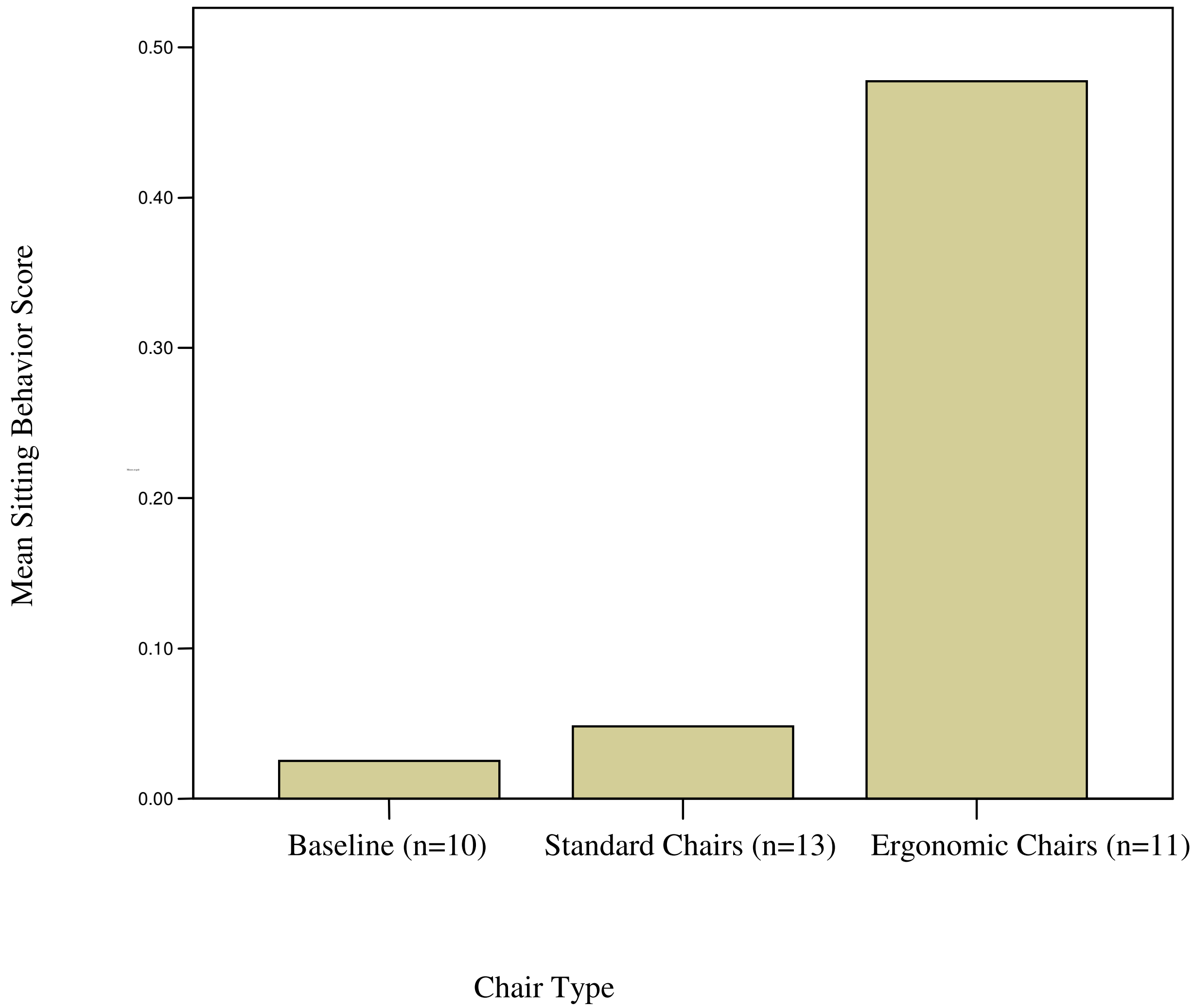


Figure 6. Mean Sitting Behavior Score by Chair Type for Experiment 2 – Language Arts Class.

In order to assess the effect of maturation on sitting behavior scores, descriptive statistics were also computed for sitting behavior for each chair type by condition (Table 7).

Table 7

Mean Sitting Behavior Scores by Condition and Chair Type

(min = 0; max = 1)

Group	Mean	SD
Experiment One – Math Classes (N=31)		
First Switch (n=28)		
Small Standard Chair (n=16)	.11	.22
Ergonomic Chair (n=12)	.35	.30
Second Switch (n=28)		
Small Standard Chair (n=12)	.11	.17
Ergonomic Chair (n=16)	.56	.30
Experiment Two – Language Arts Class (N=15)		
First Switch (n=12)		
Small Standard Chair (n=5)	.10	.16
Ergonomic Chair (n=7)	.42	.25
Second Switch (n=12)		
Small Standard Chair (n=8)	.02	.04
Ergonomic Chair (n=4)	.51	.34

Table 7 shows that in Experiment 1, average sitting behavior scores were the same in the smaller standard chairs during both the first and second furniture switches, with similar variance in scores. The mean scores for sitting behaviors varied more when students sat in the ergonomic chairs during the second furniture switch, than during the first furniture switch. In Experiment 2, mean sitting behaviors were lower during the second furniture switch when students sat in the smaller standard chairs. Mean sitting behaviors were slightly higher when students sat in the ergonomic chairs during the second furniture switch compared to the first furniture switch.

While sitting behaviors were significantly better when students sat in the ergonomic chairs compared to the smaller standard chairs and the larger baseline chairs, there was also a significant positive relationship between fit potential and sitting behavior in any type of chair. Specifically, post-hoc analyses reveal a significant correlation between fit potential and sit behaviors, for both Experiment 1, $r(29) = .479$, $p < .05$, and Experiment 2, $r(13) = .551$, $p < .05$. These findings suggest that regardless of chair type, students' sitting behavior scores were higher when the chair fit their size better (see Figures 7 and 8).

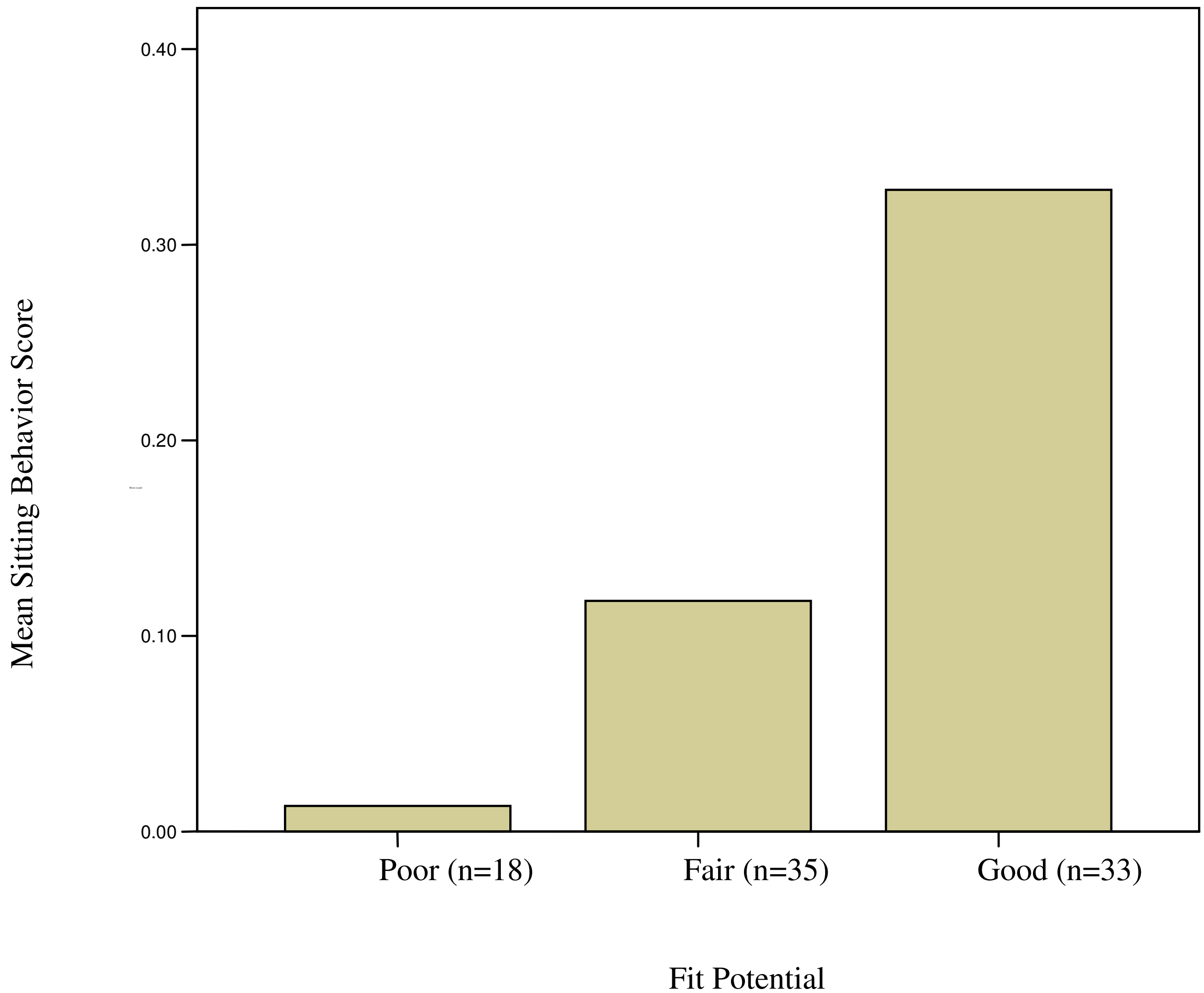


Figure 7. Sitting Behaviors by Fit Potential in All Chair Types, Experiment One - Math Classes.

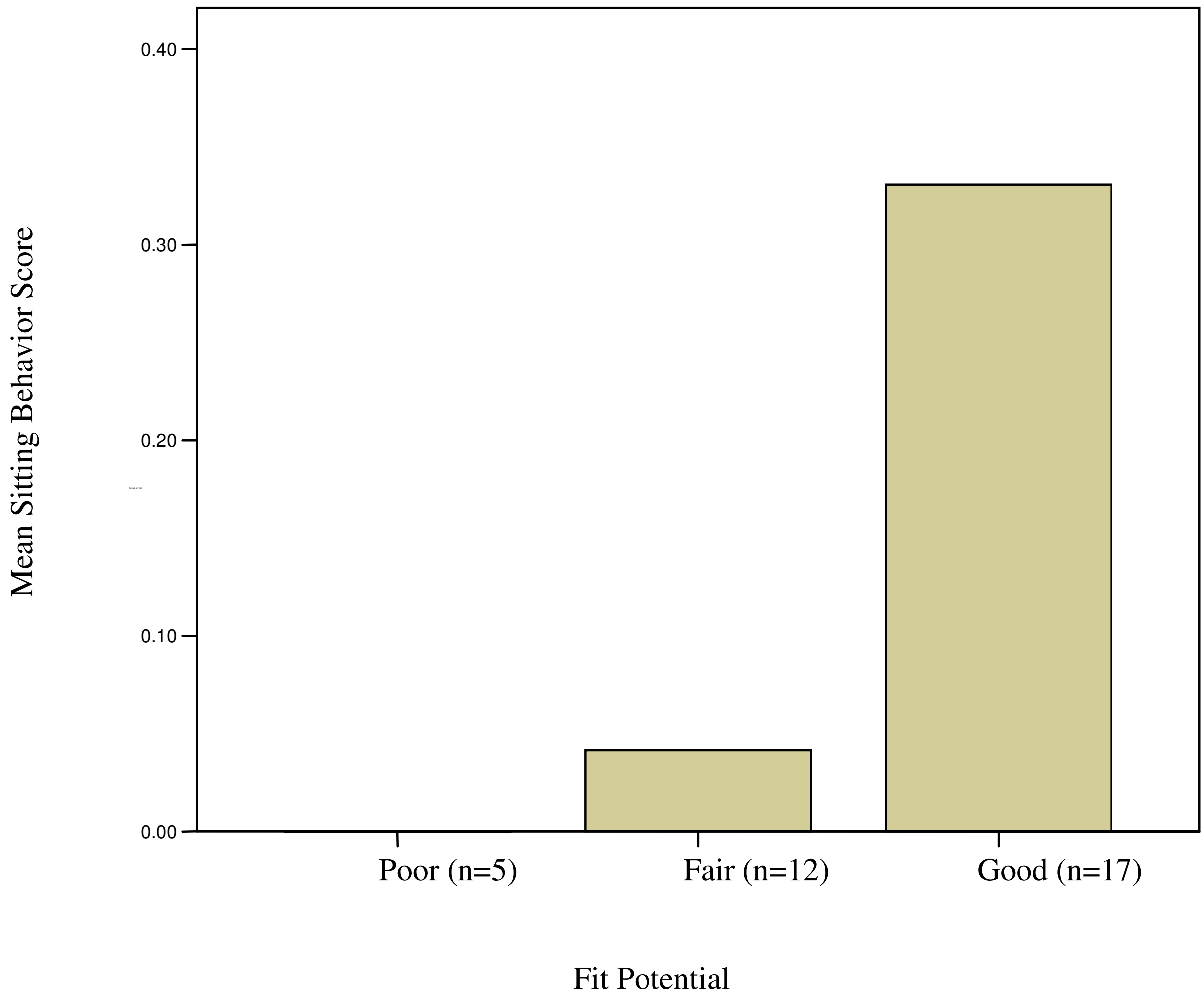


Figure 8. Sitting Behaviors by Fit Potential in All Chair Types, Experiment Two – Language Arts Class.

On-Task Scores

The data collection procedures also yielded a maximum of eight observations of on-task behaviors, per child, per condition. On-task scores were converted so that each child's total on-task score reflects the proportion of time in each condition that he or she received a positive on-task score during the observations, with a possible score of 0-1. Table 8 shows descriptive statistics for on-task scores in each type of chair for both Experiment 1 and Experiment 2.

Table 8

Descriptive Statistics for On-Task Scores by Chair Type

(min= 0; max=1)

Group	Min/Max	Mean	SD
Experiment One – Math Classes (N=31)			
Baseline Chair (n=28)	.29/1.0	.74	.17
Smaller Standard Chair (n=28)	.50/1.0	.82	.14
Ergonomic Chair (n=28)	.38/1.0	.85	.16
Experiment Two – Language Arts Class (N=15)			
Baseline Chair (n=10)	.50/1.0	.77	.15
Smaller Standard Chair (n=13)	.63/1.0	.85	.16
Ergonomic Chair (n=11)	.63/1.0	.84	.12

A 3 (chair type) x 2 (days of data colection) correlated groups MANOVA was computed to further assess the relationship between chair type and mean on-task behavior score in both Experiments 1 and 2. There was no significant difference in on-task scores by chair type for Experiment 2, PES = .279, Wilks' Lambda = .721, F (2,6) = 1.163, $p > .05$, estimated power = .173, which included the 15 students in language arts class. However, the results were significant for Experiment 1, PES = .609, Wilks' Lambda = .391, F (2,11) = 8.56, $p < .05$, estimated power = .904, and Figure 9 shows that the on-task behaviors of students in the math classes were significantly better when they sat in either of the smaller chairs than in the baseline chair. Specifically, the figure shows that the means of these two conditions fell outside and above the 95% confidence range for the baseline condition. Figure 9 also shows there was no significant difference between on-task behaviors when students sat in the smaller standard chairs or the ergonomic chairs.

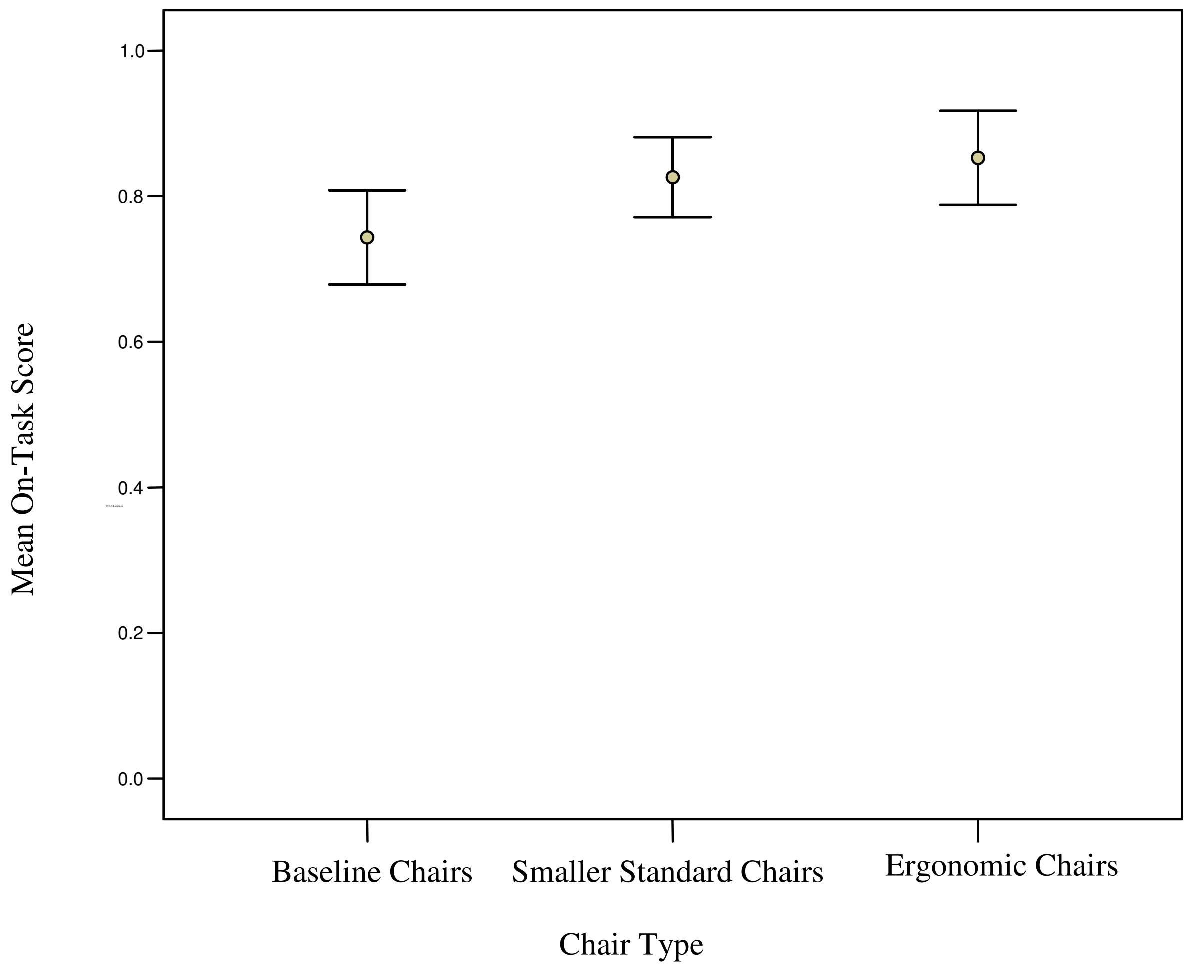


Figure 9. On-Task Score by Chair Type, Experiment One

Table 9 shows descriptive statistics for on-task scores in each condition for both Experiment 1 and Experiment 2. In order to assess the effect of maturation on on-task behaviors in the three chairs, descriptive statistics were also computed on average on-task score by condition in each chair type, for both Experiments 1 and 2 (Table 10). Table 10 shows that in both Experiments 1 and 2, mean on-task scores were somewhat lower during the second furniture switch for both types of chairs when compared to the first switch. Table 10 also presents the 95% confidence intervals computed around the means for the smaller standard chairs. For example, in Experiment 1, the mean value for the small standard chair was .86 and the 95% range was .79 to .93. The table shows that the means for the ergonomic chairs fell within the 95% range for the small standard chairs in every condition. Therefore, although there were slight changes in the means from the first switch to the second switch, the changes were not significant. This result indicates that there maturation is an unlikely factor from one chair to another because there was no significant change in on-task behavior that occurred between the two chairs. In both experiments and after both furniture switches, students were on-task at least 80% of the time in both types of chairs. This finding suggests that on-task behavior was more likely affected by chair fit than by maturation.

Table 9

Descriptive Statistics for On-Task Scores by Condition

(min = 0; max = 1)

Group	Mean	SD
Experiment One – Math Classes (N=31)		
Baseline Condition (n=31)	.74	.17
Condition 1/First Switch (n=28)	.88	.13
Condition 2/Second Switch (n=28)	.79	.17
Experiment Two – Language Arts Class (N=15)		
Baseline Condition (n=10)	.77	.15
Condition 1/First Switch (n=12)	.88	.13
Condition 2/Second Switch (n=12)	.82	.16

Table 10

Descriptive Statistics and 95% Confidence Intervals for On-Task Scores by Condition and Chair Type

(min = 0; max = 1)

Group	Mean	SD
Experiment One – Math Classes (N=31)		
Condition 1/First Switch (n=28)		
Small Standard Chair (n=16)	.79 --.86 -- .93	.12
Ergonomic Chair (n=12)	.91	.13
Condition 2/Second Switch (n=28)		
Small Standard Chair (n=12)	.64 --.80 -- .96	.25
Ergonomic Chair (n=16)	.83	.24
Experiment Two – Language Arts Class (N=15)		
Condition 1/First Switch (n=12)		
Small Standard Chair (n=5)	.79 --.93 -- 1.0	.11
Ergonomic Chair (n=7)	.86	.14
Condition 2/Second Switch (n=12)		
Small Standard Chair (n=8)	.68 --.83 -- .98	.18
Ergonomic Chair (n=4)	.91	.12

Note. The vales surrounding mean on-task scores for the smaller standard chairs show the 95% confidence intervals around the means for the smaller standard chairs in each condition.

Descriptive statistics were computed for mean on-task behaviors by fit potential. In Experiment 1, mean on-task scores were .75 for poor fit potential, .82 for fair fit potential, and .84 for good fit potential. In Experiment 2, mean on-task behaviors were .73, .82, .86 respectively. Post-hoc analyses were used to assess the relationship between fit potential and on-task scores for both Experiments 1 and 2. These analyses did not reveal any significant relationships [Experiment 1, $r(29) = .19, p > .05$ or Experiment 2, $r(13) = .30, p > .05$]. However, there was a significant positive low correlation between sit scores and on-task scores for Experiment 1, $r(29) = .234, p < .05$. There was no significant correlation between sitting behavior scores and on-task scores for Experiment 2, $r(13) = .145, p > .05$.

Handwriting Legibility

Table 11 shows descriptive statistics for legibility scores from the handwriting samples for each type of chair for the total group and by gender, and Figure 10 shows mean handwriting legibility scores by chair type and gender. Figure 10 shows that mean handwriting legibility score for boys was significantly higher in the ergonomic chairs compared to their scores when they sat in the smaller standard chairs, because the means fell outside and above the 95% confidence range for scores in the smaller standard chairs. Figure 10 also shows that girls' mean handwriting legibility in all three chair types was significantly better than boys' when the boys sat in the smaller standard chairs. In addition, analysis of variance indicated a significant difference in handwriting legibility based on gender, $F(1, 8) = 6.728, p < .05$, with girls scoring higher on handwriting legibility than boys.

Table 11

Descriptive Statistics for Legibility Scores on In-Class Writing Samples

	Min/Max	Mean	Standard Deviation
Baseline Chair			
Male (n=8)	10/50	28.6	13.5
Female (n=7)	20/50	40.0	12.0
Total (n=15)	10/50	34.7	13.6
Smaller Standard Chair			
Male (n=6)	20/30	22.5	5.0
Female (n=7)	30/70	42.9	16.0
Total (n=13)	20/70	35.5	16.3
Ergonomic Chair			
Male (n=8)	20/50	35.7	14.0
Female (n=7)	20/70	42.9	16.0
Total (n=15)	10/70	39.3	17.7

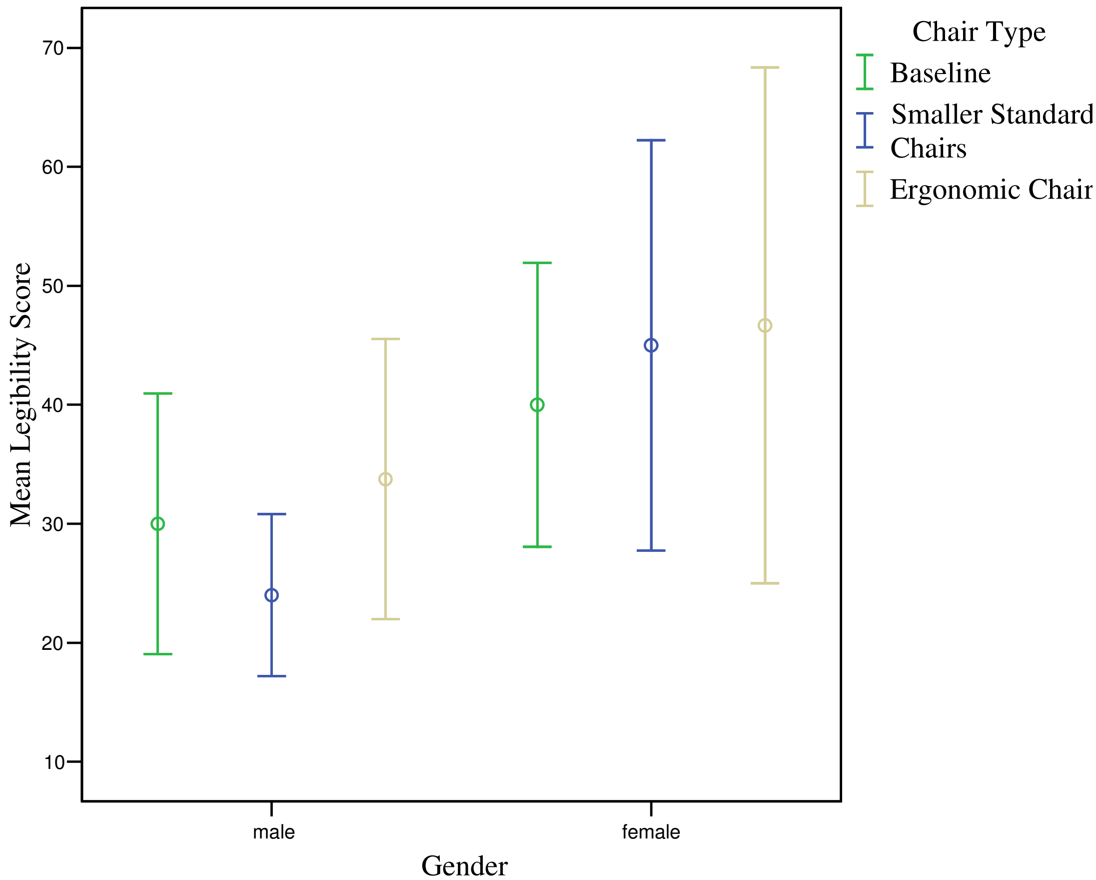


Figure 10. Mean Handwriting Legibility Scores by Chair Type and Gender.

Table 11 shows that overall, girls received similar scores for handwriting legibility across chair type, with legibility scores slightly higher when they sat in either the smaller standard or ergonomic chairs, although there were no significant differences between the chairs (see Figure 10). However, the boys' handwriting legibility was significantly lower when they sat in the smaller standard chairs compared to when they sat in the ergonomic chars, as the means in the ergonomic chairs fell outside and above the 95% confidence range for scores in the smaller standard chairs. Boys' handwriting legibility averaged 7 points higher when they sat in the ergonomic chairs compared to when they sat in the baseline chairs and was more than 13 points higher than when they sat in the smaller standard chairs. Furthermore, boys scored almost 12 points lower than girls during the baseline condition and when sitting in the ergonomic chairs, the boys' mean score was just slightly more than 7 points lower than the girls' scores in the ergonomic chairs. The girls mean legibility score in the ergonomic chairs was only 2.9 points higher than their mean baseline score.

Figure 10 shows that girls had greater variability in handwriting legibility scores than did boys, especially in the ergonomic chairs in which there was a 50 point range from lowest score to highest score. Figure 10 also shows that the lower score boundaries for boys in all three chairs was lower than for the girls, while the upper score boundaries for girls was higher than it was for the boys in all three of the chairs. Furthermore, the upper score boundary for girls was higher when they sat in the smaller chairs.

Partial Eta Square was used to assess the relationship between handwriting legibility and chair type. This relationship was not significant, PES = .069, Wilks' Lambda = .931, $F\ (2,8) = .298$, $p > .05$. However, the relationship between handwriting legibility and sitting behavior was significant, $r\ (29) = .402$, $p < .05$. This finding suggests a moderate relationship between sitting better, regardless of chair type, and better handwriting legibility.

Analyses of variance were also computed for differences in handwriting legibility among the total group by fit potential and comfort. There was no difference in handwriting legibility based on fit potential, $F(1,8) = .111$, $p > .05$ or self-reported total comfort, $F(3,8) = 2.35$, $p > .05$. However, Figure 11 shows that boys had significantly higher legibility scores when their fit was fair or good compared to when their fit was poor. Specifically, when fit potential was fair or good, the boys' mean score fell above and outside the 95% confidence range for scores when chair fit was poor. Girls had similar mean legibility scores regardless of chair fit.

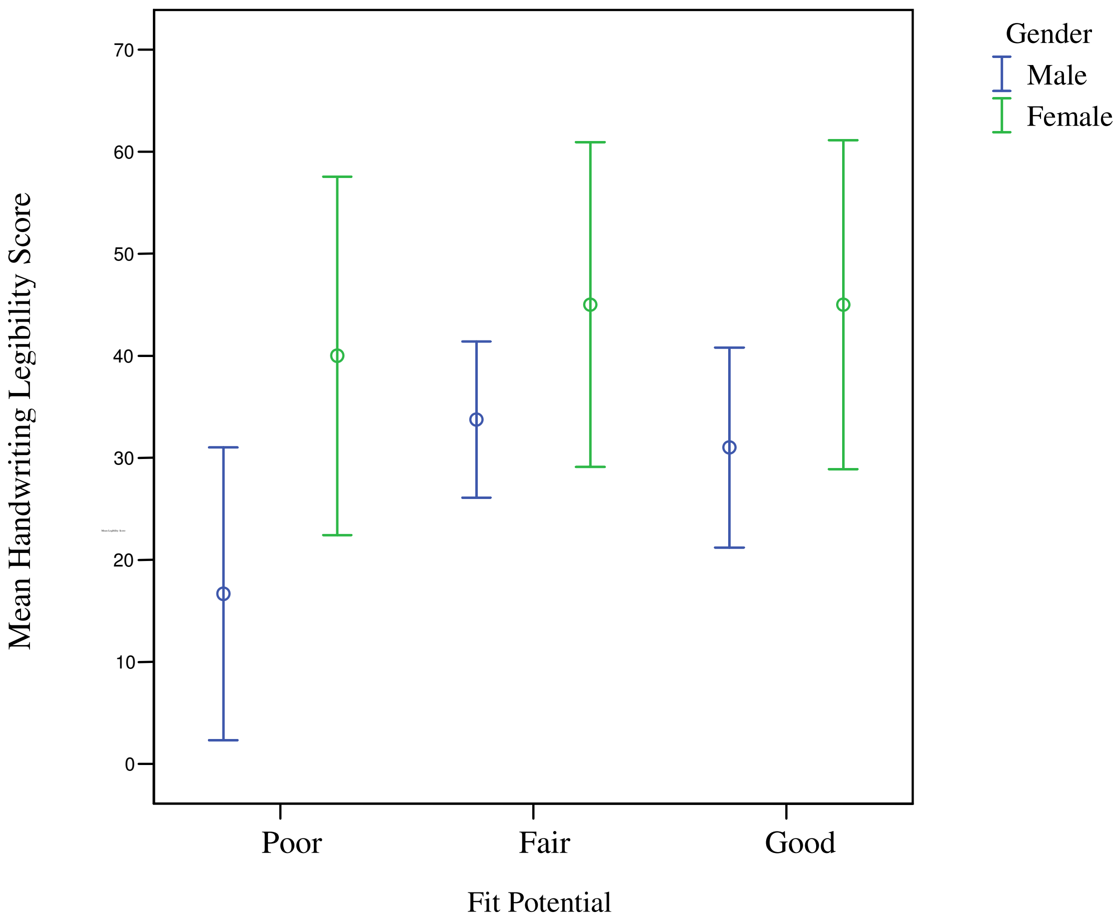


Figure 11. Handwriting Legibility by Fit Potential and Gender.

Legibility scores were compared across chair type for students with the lowest baseline handwriting legibility to students with the highest baseline handwriting legibility. The range of baseline legibility scores was 10 points to 50 points. Students who received baseline legibility scores of 10 or 20 (n = 4) were classified as low scorers. Five students with baseline legibility scores of 50 were classified as high scorers. Table

12 shows the mean legibility scores for low scorers and high scorers for both types of smaller chairs. The handwriting legibility score of low scorers averaged nine points higher when they sat in either of the smaller chairs. Students with high baseline legibility scores also had higher legibility scores when seated in either of the smaller chairs, but the increase in means was less at six to seven points. Overall, handwriting legibility scores were similar when students sat in the ergonomic chair or the smaller standard chair.

Table 12

Mean Legibility Scores for Students with Lowest Baseline Scores and Highest Baseline Scores, by Chair Type

Handwriting Legibility Score Group	Mean Legibility Score	SD
Low (10-20 points) (N=4)		
Baseline Chairs (n=4)	17.5	5.0
Ergonomic Chairs (n=4)	26.7	5.8
Smaller Standard Chairs (n=3)	26.7	5.8
High ($\geq$ 50 points) (N=5)		
Baseline Chairs (n=5)	50.0	0.0
Ergonomic Chairs (n=5)	56.0	8.9
Smaller Standard Chairs (n=3)	56.6	15.3

Note. Dashes indicate that no score was available.

In addition to comparing mean legibility score increases for students with high baseline scores to students with low baseline scores, post-hoc analyses examined trends among children who demonstrated improved handwriting legibility, decreased handwriting legibility, or no change in handwriting legibility in either of the smaller chairs. A difference of 10 or more points between legibility samples was considered a change in legibility score. Table 13 shows the number of children whose legibility score increased, decreased, or remained the same when seated in each of the smaller chairs, compared to their baseline legibility score when seated in the larger chair.

Table 13

Frequency of Increase, Decrease, or No Change in Legibility Score by Chair Type

Chair Type	Legibility Increased	Legibility Decreased	No Change	Total
Ergonomic	7	3	4	14
Standard	5	5	1	11
Total	12	8	5	25

As shown on table 13, handwriting legibility scores increased in 50% of the students when they sat in the ergonomic chairs and in 45%students when they sat in the smaller standard chairs, compared to their baseline legibility scores. Three of the 14 students (21%) had decreased legibility scores when they sat in the ergonomic chairs and 5 of the 11 students (45%) had decreased legibility scores when they sat in the smaller standard chairs, compared to their baseline legibility scores. Four of the 14 students (29%) in the ergonomic chair and 1 of the 11 students (10%) in the smaller standard chair had no change in legibility scores.

Table 14 shows the fit potential ratings for children whose handwriting legibility score increased, decreased, or stayed the same when seated in each of the smaller chairs, compared to their baseline legibility score when seated in the larger chair.

Table 14

Frequency of Increase, Decrease, or No Change in Legibility Score by Fit Potential and Chair Type

Chair Type/Fit	Legibility Increased	Legibility Decreased	No Change	Total
Ergonomic				
Poor	0	0	0	0
Fair	1	1	1	3
Good	6	3	2	11
Total	7	4	3	14
Smaller Standard				
Poor	0	0	0	0
Fair	3	1	0	4
Good	2	4	1	7
Total	5	5	1	11

Based on Table 14, fit potential may have a more positive effect on handwriting legibility when students sit in ergonomic chairs. Six out of 11 students (62%) demonstrated increased handwriting legibility scores when their fit potential in the ergonomic chairs was rated as good. Only 2 of 11 students demonstrated increased handwriting legibility when their fit in the standard chairs was good. Furthermore, 4 of the students, all of whom were male, demonstrated decreased handwriting legibility when seated in the standard chairs even though all four showed a good fit potential.

In order to determine if maturation may have affected handwriting legibility scores, the number of legibility scores that increased, decreased, and stayed the same relative to baseline were compared for each chair for each of the two furniture switches (Table 15).

Table 15

Frequency of Increase, Decrease, or No Change in Legibility Score by Condition

	Legibility Increased	Legibility Decreased	No Change	Total
First Switch				
Ergonomic	4	2	2	8
Standard	3	1	1	5
Total	7	3	3	13
Second Switch				
Ergonomic	4	2	0	6
Standard	2	4	0	6
Total	6	6	0	12

Table 15 shows that after the first furniture switch, 7 of 13 students' legibility scores increased while only 3 decreased and 3 stayed the same. However, after the second furniture switch, 6 students' legibility scores increased while 6 students had decreased legibility scores. Of the 6 students whose legibility scores increased after the second switch, 4 sat in the ergonomic chairs, while the other 2 sat in the standard chairs. In contrast, 4 of the students whose scores decreased after the furniture switch were seated in the standard chairs while only 2 were seated in the ergonomic chairs.

Math Fluency Scores

Each participant completed the Woodcock-Johnson Math Fluency Test three times, once in each type of chair. Table 16 presents descriptive statistics for students' scores on math fluency tests for each chair type.

Table 16

Descriptive Statistics for Math Test Scores by Chair Type

Chair	Min/Max	Mean	SD
Baseline (n=29)	2/54	32.0	13.8
Ergonomic (n=28)	18/65	40.8	10.6
Smaller Standard (n=26)	9/58	40.6	10.5

Partial Eta Square coefficients did not reveal any significant relationships between chair type and math fluency scores. Subsequent analyses of variance were used to assess differences in mean math fluency scores by type of chair. Results indicate a significant difference in math test scores based on type of chair, $F (2, 27) = 5.09$, $p < .05$. Figure 12 shows that students scored higher on math fluency tests when seated in either the smaller standard chairs or the ergonomic chairs compared to when they sat in the standard baseline chairs.

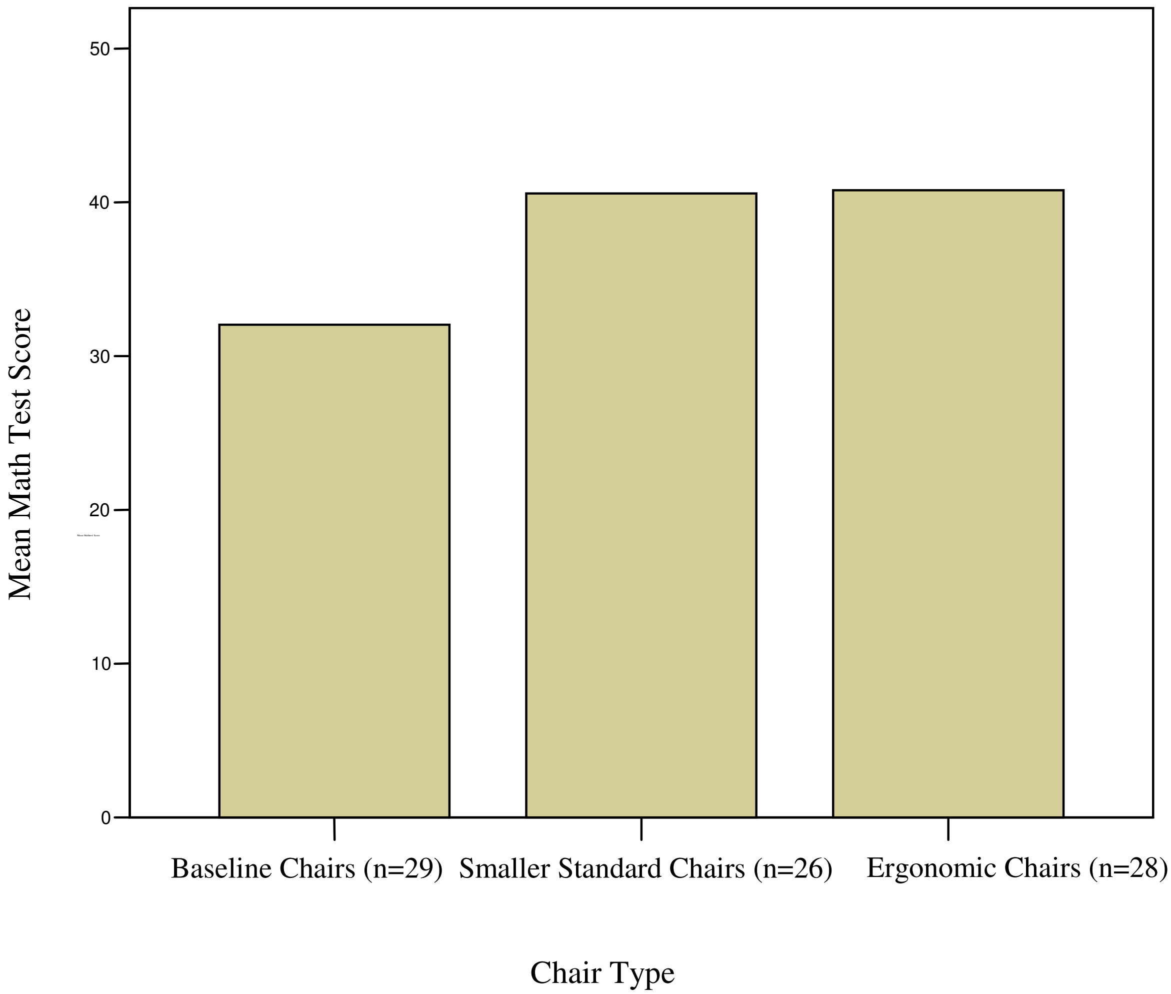


Figure 12. Math Fluency Test Score by Chair Type.

Math fluency scores of students in the regular math classes were compared to scores of students in the highest math class (gifted and talented) across chair type in order to assess any differences in performance based on chair type among students with higher skill levels and students with lower or average skill levels (see Table 17). These analyses did not reveal any significant differences.

Table 17

Descriptive Statistics for Math Fluency Scores for Gifted and Talented Students (GT) and Regular Students

Chair Type	Min/Max	Mean	Standard Deviation
Baseline			
GT (n=11)	2/48	33.27	12.51
Regular (n=18)	4/54	31.28	14.76
Ergonomic			
GT (n=11)	29/49	38.91	4.97
Regular (n=17)	9/65	41.00	13.17
Standard			
GT (n=11)	25/51	42.18	7.25
Regular (n=15)	18/63	40.53	12.52

There was no difference in math fluency score based on smaller chair type, (e.g., smaller standard chairs and ergonomic chairs). However, there was a significant relationship between math fluency score and fit potential. Specifically, post-hoc analyses revealed a significant low-moderate positive correlation between overall fit potential and math fluency score, $r(29) = .364$, $p < .05$. Analysis of variance was used to assess the impact of fit potential in any chair on math test score. The results indicated a significant difference in math test score based on overall fit potential across the three conditions, $F(2, 29) = 6.13$, $p < .05$ (see Table 18 for descriptive data).

Table 18

Mean Math Test Score by Fit Potential

Fit Potential	Min/Max	Mean	SD
0 – Poor Fit (n=19)	2/54	30.79	16.63
1 – Fair Fit (n=33)	9/55	37.00	8.68
2 – Good Fit (n=31)	18/65	42.58	10.74

Post-hoc analyses of variance were used to assess differences in math fluency scores based on gender regardless of chair type, $F(1,29) = .319$, $p = .574$; no significant differences were found. Table 19 shows math test scores by gender as obtained in the various chair types.

Table 19

Mean Math Test Score by Gender and Chair Type

Chair Type	Min/Max	Mean	SD
Baseline			
Male (n=13)	2/49	32.7	14.5
Female(n=16)	4/54	31.5	13.6
Ergonomic Chair			
Male (n=13)	35/65	45.1	9.5
Female (n=15)	18/56	37.1	10.5
Smaller Standard Chair			
Male (n=12)	9/58	37.7	13.8
Female (n=14)	36/55	43.1	6.0

Table 19 shows that mean math test scores were similar for both boys and girls in each type of chair, with no more than an 8 point difference. However, the range of scores varied by chair type as the minimum scores were lowest when boys and girls sat in the baseline chairs. The group of boys had a lower minimum score when they sat in the smaller standard chairs compared to when they sat in the ergonomic chairs, while the group of girls had a lower minimum score when they sat in the ergonomic chairs compared to the smaller standard chairs. Girls' maximum scores was similar in all three chairs. In addition, the girls' scores had less variability in both of the smaller chairs, especially the smaller standard chair as indicated by smaller standard deviations compared to the baseline chairs. Boys' scores had less variability when they sat in the ergonomic chairs.

In order to test for the effect of maturation on students' math test scores, additional post-hoc analyses compared math test scores in each of the conditions. Partial Eta Square relationships were not significant between scores during the baseline condition and the first furniture switch, PES (27) = .300, $p > .05$, or between the baseline condition and the second furniture switch, PES (25) = .015, $p > .05$. There was a significant moderate relationship between math test scores during the first furniture switch and the second furniture switch, PES (25) = .592, $p < .05$. Although analyses of variance yielded a significant difference between the baseline conditions and the experimental conditions overall, $F(2,29) = 5.389$, $p < .05$; there was no significant difference between the two experimental conditions overall (Figure 13), and no significant differences in performance based on chair type in the experimental conditions (Figure 14). Test scores were not significantly higher the third time students took the math test compared to the second time they took the test. Therefore, there was no significant learning effect that occurred as a result of the repeated use of the math fluency test across the experimental conditions, because the only difference in scores occurred between the first condition when the students were in the baseline furniture, and the two experimental conditions, when the students were in the smaller furniture.

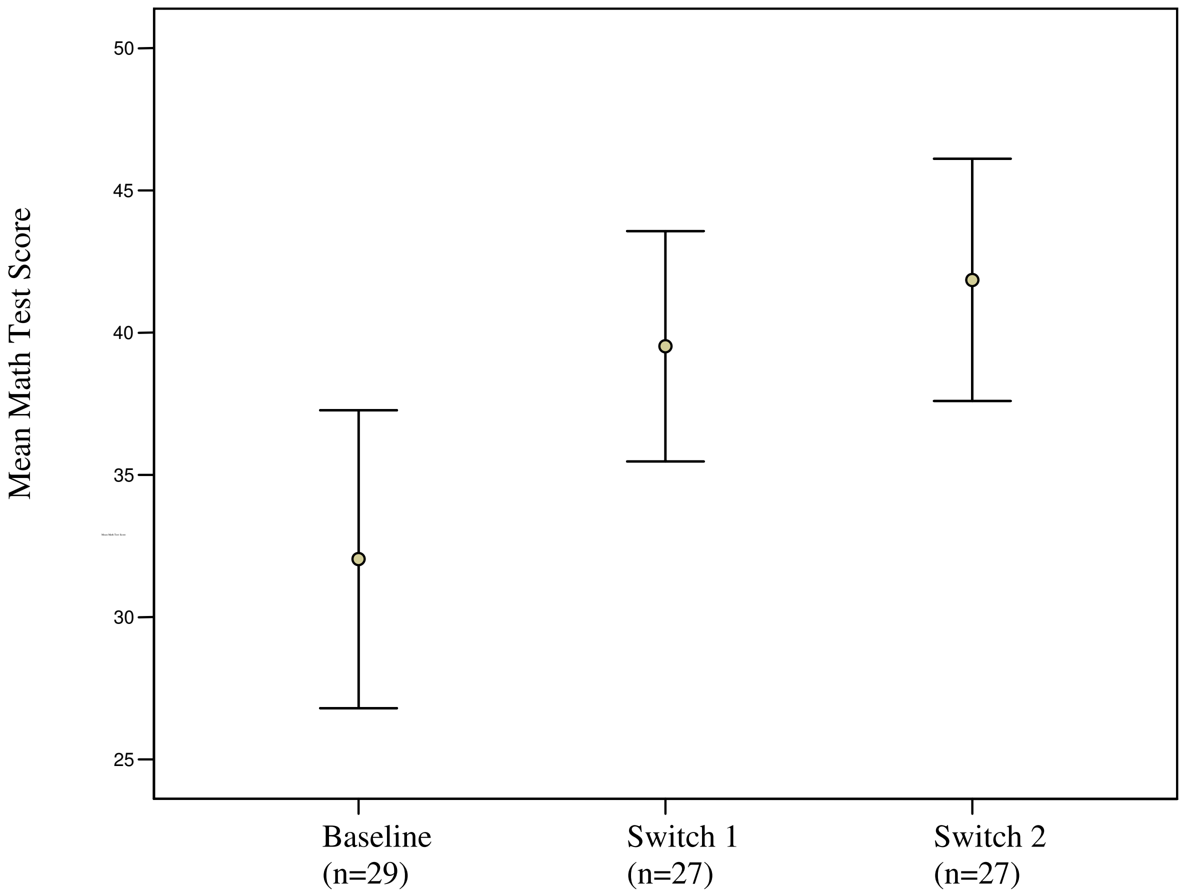


Figure 13. Math Fluency Test Score by Condition.

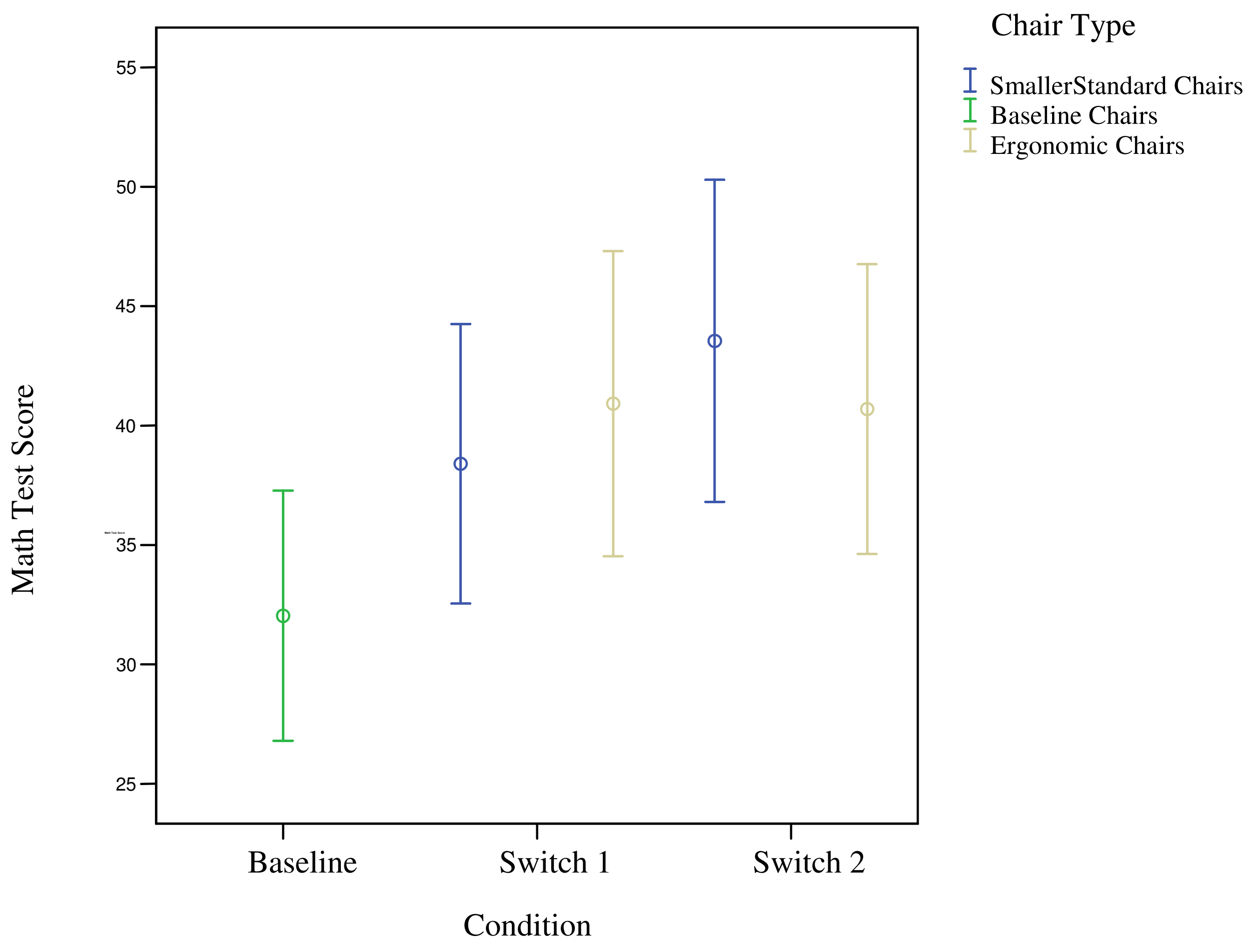


Figure 14 . Math fluency test score by chair type and condition.

Position Changes

Position changes were recorded as the number of times a student changed his or her sitting position during each of four 5-second observations per day, during each two-day observation period. While the investigators observed students changing their sitting positions throughout the each class period, few total position changes were noted during each child's individual observation. In experiment 1, the mean number of overall position changes observed was .23 during the baseline condition, 1.9 while students sat in the standard chairs, and 1.6 while students sat in the ergonomic chairs. In experiment 2, no position changes were recorded during the baseline condition and the mean position changes in the standard and ergonomic chairs were only .10 and .20 respectively. Overall, the results related to the position changes variable may lack validity due to the limited amount of data available. However, results indicate a significant relationship between chair type and mean number of position changes for Experiment 1, PES (29) = -.764, < .05. There were no significant relationships between chair type and position changes for Experiment 2.

Student-Self-Report of Comfort

The student self-reports were used to assess the relationship between chair type and chair preference on student comfort and chair preference for each condition. Students circled “yes” or “no” to indicate if their chair was comfortable and used a Likert-scale to rate their frequency of musculoskeletal symptoms including back and shoulder pain, neck pain, and incidence of legs or feet falling asleep. Likert responses were converted to point scores from 0-4 for the choices of never, hardly ever, sometimes, often, and everyday.

Fifty percent of the students in experiment 1 reported that the baseline chairs and smaller standard chairs were comfortable, while only 24% reported that the ergonomic chair was comfortable. Of the subset of children in experiment 2, 54% reported that the baseline chair was comfortable, while 57% said the smaller standard chair was comfortable and 33% reported that the ergonomic chair was comfortable. Table 20 shows descriptive data for the surveys.

Table 20

Descriptive Data for Student Self-Report Questionnaires

	Min/Max	Mean	SD
Question			
How often do your back or shoulders hurt when sitting in your chair			
Baseline Chair (n=28)	0/4	1.71	1.6
Smaller Standard Chair (n=22)	0/4	1.86	1.6
Ergonomic Chair (n=21)	0/4	2.33	1.5
How often does your neck hurt when sitting in your chair			
Baseline Chair (n=28)	0/4	1.68	1.5
Smaller Standard Chair (n=22)	0/4	1.32	1.4
Ergonomic Chair (n=21)	0/4	1.76	1.4
How often do you legs or feet fall asleep sitting in your chair			
Baseline Chair (n=28)	0/4	2.11	1.3
Smaller Standard Chair (n=22)	0/4	1.82	1.4
Ergonomic Chair (n=21)	0/4	1.76	1.2

Note. 0 = never; 1 = hardly ever; 2 = sometimes; 3 = often; 4 = everyday

Correlation coefficients were computed to assess relationships between students self-report of comfort (e.g. answer to question “is your chair comfortable?”), and Likert responses to self-reports of musculoskeletal pain. Table 21 shows moderate to high negative correlations indicating that the students were consistent in their self-analyses of overall comfort, overall discomfort, and specific musculoskeletal complaints. There were no significant correlations between gender and comfort, r (29) = .087, p > .05.

Table 21

Correlations Between Student Perception of Comfort and Self-Reported Incidence of Musculoskeletal Pain

	Chair Comfort (Yes/No)
Back/Shoulder Pain	-.785
Neck Pain	-.622
Legs/Feet Fall Asleep	-.424

Correlation coefficients were also used to assess the relationship between comfort scores and sitting behavior, math fluency score, and handwriting legibility. There was no significant relationship between comfort and sitting behavior for Experiment 1, r (29) = -.198, p> .05 or Experiment 2, r (13) = -.338, p > .05. There was no significant correlation between comfort and math fluency score, r (29) = -.322, p > .05, or comfort and handwriting legibility, r (13) = .142, p > .05.

Students' responses to questions that asked to them to describe what they like and dislike about their chairs were recorded and analyzed for common themes. The majority of the students wrote comments to describe what they liked and disliked about their chairs, but some left these areas blank. Overall, all of the students commented on the chairs in the baseline condition, 20 commented after the first chair switch, and all commented after the second chair switch.

Four primary themes emerged among the students responses: comfort/discomfort, fit, design, and aesthetics. When asked to describe what they liked about their chair in the baseline condition, the majority of responses fell into the categories of design and aesthetics. For example, in both the math class groups and the language arts class group, students reported that they liked the chair's design features such as being portable (n= 2) and sturdy (n=3), and aesthetic features including the shape (n=4) and color (n=1), and that the chair had chair bags on the back (n=6) and soundproof pads on the legs (n=9). In terms of comfort, only two students reported that the baseline chair was comfortable, and six liked it because it gave them "a place to sit." Only three students liked their chair because of the fit.

In contrast, the majority of the reasons that students disliked their chairs in the baseline condition were due to discomfort and design issues. Students reported that the chair was not comfortable (n=5), hard (n=14), often shocked them (n=7), and hurt their legs (n=1), backs (n=1), and bottoms (n=3). In terms of design, one student did not like that the chair was shaky, and two complained that the chair lacked arm rests and head rests. Only two students complained about the fit, reporting that the chair was too small.

When asked what they liked about the smaller standard chairs, the students primarily reported reasons related to comfort and fit, with only one response related to design and none related to aesthetics. Five students reported that the chair was comfortable. Other responses related to comfort were that it gave them "a place to sit" (n=3) and that they could reach their things (n=1). In terms of fit, four students reported that they liked the smaller chair because it was the right size and two liked that their feet reached the ground. Seven students reported that they did not like the smaller standard chair due to musculoskeletal discomfort including neck, back, and bottom pain. Other reported issues related to discomfort included that the chair was hard (n=4) and that it shocked them (n=1). Six students reported that they did not like the fit of the smaller standard chairs as it was not wide enough, too small, or their feet did not reach the ground. Five students did not like design aspects of the smaller standard chair including that it wiggles, tips over, and lacks armrests or a cushion. Aesthetically, one student did not like the color of the chair.

Finally, when asked to report what they liked about the ergonomic chair, students primarily reported comfort and fit responses, but also liked design and aesthetic elements. Four students reported that the ergonomic chair was comfortable. One student liked the back support of the chair and three liked that it did not shock them and gave them "a place to sit." In terms of fit, five students reported that the chair was the right size and four liked that their feet could reach the ground. Five students liked the design feature of the flexible backrest. Aesthetically, two students liked the ergonomic chair because it was not like the other chairs and it was "cool."

The students reported a number of reasons that they did not like the ergonomic chairs. Five students reported that the chair was too small, and four reported that it was uncomfortable. Three students did not like the design of the flexible backrest and one student reported that it was ugly.

Chapter V

Discussion

This study assessed person-environment, environment-occupation, person-occupation, and person-environment-occupation interactions by examining the impact of classroom furniture size and type on various areas of occupational performance including sitting behaviors, on-task behaviors, standardized math test scores, and handwriting legibility. Other variables assessed included fit potential, number of position changes, and student comfort within different sizes and types of chairs. Two experiments measured occupational performance when students sat in large standard classroom chairs, smaller ergonomic chairs, and smaller standard chairs. This discussion describes limitations of the study and addresses the findings for each hypothesis for both Experiment 1 and 2. Interpretations and implications of the findings are discussed, as well as recommendations for future research.

Limitations

The data for this study were collected within a third grade classroom in a local elementary school over the course of six regular school days. While efforts were made to control the environment to allow for valid and reliable data collection procedures, collecting data within a real-life context limited the amount of control possible. For example, because classroom tasks varied on different data collection days, the demands on the students may have been different during some or all of the data collection days, thus affecting students' behaviors and occupational performance. Also, it was not possible to control for the number of students who were actually present during a given data collection day due to absences or other factors such as trips to the bathroom or to the school nurse. While all of these factors resulted in threats to the internal and external validity of the study, the resulting data provides a reflection of the students' overall behaviors and occupational performance within the context of a third grade classroom.

The results of this study may also be limited by factors related to the outcome measures, data collection techniques, study design, and procedures. One possible limitation of the study is that three primary outcome measures -- fit potential, sitting behaviors, and on-task behaviors -- relied on observational data, which is at risk for experimenter bias. The primary investigator was aware of the purpose of the study, so some of her observational data could reflect experimenter bias. In an effort to reduce the potential for this effect, the research assistant was not informed of the hypotheses and was not fully aware of the purpose of the study, so her observations are less likely to have any biases. Furthermore, because interrater agreement was high for the majority of the observational data, the actual likelihood of experimenter bias is low. In addition to the limitations of the observational data, the handwriting legibility data were scored using a subjective method in which the handwriting samples were compared to models that represented different scores. Therefore, the scores assigned to the data collected for the study reflected the raters' judgments relative to the models. The research design attempted to control for this limitation by using the research assistant as an independent, blind rater, and by rating each sample blindly, without knowledge of the chair in which the sample was written. The high interrater agreement for the writing samples further strengthens the confidence in this outcome measure.

Another potential limitation relative to the handwriting data is that the types of handwriting samples used were different for some of the students. Differences in the demands of the writing assignments may have affected the quality of the children's handwriting, and thus affected handwriting legibility scores. However, this variability reflects the variability of writing demands within a typical classroom context, and therefore the writing samples collected for this study likely elicited students' typical handwriting abilities.

The study may also be limited by the repeated use of the Woodcock-Johnson math fluency subtest. While this test has strong test-retest reliability among 8, 9, and 10 year-olds, .89 when the children were re-tested the next day (Mather & Woodcock, 2001; McGrew & Woodcock) and .86 after one year (McGrew & Woodcock), there is still the possibility that increased math test scores found in this study were at least partially a result of maturation and familiarity with the test. Students took the math fluency test 18 days after the baseline condition and 8 days after the first furniture switch. Because the students attended math class everyday, it is likely that their math skills improved due to regular instruction. However, post-hoc analyses showed that while there was a significant difference between math test scores in the baseline condition compared to the two experimental conditions, there was no significant difference in math test scores between the two experimental conditions (see Figure 13). Therefore, while it is likely that maturation and test familiarity could have contributed to some of the variance in the difference between scores in the baseline condition and scores in the two experimental conditions, some of the variance was likely also due to the environmental manipulation, e.g., the better fitting furniture. Furthermore, test-retest correlations in this study were generally low with correlation coefficients of .300 between baseline test scores and scores during the first furniture switch, and .015 between the baseline condition and the second furniture switch. The correlation between test scores during the first and second furniture switch was moderate at .592, but much lower than the reported test-retest reliability of .86 and .89 thus suggesting repeated experience with the tests did not significantly affect subsequent test scores.

In addition to limitations of the outcome measures, the results of this study may also be limited by changes in data collection that affected the design after the study began. The initial design for Experiment 2 included assessing both handwriting legibility and the number of letters and words written within a 2-minute period, in order to determine whether children's writing output increased when they sat in smaller and/or ergonomic chairs. However, on the last day of the baseline phase, the classroom teacher indicated that the latter part of the plan was not feasible, as students began their written work at different times depending on when they finished their in-class reading. Several attempts were made to compensate for this change such as counting the total number of words written on in-class worksheets and student self-report questionnaires regardless of time spent writing, but these methods did not work because different types of worksheets were used on different days, and some students did not write on their questionnaires at all.

The other significant design change that may have affected the study's results was the decision to use only the 15" chairs during the experimental phases of the study instead of using both 15" and 13" chairs. The original plan for the study was to replace the 18½" baseline chairs with two sizes of standard and ergonomic chairs in order to accommodate different sized students. This design was based on the pilot study in which the majority of students fit in one size of chair while a small proportion required higher chairs. However, when the experimental chairs arrived in the classroom, it was immediately apparent that the 13" chairs were too low to fit at the tables with the 15" chairs, as the tables would either have to be positioned too low to fit the 15" chairs or too high to fit the 13" chairs. It was not possible to adjust some tables to fit only the 15" chairs and some tables to fit only the 13" chairs, because the students needed to remain at the tables at which they sat during the baseline phase, and each table had both smaller and larger students originally. In addition, while some students would have fit in the 13" chairs appropriately, most of the students objected that these chairs were too small and refused to sit in them. As a result, the 13" chairs were replaced so that all of the experimental chairs were 15" high, resulting in some students having only a fair fit in these chairs instead of a good fit. This change may have impacted the model being tested as some students were still not optimally fitted to their classroom furniture.

In addition to the impact on fit, the time between study phases was inconsistent between the baseline and first furniture switch, and the first and second furniture switch. Because additional 15" chairs had to be ordered to replace the 13" chairs, the time between the baseline phase and the first furniture switch was extended to 16 school days, while the time between the first furniture switch and the second furniture switch was 8 school days, as originally planned. The second switch was made after 8 school days instead of being extended to 14 to 16 days due to constraints of the school calendar including standardized testing and vacation days, which prohibited the study from being extended any longer. Therefore, the differences in outcome measures between the baseline condition and the two experimental conditions may have been due to maturation or other time-related factors, rather than due to the difference in furniture size. However, post-hoc analyses did not reveal any differences in outcome measures between the first and second furniture switches, thus indicating minimal to no maturational effect between these conditions.

Another potential limitation related to the study's design was the smaller than expected number of participants. The initial plan for the study assumed that a majority of the third graders would participate in the study, with an anticipated sample size of 65 students for Experiment 1 and 22 participants for Experiment 2. These sizes were projected from the pilot study in which 90% of the children in that grade participated, yielding a sample size of 66 students. However, the sample sizes in the current study were substantially smaller with 31 participants in Experiment 1 and 15 participants in Experiment 2, despite numerous attempts to recruit additional participants. Due to uncontrollable factors such as student absences or lack of participation in classroom activities, some data collection days included even fewer students, resulting in less data collected.

In addition to the design limitations, the study is also limited by procedural factors. First, the research assistant was not present for 10 of the 24 data collection periods, so some of the observational data reflect only the primary researcher's observations. However, the primary researcher and the research assistant maintained strong interrater agreement for observational data, as during the study, mean and median interrater agreement for on-task behaviors was 90%, and only one instance of interrater agreement for on-task behaviors fell below 85%. Therefore, the data are believed to be unbiased and reliable.

Another procedural limitation was the necessary presence of researchers within the classroom during data collection. It is possible that the observed sitting and on-task behaviors were influenced by the researchers' presence. This was not believed to be a significant factor because the researchers spent time in the classroom prior to the start of data collection and because other adults such as aides, parents, and student teachers were often present in the room as well. The students did not appear to be distracted by our presence.

Interpretations

Person-environment interaction. In this study, the person-environment interaction was examined by assessing students' fit, sitting behaviors, number of position changes, and comfort in different sizes and styles of classroom chairs. The hypothesis that there would be a significant relationship between greater fit potential and increased frequency of positive sitting behaviors was supported in both Experiments 1 and 2, as indicated by significant positive correlations between fit potential and sitting behavior scores. This finding is similar to that of Wingrat and Exner (2005) in which students used better sitting behaviors when seated in smaller chairs in which their feet reached the floor. This finding was expected in the current study because the two measures were highly correlated as the criteria for positive sitting included having feet flat on the floor, while the criteria for a good fit included ability to have one's feet on the floor when sitting upright. Therefore, if a child was fitted well to his or her chair, he or she was likely to receive a positive sitting behavior score as long as their sitting behaviors did not appear awkward. Because being properly fitted in a chair allowed the students to place their feet on the floor, they were able to assume and maintain more natural sitting positions.

Another hypothesis related to the person-environment interaction was that children would demonstrate significantly better sitting behaviors/postures when seated in appropriately sized chairs and tables compared to when they sat in larger standard chairs. Although sitting behaviors were generally low overall, this hypothesis was supported for both Experiments 1 and 2, as students sitting behavior scores were significantly higher when they sat in chairs that fit them better. Similar results have been reported in other studies including Knight and Noyes (1999), and Wingrat and Exner (2005). In the current study, the students were able to naturally assume and use better sitting postures without any external feedback such as verbal cues or direct instruction to do so. This finding suggests that school-aged children are able to use good sitting behaviors/postures in response to the environmental cue provided by an appropriately sized chair. The finding also supports the PEO principle that the most effective way to facilitate successful participation is to enhance the fit between the person and his or her environment (Law et al.).

In addition to the positive correlation between fit potential and positive sitting behaviors, the study also found that students demonstrated the best sitting behaviors when seated in the ergonomic chairs with either a fair or a good fit, compared to sitting behaviors observed when students sat in the smaller standard chairs with a good fit. While Knight and Noyes (1999) recommended that students might need instruction in how to sit in an ergonomic chair, the students in the current study were naturally able to demonstrate better sitting behaviors without any instruction. This finding supports the function of the ergonomically designed chairs in promoting better sitting behaviors as compared to chairs with non-ergonomic designs.

The hypothesis that children would report greater comfort when seated in appropriately sized chairs was not supported for either Experiment 1 or 2. In both experiments, children tended to report the same degree of comfort despite the type of chair or their fit in the chair. Several possible reasons may have contributed to the lack of difference in self-reported comfort. The first is that students' fit in their chairs simply did not affect whether or not they were comfortable. Another possibility is that the wording of the question affected students' reporting of comfort, because the question simply asked, "Is your chair comfortable?" Perhaps the question should have been more specific to ask, "Are you comfortable sitting in you chair?" Furthermore, several students reported that their chair was too hard or too small even though the chair was appropriately-sized; therefore, their perception of comfort likely did not reflect issues of fit.

Another reason for the lack of a significant relationship between fit and self-reported comfort is that the questionnaire may not have been a reliable or valid measure of comfort. In a number of cases, students who circled "no" in response the question "is your chair comfortable" then wrote that they liked the chair because it was comfortable, or vice versa. Furthermore, it is possible that 8 and 9-year-old children are not able to accurately rate subjective comfort on any questionnaire, as suggested by Panagiotopoulou et al. (2004) who found that older students reported higher levels of musculoskeletal discomfort than did younger students, due to the younger students inability to associate discomfort with their sitting position.

Person-occupation interaction. This study examined the person-occupation interaction by assessing students' on-task behaviors while they sat in different sizes and types of classroom chairs while in math and language arts classes. Two previous studies reported that students demonstrate increased on-task behaviors when seated in appropriately sized furniture (Knight & Noyes, 1999; Wingrat & Exner, 2005). The results of Experiment 1 supported the hypothesis that children demonstrate increased attention to task when seated in appropriately sized chairs and tables compared to when they sat in larger standard chairs and tables. However, this hypothesis was supported only for students in math classes. Experiment 2, did not support the hypothesis for children who were assessed in language arts classes.

Variation in characteristics and demands for the two types of classes may have contributed to the different outcomes for Experiments 1 and 2. First, Experiment 2 had a much smaller sample size than did Experiment 1. However, the on-task effect had adequate power so increasing the sample size would not likely have contributed to a significant effect. Second, the on-task behaviors of students in Experiment 1 were observed while students were in math classes. Students were assigned to their math class based on skill level, so students within a given math class were believed to comprise a relatively homogenous group. The demands of each of the three math classes required the students to be seated at their tables while working on hands-on math activities or calculating math problems appropriate for the skill level of the given class. In Experiment 2, the students were observed in their language arts class, which was comprised of a heterogeneous group of students based on their homeroom. During language arts class, students were expected to read independently at their tables and then complete worksheets related to their reading. Readings included books and poems assigned and distributed by the teacher, so that all students read the same material. Therefore, students at different reading levels may have had difficulty remaining on task if the reading level was too challenging or too easy for an individual child's skill level. In such cases, changing elements of the environment by providing better fitting furniture may not be a strong enough manipulation to affect the person-occupation interaction as indicated by students' on-task behaviors.

E*nvironment-occupation interaction.* The environment-occupation interaction was assessed by comparing students' occupational performance when they sat in ergonomic chairs instead of standard classroom chairs. Previous studies have reported increases in on-task behaviors and sitting behaviors (Knight & Noyes, 1999; Wingrat & Exner, 2005), handwriting legibility (Parush, Levanon-Erez, & Weintraub, 1998) and self-reported comfort (Murphy et al., 2004; Linton et al., 1994) when students sat in ergonomic chairs compared to when they sat in standard chairs. None of those studies compared standardized test scores in ergonomic versus standard chairs. In the current study, the hypotheses that students would demonstrate more on-task behaviors, better sitting behaviors, higher math fluency scores, better handwriting legibility, and higher self-reported ratings of comfort when seated in ergonomic chairs was only supported for sitting behaviors. There were no significant differences for the overall sample for on-task scores, math test scores, handwriting legibility, or self-reported comfort when students sat in the ergonomic chairs compared to when they sat in the standard chairs. In the previous studies in which differences were found between on-task behaviors, handwriting legibility, and/or comfort when students sat in ergonomic chairs and standard chairs, the two types of chairs were not similar in size, such that differences may have been due to chair size instead of design.

In this study, the only significant difference that was found when students sat in ergonomic chairs compared to smaller standard chairs was an increased incidence of positive sitting behaviors. This finding is not surprising because the ergonomic chairs were designed to promote good sitting postures, while the design of the standard chairs tends to encourage a posterior pelvic tilt and rounded or kyphotic back and shoulders, both of which were included as criteria for negative sitting. While there was no statistically significant relationship between sitting in ergonomic chairs and improved handwriting legibility, half of the students in Experiment 2 demonstrated improved handwriting legibility when they sat in the ergonomic chairs compared to their baseline legibility. This finding is similar to the findings of Parush et al. (1998) and Parush, Levanon-Erez, and Weintraub (1998) who reported correlations between sitting posture and body positioning with handwriting legibility, and suggests a positive impact on the environment-occupation interaction of writing while seated in an appropriately sized ergonomic chair.

Another finding related to the person-occupation interaction was that there was no significant relationship between chair type and on-task behaviors. While two previous studies reported increased on-task behaviors when students sat in ergonomic chairs compared to standard chairs (Knight & Noyes, 1999; Wingrat & Exner, 2005), neither of those studies compared ergonomic chairs to same-sized standard chairs. The finding of the current study indicates that providing students with appropriately sized chairs and tables may support the ability to attend to classroom tasks, regardless of whether the chair is standard or ergonomic in design. Furthermore, because there was a significant positive correlation between sitting behavior and on-task behavior, children are likely to demonstrate better on-task behaviors when sitting in chairs that provide the best fit and promote optimal sitting.

P*erson-environment-occupation interaction.* The PEO model defines the person-environment-occupation interaction in terms of a person's occupational performance (Law et al.). In this study, the person-environment-interaction was assessed based on students' scores on a standardized math test as well as their handwriting legibility as related to interaction between person variables, environment variables, and occupation variables. The results of Experiment 1 support the hypothesis that children will demonstrate higher math test scores when seated in appropriately sized chairs and tables than when seated in larger standard classroom chairs and tables. In addition, there was a significant positive correlation between fit potential and math test score. The finding that children performed better on a math test when seated in furniture that fit them better along with the findings of other studies such as Sents and Marks (1989), Parush et al. (1998), Parush, Levanon-Erez, and Weintraub (1998), and Smith-Zuzovsky and Exner (2004), support the PEO principle that changing elements of the environment is an effective method to facilitate occupational performance.

Despite the findings that chair size and fit positively affected math test scores, there was no overall difference in math test scores between the ergonomic and smaller standard chairs. However, score ranges appeared different for the different chairs suggesting that the ergonomic chairs may have at least some impact on math test scores for some of the participants. The highest scores for boys occurred when they sat in the ergonomic chairs compared to when they sat in the smaller standard chairs or the baseline chairs. In addition, the minimum score for boys was higher while seated in the ergonomic chairs when compared to the minimum scores for boys in both the smaller standard chairs and the baseline chairs. It is unclear what additional factors contributed to these outcomes, but the findings suggest that for some students, sitting in ergonomic chairs may contribute to improved standardized math test scores.

While the hypothesis that children will demonstrate improved handwriting legibility when seated in smaller chairs and tables was not supported overall, there was a significant positive correlation between sitting behavior and handwriting legibility. This finding suggests an indirect relationship between chair size and handwriting legibility, due to the significant relationship between chair size and sitting behavior. That is, while the smaller chairs did not directly affect improved handwriting legibility, the person-environment interaction may have affected the occupational performance of handwriting legibility, as children sat better in the appropriately sized chairs and demonstrated subsequent improvement in legibility. While other factors such as maturation or differences in writing demands may have contributed to this finding, the interaction is similar to the findings of Schilling et al. (2003) who reported that students who sat on therapy balls demonstrated improved handwriting legibility. The improved handwriting legibility reported in the study by Schilling et al. was likely due in part to a person-environment interaction as the balls provided sensory input, which helped to maintain an optimal arousal level needed for successful task performance. In the current study, sitting in smaller chairs and thus sitting better may have similarly improved the students' arousal level, which contributed to better task performance as measured by handwriting legibility.

While overall the students did not demonstrate better handwriting legibility when seated in the ergonomic chairs, a small group of boys scored significantly higher on handwriting legibility when seated in the ergonomic chairs than when seated in the smaller standard chairs. Boys also scored significantly higher on handwriting legibility when their fit potential was fair or good compared to when it was poor. These findings suggest that the person-environment and environment-occupation interactions affected these boys' occupational performance, as sitting in better fitting, ergonomically designed chairs contributed to better handwriting legibility for this group. That is, some boys may be more amenable to the enhanced environmental support that is provided by sitting in a better fitting chair and/or a chair with ergonomic features.

Environmental docility. This study assessed principles of Lawton's theory of environmental docility by comparing the effect of environmental support on the occupational performance of children with lower average skills to children with higher average skills. The results did not support the hypothesis that students with lower baseline math skills would demonstrate greater improvements compared to students with highest baseline skills. There are several possible explanations for the lack of significant findings. The first possibility is that while there were children with different skill levels, the differences between the children were minimal. Furthermore, because all of the students were typically developing children without known physical or developmental disabilities, those with the lower baseline skills did not have impairments that required significant environmental intervention such as enhancing environmental support through seating and positioning. Finally, it is possible that two weeks was not enough time for a significant change to occur among the lower baseline performing students relative to students with higher baseline skills.

In addition, the results of these experiments did not support the hypothesis that students with the lowest baseline handwriting legibility scores would demonstrate greater improvements with changes in furniture as compared to students with the highest baseline handwriting legibility scores. The mean handwriting legibility scores for students with the lowest baseline legibility were an average of 10 points higher when the students sat in both types of smaller chairs; mean legibility scores for those with the highest baseline legibility increased 5 to 6 points (see table 12). One possible explanation for the lack of significant differences is due to the low variability among the groups. Also, the number of students in the low scoring group and high scoring group was very low. It is also possible that not enough time had passed to allow for students to master improvements in handwriting legibility associated with their improved sitting behaviors.

Despite the lack of significant findings for the group of students with lowest baseline scores and the students with highest baseline scores, the finding that the small group of boys scored significantly higher on handwriting legibility when seated in the ergonomic chairs may lend some support to Lawton's principles. That is, as an initially low-scoring group, the boys demonstrated greater improvements in handwriting legibility when seated in the ergonomic chairs than did the girls who were an initially high-scoring group. This finding is similar to that of Burkhart (1999) who found that students with lower baseline scores on a visual motor test performed better on a handwriting legibility assessment when properly positioned compared to students who were poorly positioned.

This finding along with the current study's finding may lend some support to the principle of environmental docility, as the boys may have achieved more benefit from the environmental support of the ergonomic chairs than did the girls who were in less need of support.

Implications/Recommendations for Practice

Schoolchildren. The results of this study have implications for third grade schoolchildren who spend much of their day seated at tables in their classrooms. In Experiment 1, students demonstrated better sitting behaviors, on-task behaviors, and higher standardized math test scores when they sat in the smaller furniture that fit their size better. Children in Experiment 2 also demonstrated improved sitting behaviors in the smaller sized furniture, and improved sitting was positively correlated with better handwriting legibility. Therefore, this study of a small group of third grade children suggests that their overall occupational performance as indicated by sitting posture, attention to task, math test scores, and handwriting legibility was better when they sit in furniture that fit their size. In addition to being important relative to these aspects of occupational performance, these findings may have significant implications for supporting the overall well-being of schoolchildren, as successful occupational performance is important for providing a sense of achievement, mastery, and competence (Law et al., 1996).

Based on the findings that these students' occupational performance was supported and enhanced by sitting in furniture that fit them better, recommendations that classroom environments in which children sit to engage in school-related tasks should be equipped with appropriately sized/well-fitting furniture can be made with greater confidence. In schools, classrooms, libraries and computer labs, should be furnished with appropriately sized desks, tables, and chairs in order to enhance the fit between students and their school furniture. In addition, these findings suggest that enhancing children's workspaces at home with appropriately sized furniture is likely to be important as well.

School administrators. The results of this study may be used to influence school administrators due to the evidence that student performance in the classroom can be affected by furniture. Because public schools are mandated by No Child Left Behind (NCLB) to demonstrate accountability and to use proven education methods to meet state standards via standardized testing (USDE, n.d. a), the findings of this study suggest a method that may contribute to higher math test scores. This study's findings that students demonstrated improved math test scores and improved on-task and sitting behaviors when they sat in furniture that fits supports recommendations to school administrators for adjustable and appropriately sized and fitted classroom furniture

School administrators can use the findings of this study to select classroom furniture and support teachers in addressing the fit of their students to their classroom furniture. Administrators can also support research within their own school environments to further explore the impact of classroom furniture size, type, and fit on academic performance and related issues.

Occupational therapists and occupational scientists. The results of this study can be used to influence the role of occupational therapists and occupational scientists in schools and other clinical settings. In school-based settings, occupational therapists can use the findings from this study to address the occupational performance of all students within any classroom, in addition to providing direct treatment for children with diagnosed disabilities. Specifically, occupational therapists can consult with students, parents, teachers, and school administrators to recommend optimal seating for students at home and in school in order to maximize students' overall occupational performance. Occupational therapists can recommend adjustments or modifications for existing classroom furniture and implement adaptations when appropriately sized furniture is unavailable by using and creating footrests, back supports, and seat cushions for chairs that are too high and/or too deep.

Occupational scientists can use the results of this study to can collaborate with other health professionals in clinical settings, such as speech language pathologists, physical therapists, and psychologists, to recommend optimal seating during testing and treatment to support performance and enhance skill development. Additionally, occupational scientists can consult with furniture manufacturers about optimal design and height of adjustable school furniture to support healthy sitting postures and successful performance of school-based tasks. Occupational scientists can also play an important role in classrooms, schools, clinics, and homes by recommending and designing optimal workstations within these environments. Both occupational therapists and occupational scientists can offer inservices and workshops to teachers, principals, colleagues, parents, and students regarding furniture size and ways to enhance fit.

Theoretical models. The results of this study support occupation-based models and occupational scientists' understanding of the significance of the environment on the occupations of schoolchildren. Specifically, this study provides evidence to support the PEO principles that environmental features can be used to enhance or inhibit occupational performance and that occupational performance is enhanced by maximizing the fit between the person, the environment, and the occupation (Law et al., 1996). In this study, providing classroom furniture that fit the students better, thereby maximizing the fit between students and their classroom environment, enhanced areas of children's occupational performance by targeting the environment element of the model. The findings that students demonstrated improved sitting behaviors, improved on-task behaviors, better handwriting legibility, and improved standardized math test scores when seated in chairs that fit them better, supports the application of the PEO principles to improve occupational performance. Furthermore, the results of this study specifically support the principle that occupational performance can be enhanced by changing elements of the environment and supports the application of this principle in a group situation, where one type of environmental intervention successfully affected the class of students overall. This evidence further supports occupational therapists' and scientists' role in designing classroom furniture and helping to set-up classrooms to best support all students' occupational performance.

The implications of this study for Lawton's (1980) Theory of Environmental Docility are less strong then the implications for PEO. This study did not directly support Lawton's principle that the environment most significantly affects those with lower skill levels, as in this sample of children without known disabilities, there were no differences in the performance of students with highest and lowest baseline math test scores or handwriting legibility. However, the impact on boys' handwriting legibility appeared to be greater than it was for girls, thus suggesting some support for Lawton's principle. The overall finding that children's classroom occupational performance was enhanced by facilitative changes in the environment lends some support to the application of Lawton's theory among schoolchildren, by demonstrating that changes in the environment can enhance a person's success within that environment.

Policies affecting schools. Finally, the findings of this study have implications for policies related to classrooms and schools, particularly the NCLB law which mandates accountability and use of proven education methods to meet specified state standards, primarily regarding standardized testing (USDE, n.d. a). Specifically, the findings that standardized math test scores for the students in this study were significantly higher when they sat in classroom furniture that fit their sizes better, provides preliminary evidence for a potential method to improve student performance. While the findings may have been affected at least in part to maturation effects, these findings can generate additional research and can be used by public schools to address and attend to the size of the furniture used in their classrooms or other testing situations. Occupational therapists and occupational scientists can use the results of this study as a guide to apply principles from PEO to address the furniture needs in public schools.

In addition to the implications for NCLB, this study also has implications for enhancing children's access to education and occupational therapy services provided under IDEA (USDE, n.d. b). That is, in addition to their roles in providing direct and indirect services to children with disabilities, occupational therapists and occupational scientists have a role in creating classroom environments that support all students' needs, not only those with special needs. Occupational therapists and scientists can use principles of PEO to provide all students with classroom furniture and environmental designs that best support their successful occupational performance in the classroom.

Application of Findings

As described above, one implication of this study is for occupational therapists and occupational scientists to use the findings in consulting with parents, teachers, and school administrators to improve the sitting environments in their schools and homes. In February 2007, the primary researcher met with a group of parents during a Parent Teacher Association (PTA) meeting at the school where the study was conducted to review the study and provide recommendations to address their children's seating at home and in school. Seventeen parents including the PTA president, one teacher, and the assistant principal attended the meeting in the school's library. The presentation had four primary objectives: (a) introduce issues of furniture size, type, and fit; (b) identify and describe "good" and "poor" fit, and "good" and "poor" sitting behaviors; (c) review and discuss the current study and relevant findings; and (d) identify, discuss, and demonstrate methods to improve children's fit in their furniture at home.

During the presentation, the primary researcher presented information about seating issues including a review of the findings of related studies and pictures of children seated in poorly fitting furniture, and then summarized the current study including information about procedures and findings (Appendix H). Following the summary of previous and current studies, the primary researcher distributed a tip sheet for healthy sitting (Appendix I) and presented practical recommendations to improve children's fit in their furniture, such as using footstools to provide support when chairs are too high. Examples of footstools included actual footstools as well as other solutions including a plastic milk crate, small plastic storage bins, and a shoebox stuffed with newspaper for support. The primary researcher also demonstrated the use of a rolled towel to provide back support in chairs that are too deep and using folded towels or seat cushions to elevate sitting height for high tabletops.

During the presentation, several parents were observed to look at the furniture in the library, and at least one parent noted aloud that the table and chairs in which they were sitting were adult-sized rather than child-sized. Several of the parents commented that they were unable to place their feet flat on the floor. The teacher confirmed that all grades of schoolchildren use the tables and chairs during library activities. Many of the parents then expressed concern about how the large furniture in the library may affect their children, since the furniture was clearly too large for an elementary school child. Several parents also noted that their children typically do homework in adult-sized furniture, such as at the kitchen table. Many of the parents indicated that they intended to modify their children's seating environments at home.

In addition to their concerns about the size of the furniture in the library, a number of the parents expressed concerns about the size of the furniture in their children's classrooms within the school. The primary researcher reiterated that the purpose of the presentation was to raise their awareness of the topic and to provide practical recommendations, as they are likely to encounter poorly fitting furniture in many environments in which their children participate. In addition, the primary researcher also reassured the parents that many classrooms at the school have more appropriately sized furniture, due in part to the school's support of and cooperation with this study and several previous studies. The primary researcher discussed recommendations for modifications within the schools' classrooms if needed, such as using large building blocks or extra storage bins for foot support in chairs that may be too big.

At the conclusion of the presentation, the parents were asked to informally evaluate the presentation by stating what information they found to be helpful and to describe if and how they would implement the recommendations. The parents in attendance all agreed that they had never previously considered issues of furniture size or fit at home or school. All of the parents stated that they planned to implement at least some of the suggestions provided in the presentation. Some examples of their plans to implement the suggestions included improving their children's fit in their furniture at home by using bathroom footstools that their children had outgrown, using overturned milk crates or storage bins, and buying footstools. Many parents also stated that they planned to use rolled towels and/or pillows to enhance back support in larger chairs while their children did their homework. Several parents stated that they would move their small child-sized tables out of their playrooms/play areas to use for homework time. Overall, the parents reported to be very satisfied with the presentation and noted that the information was very relevant, practical, and useful. The president of the PTA verbally reported that all of the objectives had been met effectively.

Recommendations for Future Research

In this study, several areas of occupational performance of third grade students were better when the students sat in more appropriately sized classroom furniture compared to when they sat in furniture that was too large. The findings suggest a number of areas for future research, including those that relate to this study's constraints, which affect its generalizability. First, future studies with a similar design are needed to determine whether the findings are replicated among additional samples of children. Additional studies can include similar-aged children from different geographical areas along with children in different grade levels including middle schools. In addition, studies on the impact of furniture size and type on students diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and sensory processing disorders are needed to determine whether environmental interventions can facilitate improved occupational performance among these children.

Future studies should also assess the impact of furniture size and type on additional variables and performance areas. Writing productivity in addition to handwriting legibility is an important area to assess relative to the impact of different sizes and types of chairs on children. Similarly, research assessing the number of math problems completed on math tests in addition to math test scores in order to explore the impact of different sizes and types of chairs further. Future studies could also compare students' performance on the School Assessment of Motor and Process Skills (AMPS) while seated in different sizes and types of furniture. Studies should also assess the impact of differences in chair seat depths and use of desks versus tables. In addition, future studies should assess furniture fit more closely, by matching each child to his or her furniture instead of using only one or two sizes for all of the children. It would also be interesting to compare standard tabletops to angled table or desktops, especially relative to the impact on motor skills such as handwriting legibility and productivity. Studies in which gender differences are more thoroughly assessed are needed as well.

In addition, studies should use enhanced or varied designs. Students could be videotaped during class periods in order to allow for independent rating and the collection of more comprehensive data on the observational variables including sitting behaviors, on-task behaviors, and number of position changes, during a longer time duration. Students' performance in larger and smaller chairs could be compared simultaneously in order to reduce the potential for maturational effects.

Further research is also needed to assess Lawton's principles with children, in order to determine if his principles can be successfully applied to enhancing environments to optimize occupational performance for children in schools. In order to better compare the impact on students with different skill levels, future studies should compare more homogeneous groups such as groups of children that are pre-tested or classified with above average and below average skills.

Conclusion

This study assessed person-environment-occupation interactions by examining the impact of classroom furniture size and type on the occupational performance of third grade children. Two experiments compared third graders' classroom-based occupations and areas of occupational performance, including sitting behaviors, on-task behaviors, standardized math test scores, and handwriting legibility, as well as person-environment factors of fit potential, position changes, and comfort when students sat in large standard classroom chairs and tables, and smaller ergonomic and standard chairs and tables. Experiment 1 included 31 third graders in three math classes and assessed the impact on math test scores. Experiment 2 included a subgroup of 15 students from Experiment 1 and assessed impact on handwriting legibility.

Overall, students demonstrated better sitting behaviors when seated in appropriately sized chairs and tables than when seated in larger standard classroom chairs and tables. Sitting behaviors were even more improved when students sat in smaller ergonomic chairs compared to both smaller and larger standard chairs, and there was a significant positive moderate correlation between fit potential and sitting behaviors, regardless of chair type. In addition, students in Experiment 1 demonstrated increased attention to task, as indicated by increased on-task behaviors, and higher math test scores as reflected on higher scores on a standardized math test when seated in smaller furniture compared to when they sat in standard classroom furniture that was too large. Significant positive correlations were found between furniture size and type with sitting behaviors, fit potential and furniture size with math test scores, and sitting behaviors with handwriting legibility. Findings were not significant for furniture size and type with handwriting legibility or comfort. There were no significant relationships between fit potential or chair type with on-task behavior, or between comfort with math score or handwriting legibility.

Many studies on classroom seating and positioning issues recommend the use of ergonomic chairs to promote improved sitting and to support musculoskeletal health. While this study found that students sat better in ergonomic chairs, there were no significant relationships between self-reported comfort or musculoskeletal complaints and chair size or type. In fact, the majority of the students preferred the smaller standard chairs to the smaller ergonomic chairs. Overall, these findings suggest that as long as the child fits well in his or her chair, having an ergonomic design may not be important to facilitate optimal occupational performance.

Despite some unexpected limitations, the results of this study support the principles of the PEO model and suggest that it is important for schoolchildren to sit in appropriately sized classroom furniture. Therefore, occupational therapists and occupational scientists can use the findings of this study to apply PEO principles in evaluating classroom environments and recommending environmental interventions to maximize students' occupational performance. School personnel including teachers, principals, and administrators can use the findings to support decisions regarding classroom furniture by choosing adjustable furniture and providing different sizes of chairs to accommodate different sizes of students. Overall, this study demonstrates that enhancing the person-environment interaction by providing schoolchildren with furniture that fits their size, leads to improved performance in a primary area of children's occupations, classroom-based tasks. Future research is still needed to support and confirm the generalizability of these findings.

APPENDICES

Appendix A

Parental Consent Form for Experiment One

January 2006

Dear Parent,

I am a doctoral candidate at Towson University and I am conducting a research study on the impact of school furniture on children's performance in the classroom. The purpose of this study is to determine whether children are better able to focus on classroom tasks, to sit more naturally, and perform better on test taking while seated in chairs and tables that fit their size, compared to furniture that may be too large for them. Therefore, I am writing to request your permission for your child's participation in the study.

Children who participate in this study will be observed during their math class six times in January, February, and March of this school year. First, the children will be observed while in their regular classroom furniture and I will record whether they appear to be paying attention to the classroom task and if they are using a natural sitting posture. The students will be given a basic math skills test and will also be asked to complete a survey about their classroom furniture. Then, the classroom furniture in their math classroom will be replaced with two types of smaller chairs and lower tables that are better-sized for 3rd graders. The children will be observed again in the new furniture. Each child will have the opportunity to sit in each type of chair, and will complete the math skills test and survey after they sit in each type of chair. When all of the observations are completed, statistical analyses will determine whether children are able to pay attention and sit better in different types of furniture. I will also compare their scores on the math skills test taken in the different types of furniture, and look for differences between boys and girls, and older and younger students.

Please note that participation in this study is completely voluntary. The anonymity of those students who are participating will be ensured, as codes will be used on the observation forms instead of names, and only group results will be reported. When the study is finished, a summary of the group results will be available to all interested parents and teachers. The results of this study have the potential to provide important information about ways to promote success in school for all children. Also, the results may be considered in making furniture-purchasing decisions for this school in the near future.

If you have any questions, please call me at (410) 542-8085. You may also contact my advisor, Dr. Charlotte Exner, Dean of the College of Health Professions at (410) 704-4330 or Dr. Patricia Alt, Chairperson of the Institutional Review Board for the Protection

Appendix A (Cont.)

of Human Participants at (410) 704-2236. Thank you in advance for your participation and support.

Sincerely,

Jennifer K. Wingrat, MS, OTR/L
Doctoral Candidate
Department of Occupational Therapy and Occupational Science
Towson University

Please indicate whether or not you wish to have your child participate in this project by checking a statement below and returning to your child's teacher by January 13.

___ My child __________________________ may participate in this project

___ My child __________________________ may not participate

___ Please have child check here to provide his or her agreement

________________________________ ________
Signature of Parent/Guardian Date

Please provide the following demographic information. This information will be used only to describe the whole group and to compare gender and age differences.

Gender M F

Age on last birthday __________________ Date of Birth ____________

Appendix A (Cont.)

Parental Consent Form for Experiment Two

TOWSON UNIVERSITY

January 2006

Dear Parent,

I am a doctoral candidate at Towson University and I am conducting a research study on the impact of school furniture on children's performance in the classroom. The purpose of this study is to determine whether children are better able to focus on classroom tasks, to sit more naturally, and perform better on handwriting and test taking while seated in chairs and tables that fit their size, compared to furniture that may be too large for them. Therefore, I am writing to request your permission for your child's participation in the study.

Children who participate in this study will be observed during language arts and math class six times in January, February, and March of this school year. First, the children will be observed while in their regular classroom furniture and I will record whether they appear to be paying attention to the classroom task and if they are using a natural sitting posture. The students will be given a basic math skills test and will also be asked to complete a survey about their classroom furniture. Then, the classroom furniture in their homeroom classroom will be replaced with two types of smaller chairs and lower tables that are better-sized for 3rd graders. The children will be observed again in the new furniture. Each child will have the opportunity to sit in each type of chair, and will complete the math skills test and survey after they sit in each type of chair. When all of the observations are completed, statistical analyses will determine whether children are able to pay attention and sit better in different types of furniture. I will also compare their handwriting on language arts class work and scores on the math skills test taken in the different types of furniture, and look for differences between boys and girls, and older and younger students.

Please note that participation in this study is completely voluntary. The anonymity of those students who are participating will be ensured, as codes will be used on the observation forms instead of names, and only group results will be reported. When the study is finished, a summary of the group results will be available to all interested parents and teachers. The results of this study have the potential to provide important information about ways to promote success in school for all children. Also, the results

Appendix A (Cont.)

may be considered in making furniture-purchasing decisions for this school in the near future.

If you have any questions, please call me at (410) 542-8085. You may also contact my advisor, Dr. Charlotte Exner, Dean of the College of Health Professions at (410) 704-4330 or Dr. Patricia Alt, Chairperson of the Institutional Review Board for the Protection of Human Participants at (410) 704-2236. Thank you in advance for your participation and support.

Sincerely,

Jennifer K. Wingrat, MS, OTR/L
Doctoral Candidate
Department of Occupational Therapy and Occupational Science
Towson University

Please indicate whether or not you wish to have your child participate in this project by checking a statement below and returning to your child's teacher by January 13.

___ My child __________________________ may participate in this project

___ My child __________________________ may not participate

___ Please have child check here to provide his or her agreement

___________________________________ _________
Signature of Parent/Guardian Date

Please provide the following demographic information. This information will be used only to describe the whole group and to compare gender and age differences.

Gender M F

Age on last birthday ____________________ Date of Birth _____________

Appendix B

Operational Definitions of Terms

On-Task Behaviors:

- Attending to teacher or task
- Body and gaze oriented to appropriate materials (i.e., reading, facing blackboard, etc.)
- Manipulating learning aids
- Eye-contact with teacher or task
- Following instructions
- Raising hand/ answering a question or offering relevant information

(Lack of these behaviors = "-" task)

Positive Sitting Behaviors:

- Elbows or forearms resting on desk in forward working position
- Feet on floor or foot rest, or legs crossed at knees or ankles
- Buttock in contact with at least half of the chair
- Contact with backrest when in listening position

Negative Sitting:

- Upper body laying on desk/table top
- Less than half of buttock in contact with chair - i.e., sitting on knees or on one leg bent under buttocks, etc.
- Standing (unless directed by teacher)
- Trunk twisted
- Frequent position changes – i.e., a shift from one sitting position (as defined above) to another different position
- Other awkward positioning (describe)

Comfort:

- Mean combined score on student survey questions 4-6

Appendix C ______________________

Student Self-Report

Please answer the following questions:

1. Is your chair comfortable? (circle one) Yes No

2. Describe what you **like** about your chair:

____

____

____

3. Describe what you **don't like** about your chair:

____

____

____

4. How often do your back or shoulders hurt when sitting in your chair? (circle one)

Never Hardly Ever Sometimes Often Every Day

5. How often does your neck hurt when sitting in your chair? (circle one)

Never Hardly Ever Sometimes Often Every Day

6. How often do your legs or feet fall asleep when sitting in your chair? (circle one)

Never Hardly Ever Sometimes Often Every Day

Appendix D

Woodcock-Johnson III Handwriting Legibility Scale

(Mather & Woodstock, 2001, p. 143)

Appendix D (Cont.)

(Mather & Woodstock, 2001, p. 144)

Appendix D (Cont.)

(Mather & Woodstock, 2001, p. 145)

Appendix D (Cont.)

(Mather & Woodstock, 2001, p. 146)

Appendix E

Woodcock-Johnson III Math Fluency Test

(Woodstock , McGrew, & Mather, 2001, p. 93)

Appendix E (Cont.)

(Woodcock, McGrew, & Mather, 2001, p. 94)

Appendix F

IRB Approval

Appendix G

Data Analyses and Model Testing

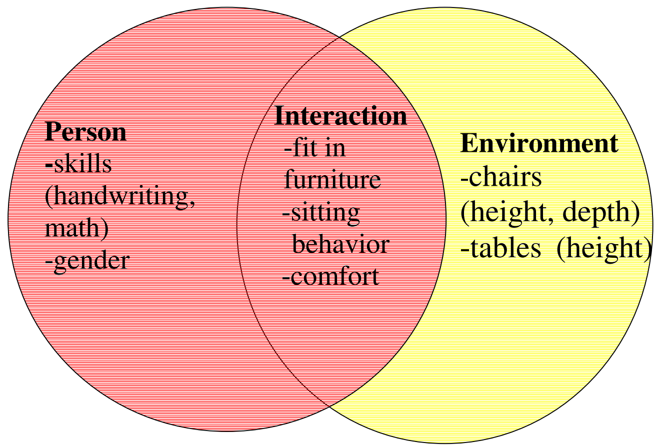


Figure G1. *Person-Environment Interaction: Fit in Furniture, Sitting Behavior, and Comfort by Furniture Size and Type*

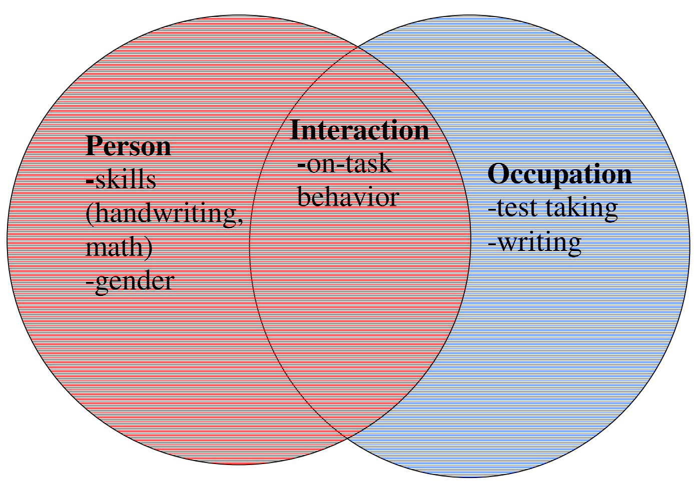


Figure G2. *Person-Occupation Interaction: On-Task Behavior by Skills and Gender*

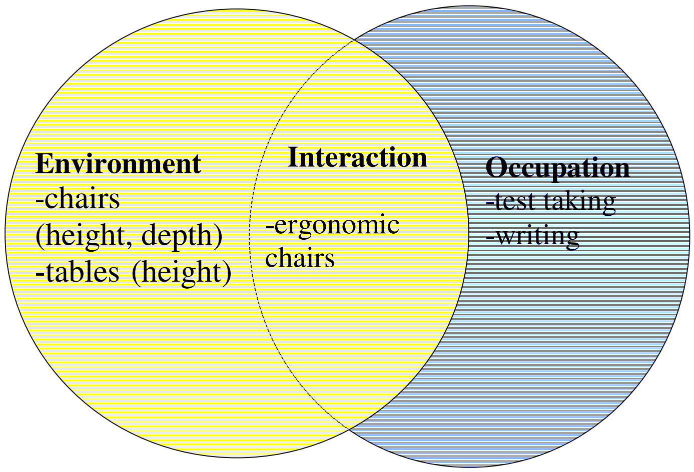


Figure G3. *Environment-Occupation Interaction: Occupational Performance by Chair Type*

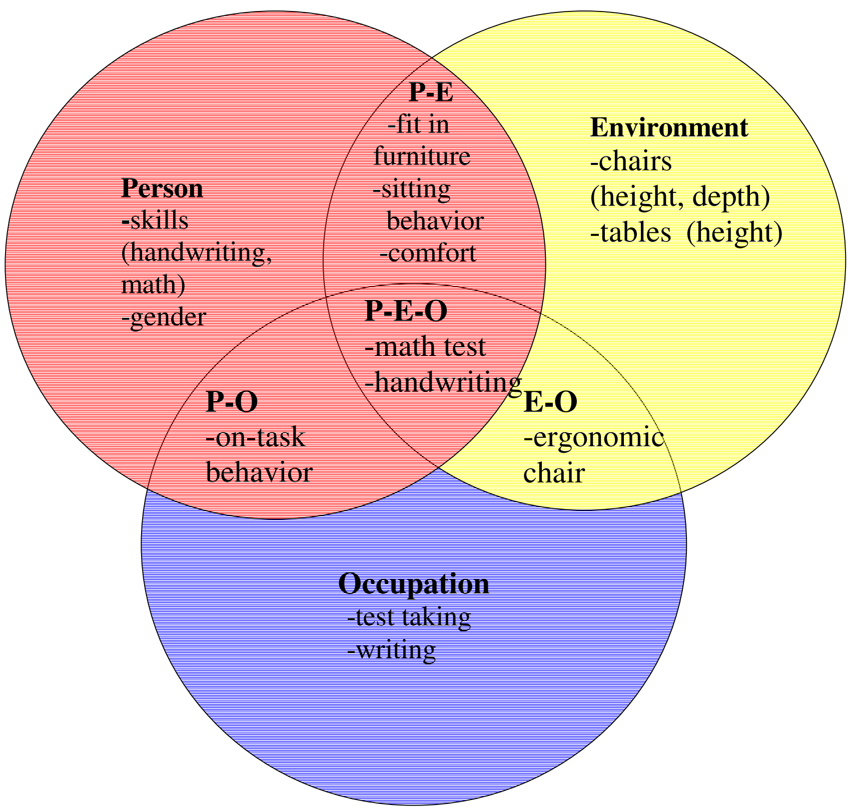


Figure G4. *Person-Environment-Occupation Interaction: Math Fluency Score and Handwriting Legibility by Furniture Size and Type*

Appendix H

Presentation to PTA

Appendix H (Cont.)

Appendix H (Cont.)

Appendix I

Tip Sheet for Healthy Sitting

Tip Sheet: Healthy Sitting in the Classroom

School-aged children spend as much as 60% of the school day sitting in their classroom furniture. Their position in their chairs and at their desks or tables can affect their comfort and health, as well as their attention to task, handwriting, and even testing.

Occupational therapists and occupational scientists are trained to evaluate how a child's environment can help or hinder his or her performance of classroom tasks. A child who sits in a chair that is too big or too small may use unnatural sitting positions, which may lead to back, neck, and leg pain. Sitting at desks or tables that are too high can also cause children to assume unnatural sitting positions. Using unnatural sitting positions can make it harder for a child to pay attention, can make handwriting more difficult, and may even lead to lower test scores. An occupational therapist or occupational scientist can help teachers and principals match children to classroom furniture that fits their size better, or make recommendations to alter the furniture that is available in their schools.

What can an occupational therapist or occupational scientist do?

- Evaluate a child's current classroom furniture set-up to determine whether it is ergonomically correct to prevent unnecessary strain
- Advise teachers and principals on how to create a healthy workspace by adjusting the height of furniture, using footrests, or replacing furniture that is too big or too small
- Educate students, teachers, school officials, and parents about proper sitting posture to prevent strain and improve attention, testing, handwriting, and other classroom tasks

What can teachers and school officials do?

- Encourage students to use proper sitting postures including: sitting with the body facing the front of the classroom (not twisted), using footrests or resting feet flat on the floor, resting forearms on the desk or table while doing table-top activities such as writing, leaning on the backrest with listening or reading
- Arrange classroom furniture so few or no students need to twist their necks or bodies to see the front of the room
- Provide or adjust chairs and tables/desks to appropriate height for the child: The child's elbows should be even with the tabletop, feet should rest flat on the floor, and the child's hips should be at a 90° angle while seated.

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