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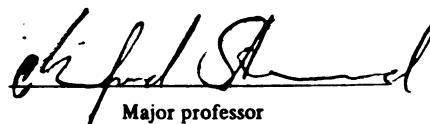
Classroom Furniture and
Anthropometric Measurements:
An Evaluation of Fit

presented by

Claudia Parcells

has been accepted towards fulfillment
of the requirements for

Master's degree in Nursing



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**CLASSROOM FURNITURE AND ANTHROPOMETRIC MEASUREMENTS:
AN EVALUATION OF FIT**

By

Claudia Parcels

A THESIS

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

MASTER OF SCIENCE

College of Nursing

1997

ABSTRACT

CLASSROOM FURNITURE AND ANTHROPOMETRIC MEASUREMENTS: AN EVALUATION OF FIT

By

Claudia Parcels

When the design of classroom chairs and many desks are not based on properly selected anthropometric ergonomic data then, evidence suggests that greater muscular force will be needed to maintain postural stability and balance. The greater force results in greater fatigue and discomfort and creates the basis for poor postural habits as well as neck and/or back problems.

Five body dimensions pertinent to appropriately sized chairs and desks were measured on students between the ages of 11 and 13 years to determine what percentage of students are using furniture that is improperly sized for them, and what student characteristics most likely predict a poor fit.

The results indicate substantial variability of student dimensions and that a large majority of students measured are sitting in chairs with seats that are too high and too deep and at desks that are too high.

ACKNOWLEDGMENTS

A research project such as this would not be possible without the assistance of my thesis committee. Their combined years of knowledge and experience in research and thesis preparation have given me a better understanding of this challenging process.

I would like to thank the following members of my thesis committee:

- *Manfred Stommel, Ph.D.* (College of Nursing) research mentor and thesis chairperson, for his encouragement and excellent direction in turning the concept of posture into a realistic and meaningful research project. His love of research and statistics is evident and contagious.
- *Bob Hubbard, Ph.D.* (College of Osteopathic Medicine; Department of Biomechanics) for his assistance in developing the concept of posture and seating and for his constant prodding to “stay positive” when the details seemed never ending.
- *Patty Peek, MSN* (College of Nursing) for her enthusiastic support to incorporate my knowledge of functional interior design into a project with meaningful implications for adolescent health.

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INTRODUCTION

Eighty percent of the US population seeks medical attention for back problems at some time in their lives (Mulry, 1992). Back pain however, is not confined to the adult population. A surprising number of grade school children and adolescents report regular bouts of back, neck and headache pain. It has been reported that over 22 % of elementary school children and over 33 % of the secondary school population complain of backache (Mierau, Cassidy, Hamin, & Milne, 1984). In a study of 370 Finnish school children ages 11- 17 years, 19.7% of the students reported present neck and/or back symptoms. Of the students with present neck and/or back symptoms, 58.9% reported having symptoms while sitting (Salminen, 1984).

In 1990, direct medical costs for low back pain exceeded \$24 billion, and total costs increase substantially when disability is included (Lahad, Malter, Berg, & Deyo, 1994). Given these statistics, the importance of prevention in contrast to cure should be evident.

During the past decade there has been an increasing interest in the technology of work design based on human biological sciences (ergonomics) and the biomechanics of back health. The debate, building on early work in the field by Branton (1969) and Keegan (1953), has been especially active concerning the recommendations of new

principles for the design of chairs and desks in the work place. However, little interest has been shown in the largest work-place of them all -- the school.

Children in the classroom have, to large extent, been excluded from ergonomics applications designed to prevent musculoskeletal problems. Although, musculoskeletal pain complaints are believed to be multifactorial, (Balague, 1988; Sardelic, 1989) the school environment, specifically the available chairs which students occupy could be a major source of the problem.

School children are at special risk for suffering negative effects due to the prolonged periods spent seated during school. As a result, the formation of poor postural habits places stresses during formative years on the developing musculoskeletal system.

Craven (1993) cites a study by the Anglo-European College of Chiropractic which revealed that 72 percent of British schoolchildren aged 6 to 11 years old were sitting on chairs that were either too high or too low for them and often at the wrong-sized desks. Thus, children experience "early fatigue" of the muscles in their upper limbs and shoulders from large desks while chairs compress blood veins and nerves in the legs.

Classroom furniture from manufacturers is not typically designed to adjust to accommodate the dimensions of the individual user. According to R. Agee (personal communication, March 26, 1996) and S. Finney (personal communication, March 28, 1996), executives with two school furniture manufacturers, a few desks offer an overall height adjustment and chairs of different sizes are available, but individual adjustments

for the seat, arm and back are not offered. Instead, a “one size fits all” philosophy is adopted because it is less costly to manufacture, easier to sell at a competitive price, and lessens inventory problems for the manufacturer and the school.

Manufacturing, selling, and inventory are realistic concerns, but the product should at least reflect a design based on properly selected anthropometric data and ergonomics. If proper design is not there, the seating design will require greater muscular forces or control to maintain stability and equilibrium. The greater forces result in greater fatigue and discomfort and lead to poor postural habits as well as neck and/or back complaints.

Musculoskeletal stress resulting from efforts to maintain seated stability, and comfort, make for a fidgety individual--hardly conducive to focused learning. Healthcare providers, interested in managing care and fostering health protecting behaviors, can be instrumental in focusing consumer attention on environmental influences that impact health. Good posture facilitates lung expansion, reduces organ crowding and strain on developing bones, tendons and muscles (Chaffin, 1991). Our schools have implemented health education programs (Department of Education, et al, 1988) in an effort to introduce young people to health protecting and health promoting practices. Classroom chairs and desks that fit should be viewed as among the most important facilities provided for students by schools.

Floyd and Ward (1969, p. 18) have commented: “the longer a particular habit has endured the more difficult it is to change or abandon it. This being so, it would appear to be of the greatest importance to instill, and maintain, good sitting habits as

early in the individual's life as possible. Our contention is that the schoolroom is a most suitable place for this habituation to occur to the individual's maximum advantage." They further add that it is an "individual's early training in good postural habits at correctly dimensioned and designed furniture" that will carry over into adult life and the workplace.

The growth rate amongst children varies tremendously and is influenced by genetic as well as environmental factors. The variation in children's physical sizes is especially apparent in the preadolescent and adolescent periods when the onset of puberty further differentiates body sizes and shapes.

Chair designs that lack adjustability are designed to fit a range of users-- small as well as large body sizes (Panaro, 1979; Diffrient, Tilley, & Bardagjy, 1974). As a result, standardized chairs and desks may create a mismatch or poor fit for the majority of children in the classroom.

The information gathered in this study can enlighten school administration, parents and furniture manufacturers to factors necessary to create furniture for our youth which promotes good postural habits (*healthful options*) and an environment reduced of stress and discomfort (*protective environmental measures*). This information is also important to those disciplines that are concerned with environmental factors which promote optimal human functioning. As a leader in primary health care, the profession of advanced practice nursing (APN) is particularly concerned with health protection and health promotion. This is achieved by educating individuals as well as by promoting change which can impact entire groups of people.

Research Problem

The problems under study are (a) what percentage of students age 11-13 years old have a mismatch between their individual anthropometric dimensions and their classroom furniture, and (b) what student characteristics of age, gender, and stature most likely predict the anthropometric dimensions of popliteal height, buttock-popliteal length and elbow height?

Conceptual Definitions of Variables

Gender

Webster defines gender as “a person’s sex” either male or female (Neufeldt & Sparks, 1990, p. 246). This definition is accepted for this variable.

Age

The age of the student is defined as the chronological time expressed in years and whole months from the date of birth to the date of measurement.

Anthropometric

Anthropometrics is the comparative study of human body measurements as they apply to the physical fit, or interface, between the human body and the various components of interior space (Panero, 1979). Anthropometric measurements are human body dimensions that impact on the design of interior spaces (including furnishings). The essential anthropometric dimensions for seating and work surface design used in this study are defined below (Panero, 1979).

Elbow height. With the subject in a relaxed seated erect posture, the elbow height (taken with 90° elbow flexion) is the vertical distance from the bottom of the tip of the elbow (olecranon) to the subject’s seated surface.

Shoulder height. With the subject in a relaxed seated erect posture, the shoulder height is the distance taken vertically from the top of the shoulder at the acromion process to the subject's sitting surface.

Upper arm length. The difference between the elbow height and shoulder height.

Knee height. Knee height is the vertical distance measured with 90° knee flexion from the foot resting surface to the top of the kneecap just in back and above the patella.

Popliteal height. Popliteal height is the distance, taken vertically with 90° knee flexion, from the foot resting surface to the posterior surface of the knee or popliteal space.

Buttock-popliteal length. With 90° knee flexion, the buttock-popliteal length is the horizontal distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal space.

Height. Height is the vertical distance from the floor to the top of the head, while the subject stands erect, looking straight ahead.

Furniture dimensions

The dimension variables for the classroom desks, tables and chairs (non upholstered) are defined as follows:

Seat height. The chair seat height is the distance, taken vertically, from the floor to the highest point on the front of the seat.

Seat depth. The chair seat depth is the horizontal distance of the sitting surface from the back of the seat, at a point where it is assumed that the buttocks begins, to the front of the seat.

Seat slope. The chair seat slope is the direction and angle of pitch of the seat of the chair.

Desk/table height. The desk/table height is the vertical distance from the floor to the top of the front edge of the desk or table.

Desk/table clearance. The desk/table clearance is the vertical distance from the floor to the bottom of the front edge of the desk or table.

Desk slope. The desk slope is the angle of pitch of the top of the desk.

Mismatch

Mismatch is defined as a lack of compatibility between the dimensions of the classroom furniture under study and the dimensions of the user's body. A mismatch occurs when the dimensional configuration of the student's body is not consonant with the dimensional configuration of the classroom chair the student uses and results in decreased body stability or musculoskeletal stressing adaptations (Panero, 1979; Zacharkow, 1988; Chaffin & Andersson, 1990). A mismatch will be further defined by the relationships and operational definitions as described in the methods section.

LITERATURE REVIEW

School Seating

The detrimental effects of improper classroom furniture on the spine have been realized for a long time. Commenting on school desks and chairs, Shaw (1902), stated that the desks and chairs used in schools are “constructed with but the slightest regard for hygienic principles” and made reference to the “injurious effects as to posture, and wrong habits of carriage, which are borne through life.” Bennett (1928) considered school to be a sedentary occupation and a place where permanent habits of sitting are formed.

Observations on students’ sitting behavior have been reported in studies by Wotzka et al. (1969) and Floyd & Ward (1969). Both studies reported that a forward “arms on the desk-supported” posture was observed to occur between 65 to 80 percent of the time. The major part of the school posture problem is that most sitting activities encourage the forward position of the head and arms, which tends to draw the head and shoulders forward into a slumped sitting posture (Drew, 1926). This slumped posture not only stresses the back and shoulder musculature but, the abdominal cavity is shortened and compressed and the ribs are lowered. As a result, some of the upper trunk weight will be upon the abdominal viscera and lung expansion is reduced (Knudsen, 1947).

Dynamics of Sitting

The dynamics of sitting can best be understood by studying the mechanics of the support system and the general bone structure involved. To begin, 75 % of the total body weight is supported on only 4 square inches or 26 square centimeters when sitting. This small area covers the ischial tuberosities. This heavy load, distributed over a relatively small area, result in high compressive stresses estimated at 85 to 100 pounds per square inch (psi) (Tichauer, 1978). Compression pressures on the areas of the skin between the buttocks and a hard seat pan to be as high as 40 to 60 psi and 4 psi only a few inches away (Branton, 1969). Therefore, seating should provide for the distribution of the body weight over an area larger than the ischial tuberosities. The seating should also allow the sitter to change posture when necessary to alleviate discomfort. To accomplish these ends, proper anthropometric data are essential in determining the proper measurements and clearances needed.

Structurally, the tuberosities form a two-point support system which, in conjunction with a center of gravity (when seated) outside of and in front of the navel, is inherently unstable (Branton, 1969). Therefore, the seat alone is insufficient for stabilization and the use of the legs, feet, and back in contact with other surfaces, as well as muscular forces, are used to produce the necessary equilibrium (Branton, 1969). Leg support is critical to distribution and reduction of the buttock and thigh loads. Feet should rest firmly on the floor or foot support so that the lower leg weight is not supported by the front part of the thighs resting on the seat (Chaffin, 1991).

Seat support should be under and anterior to the ischial tuberosities (Babbs, 1979) which places the major weight bearing on the ischial tuberosities and the upper half of the posterior thighs (Bennett, 1928; Floyd & Ward, 1967). When the weight is shifted posterior to the ischial tuberosities, pressure is placed over the coccyx along with distortion and compression of the gluteus maximus muscles (Bennett, 1928; Babbs, 1979).

To maintain the weight bearing over and anterior to the ischial tuberosities, sacral and pelvic support are needed to prevent or reduce backward rotation of the pelvis and subsequent lumbar kyphosis (posterior curve)(Zacharkow, 1988). Lumbar lordosis (normal anterior curve of the lumbar vertebrae) helps to transfer some of the weight (as much as 25 %) over the posterior thighs (Drummond et al., 1985; DuToit & Gillespie, 1979; Watkin, 1983). Lumbar lordosis and the proper thigh to trunk angle facilitate (a) greater upper trunk support from a backrest, (b) placement of ischial weight further posterior on the seat, and (c) a shift forward on the seat of the trunk weight line (Bennett, 1928; Watkin, 1983; Zacharkow, 1984).

Achieving Postural Alignment

The normal lumbar curve (lordosis) was considered by Keegan (1953) to be maintained by a trunk-thigh angle of 135° . The flattening of the lumbar curve and posterior rotation of the pelvis occurred when the hips flexed and the trunk-thigh angle narrowed. Therefore, Keegan considered that a chair should have a rearward sloping backrest as a means of achieving a minimum trunk-thigh angle of 105° .

Mandal (1981) suggested that when working at a desk, seats should slope forward to accommodate a trunk-thigh angle greater than 90° and still maintain the trunk in an erect position. Mandal also suggested that work surfaces be tilted toward the user which was more compatible with upright sitting because of the improved visual angle. Reducing the need for users to flex the neck and trunk for improved viewing angle also should reduce lumbar flexion.

Studies of sitting posture which evaluated postural adaptations to seats with forward slope angles have found that with increasing forward slope, the spine moved toward lumbar lordosis (Bendix & Biering-Sorensen, 1983; Bridger, 1988; Bridger et al., 1989). However, Bendix and Biering-Sorensen (1983) point out that postural adaptation to a forward-sloping seat may take place in a number of ways: (a) the whole body may tilt forward such that no increase in the trunk-thigh angle occurs; (b) the hip joints may extend, which increases the trunk-thigh angle but without necessarily altering the posture of the spine and pelvis; (c) the upper trunk does not move but, anterior pelvic rotation accompanies increased trunk-thigh angle which results in reduced lumbar flexion. In their own study of trunk adaptation to forward inclining seats, Bendix and Biering-Sorensen (1983) noted that 1/3 of the body's adaptation took place in the spine and 2/3 in the hip joints. Evaluations based on user comfort indicated a preference for 0° (horizontal) and 5° forward inclinations.

A forward-inclining seat seems to affect the lumbar spine in a positive direction (towards lordosis), but to a lesser extent than a sloping desk which additionally

improves the posture of the other parts of the spine (Bendix, 1987). Additional studies have evaluated the positive postural adaptations of sloping desks.

Bridger (1988) noted that using a sloped work surface resulted in less trunk flexion, a more erect trunk, and less neck flexion than using a horizontal work surface. Bendix & Hagberg (1984) reported that sloping the desk 22° or 45° increased the lumbar angle more than the $+5^{\circ}$ (forward slope) seat, and caused the head and trunk to be more upright. An investigation carried out by Freudenthal, van Riel, Molenbroek, and Snijders (1991) concluded that the average position of the trunk was changed from 26° to 18° when working with a desk with a 10° incline. The moment of force on the back at L5-S1 decreased by 29% with the largest individual decrease of 86%. The average change of the position of the head was changed from 38.5° to 29.6° , resulting in an average decrease of the moment of force, on C7-T1, of 21%. The change found between a flat desk and an inclined desk of 10° was relatively large compared with the results of Bendix and Hagberg (1984). This indicates that desks with a small slope have a relatively large effect on the position of the trunk and the head. The advantage of a small slope is that it is easy to use while reading and pencils and paper do not slide down when writing. Evaluations based on user comfort indicated preferences for sloped desks (Aagaard-Hansen & Storr-Paulsen, 1995; Hira, 1980).

Anthropometric Data

A review of the literature reveals that the most currently collected and extensive anthropometric data available for children aged 11 to 13 years was completed in 1975

by the Highway Safety Research Institute for the Consumer Product Safety Commission (Snyder, Schneider, Owings, Reynolds, Golomb, & Schork, 1977). Unfortunately, two key measurements needed for school seating design were not included in the study -- popliteal height and buttock to popliteal length. Growth studies by Marshall and Carter (1975) have found that children today are taller and heavier than children in past generations. Thus, it is questionable how representative less recent anthropometric data may be of the current population of US children.

When each of five major school furniture manufacturers in the United States were asked what research the company used to design school furniture to optimize student learning, the response was that they did not rely on research. Instead, each company relied upon specifications from the American Furniture Manufacturers Association and the National Standards Board to decide "seat width, belly room, and prohibited combustible materials" (Lane & Richardson, 1993, p. 22). Each of the five companies was also asked how design decisions were made regarding school furniture. The predominant answer was that designs were basically unaltered for years and that designs reflected what the customer wants. Perhaps, the situation is circular. The schools in this country keep ordering the same furniture that has been ordered for the last 25 years because that is what there is to order and the manufacturers keep producing the same designs because that is what is being ordered.

The literature reveals that research in the area of school chair and desk design is predominantly being done in the Scandinavian countries. Observations and measurements of body alignments indicate that furniture designed to accommodate the

task and the individual's size is more widely accepted by the user than the styles that have been unaltered for years. Research based designs of student furniture are now being produced in Denmark and Sweden. The trend is also spreading in Germany, France and Switzerland (Mandal, 1992). The dimensions and styles of the chairs and desks reflect the body dimensions and the functional needs of the student population.

CONCEPTUAL FRAMEWORK

“Form follows function” is a statement made famous by the American architect Louis Sullivan and has become a guiding principle for design planning of interior spaces and furnishings. Form is the result of design planning which is based on the solution of a functional problem. Form is not an abstract object but rather an object, such as a chair, created for a specific purpose, that is “created for the sake of a particular end and cause” (Friedman, Pile, & Wilson, 1982, p. 48).

Form that does not follow function, such as classroom furniture that does not meet the needs of the student, is experienced as noxious environmental stimuli because it does not meet user needs. Stimuli that is not within an individual’s coping zone (i.e. that is not ergonomically designed), causes an energy depleting response (muscular fatigue, discomfort and poor organ alignment). When environmental stimuli are within an individual’s coping zone, then energy is free to respond to other stimuli. This freeing of energy can promote integrity and enhance health (Roy, 1984).

According to Rene’ Dubos, a noted writer of works on human environment, the nearest approach to high level health is a physical and mental state free of discomfort and pain that permits one to function effectively as long as possible within the environment (Dubos, 1965).

In 1979, the term “health protective behavior” was introduced into the literature (Harris & Guten, 1979). The term is inclusive of both prevention and health promotion activities and is defined as any behavior performed by a person, regardless of his or her perceived or actual health status, in order to protect, promote or maintain his or her health, whether or the behavior has an objective effective toward that end. In *Healthy People: The Surgeon General’s Report on Health Promotion and Disease Prevention*, health protection is defined as *protective environmental measures* in the environment that can be used by governmental and other agencies, as well as by industries and communities, *to protect people from harm* (1979).

Habits detrimental to health that are established in early childhood and carried into adolescent and adult years not only decrease the potential for healthful and productive living but increase morbidity and mortality. It is noteworthy that positive health behaviors, developed during adolescent years, are resistant to change and can persist over time. Development of health protection and promotion behaviors is easier as an adolescent than as an adult (Pender, 1979). As stated by Floyd and Ward (1969), it is an “individual’s early training in good postural habits at correctly dimensioned and designed furniture” that will carry over into adult life and the workplace. Therefore, adolescents are an important target group for well planned health protection and promotion programs (Pender, 1979).

Providing adolescent students with chairs and desks (forms) that do not require energy depleting body adaptations can be an important component of any health protection and health promotion program. However, furniture forms must begin with

designs based on appropriate and correct data. This data includes the body dimensions of the user (target population) as well as the functional requirements of the tasks being performed.

Health protection and health promotion are emphasized within the scope of practice of the advanced practice nurse (APN) (American Academy of Nurse Practitioners, 1993). As leaders in primary health care, the APN combines many roles including those of researcher, consultant and change agent.

Individuals may wish to behave in ways that promote health, but environmental constraints prevent access to healthful options (i.e. lack of appropriately sized and designed furniture for student use) (Pender, 1979). The APN can be instrumental in increasing the level of well being and in actualizing the health potential of individuals. This is achieved by pursuing scientific investigations of clinical problems, providing information to broaden awareness of factors affecting health and by coordinating activities to bring about positive alterations in individual health behaviors as well as environmental conditions which impact healthful options.

METHODS

Research Design

This study is based on a non-experimental, cross-sectional, observational design. The investigation explores the interrelationships among variables as observed without any active intervention on the part of the researcher (Polit and Hungler, 1991).

Sample Procedures

The target population was school children between the ages of 11 and 13 years. The sample was drawn from a single school district for convenience of location and for its diversity of ethnic and socioeconomic backgrounds. The target student population in the school district was divided into three strata by grade level (6th, 7th and 8th) (total census approximately 900 students). Consent forms were distributed to students in eight physical education classes (approximately 250 students total) in an effort to yield an equal number of males and females from each stratum.

Physical education classes were used in the sampling process because of the requirement that all students enroll in physical education and the ease of data collection within this setting.

The selection of chairs and desks was based on the two to three styles which predominate in each of the classrooms.

Ethics

Parental permission and student assent was required for each participating student. No identifying characteristics were included in the data coding process. Approval for this study was obtained from Michigan State University UCRIHS, and the Research Review Committee from the sample school district.

Data Collection

All measurements were gathered by the researcher with the aid of one data recording assistant. In addition to the anthropometric measures, data for each of the subjects includes age (in years and months), grade level, and gender.

Each student was measured in T-shirt, shorts and the shoes normally worn to school. Student dimensions (with the exception of height) were taken with the student seated erect on a flat horizontal surface with knees bent 90° and feet (without shoes) flat on an adjustable resting surface. Height was taken standing erect without shoes.

Linear anthropometric variables, as previously described, were measured using an anthropometer. Other equipment to facilitate the measuring process included a portable sitting surface with an adjustable footrest. This sitting surface with footrest allowed the subjects to be oriented into position by the researcher for ease and accuracy in taking measurements. Chairs, desks, and tables were measured using a metal tape measure; slopes were measured with an angle finder.

Operational Definitions of Variables

Popliteal height and seat height mismatch (PHSH).

If the seating surface is too high, the underside of the thigh becomes compressed causing discomfort and restriction in blood circulation. To compensate for this, the user usually moves his buttocks forward on the chair seat. This can result in a slumped, kyphotic posture due to lack of back support. When the seat is too high, the soles of the feet do not have proper contact with the floor surface (heels are off of the floor) and body stability is weakened.

If the seat surface is too low, the knee flexion angle becomes small, the user's weight is transferred to a small area at the ischial tuberosities and there is a lack of pressure distribution over the posterior thighs.

Chaffin and Andersson (1991, p. 363) recommend that the seat be "3-5 cm. below the knee fold when the lower limb is vertical" if the seat is not tiltable or does not slope forward. Bendix, (1987, as cited in Chaffin, 1991) recommends 3-5 cm above the popliteal level if the seat slopes forward. These recommendations are based on adult anthropometric measurements. Bendix et al., (1985) and Bendix (1984) studied acceptability of seats of variable heights. Higher seats were favored for comfort and the sitting posture was less constrained with more spontaneous body movements.

Anthropometric data collected for adults (male and female) age 18-79 years shows that popliteal height ranges from 36.1 cm (10th percentile, female) to 47.8 cm (90th percentile, male) with 41.9 cm the average for males and females in the 50th

percentile (Panero, 1979). This suggests a clearance of approximately 7-12% of the popliteal length. Taking into consideration the preference for higher seating and allowing for some popliteal clearance (approx. 2 cm. or 5% of popliteal height), this study defined a mismatch of popliteal height and seat height to be a seat height $\geq 95\%$ or $\leq 88\%$ of the popliteal length.

Buttock-popliteal length and seat depth mismatch (BPSD)

When the seat depth is too great, the front edge of the seat will press into the area just behind the knees, cutting off circulation to the legs and feet. To alleviate the discomfort, the user will slide forward on the seat but will lose proper support from the backrest and lumbar support. This again usually results in a slumped, kyphotic posture with excessive pressure over and posterior to the ischial tuberosities (Panero, 1979; Zackarkow, 1988).

Too shallow a seat depth may cause the user to have the sensation of falling off the front of the chair as well as result in a lack of support of the lower thighs (Panero, 1979). A free area between the back of the lower limb and the seat pan is useful to facilitate the suggested 80° flexion of the knees for rising out of the chair and for leg movements (Diffrient et al., 1974). Diffrient et al. (1974) suggest a seat depth of 32.5 cm for an eleven year old. Based on available anthropometric data (Malina, 1965), this depth corresponds to somewhere between 80% and 95% of the buttock/popliteal length of eleven year olds between the 10th and 90th percentiles.

Therefore, for this study, a mismatch of buttock/popliteal length to seat depth was defined as a seat that is $\leq 80\%$ or $\geq 95\%$ of the buttock/popliteal length.

Knee height and desk/table clearance mismatch (KHDC).

When the knee height meets or exceeds the desk/table clearance, the patella or anterior thigh will strike the underside of the desk or table during use. This may lead the user to extend and position the legs forward. The feet then lack stability. This researcher feels that a clearance of 2 cm allows for a comfortable margin. Therefore, a mismatch occurs when the desk/table clearance is < 2 cm higher than the knee height.

Elbow rest height and the desk/table height mismatch (EHDH).

If the desk/table is too high, the working arm will lack adequate support. To compensate, the shoulders must be raised or abducted which places stress on the deeper posterior neck musculature in order to provide stabilization of the head posture.

A desk height that is too low will result in the user bending forward by spinal flexion, with the body weight being supported by the arms. A kyphotic spinal posture with round shoulders will result.

When performing desk work, a shoulder flexion angle of $\leq 25^\circ$ and a shoulder abduction angle of $\leq 15-20^\circ$ is suggested (Chaffin, 1991). To determine elbow height with shoulder flexion and abduction (hE), the measurements of shoulder height (hS), vertical elbow height (hEv) upper arm length ($U = hS - hEv$), shoulder flexion (θ), and shoulder abduction (β) will be used in the following equation (Hubbard, personal communication, April, 1996).

$$hE = hEv + U[(1 - \cos\theta) + \cos\theta(1 - \cos\beta)]$$

The types of work being performed (fine detail vs. forceful leverage) are important considerations. Given the formula and the angles suggested by Chaffin (1991), it is possible to determine for each student the maximum and minimum desk height acceptable for the student. With minimum and maximum shoulder flexions of 0° and 25° , the corresponding cosines are 1 (0°) and .9063 (25°). For abduction angles of 0° and 20° (maximum), the corresponding cosines are 1 and .9397. Given that the cosines are monotone functions of the angles, a student's minimum desk height is determined by the vertical elbow height alone ($h_E = h_{Ev} + U[(1-1) + 1(1-1)] = h_{Ev}$). The maximum desk height is determined by:

$$\begin{aligned}
 h_E &= h_{Ev} + U[(1-.9063) + .9063(1-.9397)] \\
 &= h_{Ev} + U(.1483) \\
 &= h_{Ev} + .1483h_S - .1483h_{Ev} \\
 &= .8517h_{Ev} + .1483h_S, \text{ since } U = h_S - h_{Ev}
 \end{aligned}$$

Thus, the maximum desk height acceptable for an individual student was determined by that student's shoulder height and vertical elbow height.

Seat slope and desk slope

The review of literature discussed the significance of body adaptations to various seat and desk angles. These variables were measured in degrees from a horizontal plane with an angle finder. To measure the seat slope, a straight, flat metal bar was placed, from the front edge of the seat to the back edge of the seat, along the plane of the seat that the user's thigh would rest. The angle finder was placed on top of the bar. To measure the back to front desk slope, the angle finder was placed directly on the top of the desk.

RESULTS

The results are presented in two sections. In the first section, a breakdown of the sample by gender, age and grade is presented. In addition the results for the measurements taken are reported so as to be useful to product designers and other users of these data.

The second section presents frequencies, correlations and regressions to determine which student characteristics most likely predict a mismatch between students and the classroom furniture. This section organizes the information and analysis on the basis of the four “mismatches” described in the methods section under operational definitions of variables.

Section I

The Sample

The sample consists of 74 students; 37 males and 37 females. There are 12 or 13 males and 12 or 13 females representing each of the three grades. Students’ age ranges from 10 years 11 months to 14 years 3 months with a median age of 12 years 5 months and a mean age of 11 years 2 months.

The classroom furniture under study consisted of three sizes of chairs and three sizes of tables. Two sizes of chairs have an attached desk surface. The furniture styles and dimensions are shown in Table 1.

Table 1 Chair and desk data

Chairs	Seat Hgt.	Seat Depth	Seat angle
1.	42.4 cm	44.6 cm	5° back
2.	42.4 cm	40.0 cm	5° back
3.	44.5 cm	39.0 cm	5° back
Desks	Height	Clearance	Surface angle
1.	71.2 cm	69.6 cm	0°
2.	71.2 cm	68.0 cm	0°
3.	69.3 cm	67.8 cm	5°

Anthropometric Data

In the following, descriptive information on all anthropometric variables measured in this study is reported separately for three age groups centered around integer years: 11 years old (including 2 students 10 yrs./11 mos.), 12 years old and 13 years old (including 3 students 14 yrs. to 14 yrs./3 mos.). For each age group the group size (N), mean, standard deviation, 10th, 50th, and 90th percentiles, and minimum and maximum values are given. The 5th and 95th percentiles are not given due to small sample size.

Table 2 Stature (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	149.6	7.1	138.5	139.5	149.3	158.6	162.7
12/0-12/11	21	157.6	6.9	141.0	147.6	159.0	166.3	168.0
13/0-14/3	27	163.1	10.7	139.0	149.3	164.5	174.8	192.5
TOTAL	74	156.8	10.2	138.5	143.5	156.3	168.0	192.5

Table 3 Shoulder height sitting (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	49.7	3.0	45.3	46.3	49.6	55.0	56.5
12/0-12/11	21	51.1	2.4	45.5	47.8	51.5	54.6	55.0
13/0-14/3	27	54.2	4.7	43.0	48.4	54.4	59.1	66.4
TOTAL	74	51.7	4.1	43	46.6	51.4	57.3	66.4

Table 4 Elbow height vertical (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	18.2	2.3	14.3	14.9	18.0	21.2	23.0
12/0-12/11	21	18.6	2.9	13.2	14.9	18.5	22.3	25.0
13/0-14/3	27	20.0	3.5	13.8	15.0	20.0	25.7	29.5
TOTAL	74	19.0	3.0	13.2	15.1	18.5	22.8	29.5

Table 5 Knee height (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	47.2	2.3	43.4	44.0	47.2	50.6	51.0
12/0-12/11	21	50.5	3.0	44.3	46.2	50.7	55.1	55.5
13/0-14/3	27	51.4	3.7	43.5	44.6	51.0	55.8	57.3
TOTAL	74	49.7	3.5	43.4	44.6	49.5	55.3	57.3

Table 6 Buttock popliteal length (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	42.7	3.2	38.0	38.1	42.6	48.7	49.6
12/0-12/11	21	45.5	2.9	40.4	41.2	46.0	49.8	50.3
13/0-14/3	27	46.3	2.7	40.5	43.0	46.5	49.7	50.4
TOTAL	74	44.8	3.3	38.0	40.4	44.8	49.4	50.4

Table 7 Popliteal height (cm)(males and females)

Age (yrs/mos)	N	Mean	s.d.	Min.	10th	50th	90th	Max.
10/11-11/11	26	37.6	1.8	33.4	34.9	37.6	39.9	41.7
12/0-12/11	21	40.1	2.7	34.0	36.9	39.8	44.2	44.6
13/0-14/3	27	40.8	2.8	35.4	36.2	41.0	44.5	45.5
TOTAL	74	39.5	2.8	33.4	35.7	39.0	43.9	45.5

All of the variables show almost identical means and medians indicating symmetrical distributions. There is a consistent increase in means and medians by age group and with the exception of the buttock-popliteal length measurement, standard deviation increases with age. The increase in standard deviation is indicative of greater variability with increasing age except for buttock-popliteal length.

Section II

Popliteal height and seat height mismatch (PHSH)

Each student's popliteal height is measured in stocking feet to avoid measurement error resulting from possible variations in shoe height. However, for the purposes of defining a mismatch with chair seat height, the student's popliteal height is adjusted for a standard shoe height by adding 3 cm to the popliteal height. This amount is arrived at by taking the mean heel height from a sample of 10 students' shoes.

A fit between chair seat height and popliteal height occurs when the seat height is $\geq 88\%$ and $\leq 95\%$ of the popliteal height. Using these criteria, the number and corresponding percentage of students who fit and don't fit the three chairs are presented in Table 8.

Table 8 Chair seat height fit

	Seat hgt < 88 % (seat too low)	Seat hgt $\geq 88\% \leq 95\%$ (fit)	Seat hgt > 95 % (seat too high)
Chair 1 or 2 42.4 cm	n=1 1 %	n=17 23 %	n=56 76 %
Chair 3 44.5 cm	n=0 0 %	n=9 12 %	n=65 88 %

Only 23% of students fit chairs 1 or 2 and only 12% fit chair 3. Both chair seat heights are too high for the majority of students measured. The popliteal space for the majority of students does not even clear the front edge of the chair seat. The amount of clearance between popliteal space and the front edge of the seat is presented in Table 9.

Table 9 Popliteal space clearance for height

	0 clearance	≤ 2 cm	> 2 cm
Chair 1 or 2 42.4 cm	n=40 54 %	n=17 23 %	n=17 23 %
Chair 3 44.5 cm	n=56 76 %	n=9 12 %	n=9 12 %

A look at the difference between student's adjusted popliteal height and chair seat height for the two seat heights under study reveal that 54% of students for chairs 1 & 2 and 76% of the students for chair 3 have a popliteal height that is shorter than the seat height of the chair. Only 23% (chairs 1, 2) and 12% (chair 3) of students respectively have popliteal heights that clear the seat by > 2 cm (0.8 in.).

Hypothetically a chair seat height of 40.5 cm will accommodate 23% of the measured students; lowered to 38 cm and 50% of students are appropriately accommodated for seat height. Lowered again by just 1.25 cm and the seat height becomes too low for an additional 13 students while only accommodating an additional 8 students. Therefore, a seat height of 38 cm would appear to accommodate the largest number of the students measured.

Correlation and regression analysis is used to address the question of what student characteristics (age, gender and stature) most likely predict popliteal height (the prime determinant of seat height fit). Popliteal height correlates strongly with age, gender and stature. However, when the sample is split by gender, the correlation with age is much stronger for males than for females (Table 10).

Table 10 Correlations for popliteal height

	Stature correlation	p=	Age correlation	p=
Females	.869	.000	.360	.014
Males	.856	.000	.675	.000

In the regression analysis that includes age, gender and stature as predictor variables, only stature has an independent (and statistically significant) effect (Table 11). Alone, this factor accounts for 73-76% (based on the R^2) of the variation in popliteal height. The standardized regression coefficients also indicate that relative to age, stature is a much stronger predictor of popliteal height.

Table 11 Regressions for popliteal height

	R^2 Stature	R^2 Age	R^2 Stature w/age	Beta Stature	p= Stature	Beta Age	p= Age
Females	.755	.13	.765	.970	.000	-.182	.071
Males	.732	.456	.754	.727	.000	.195	.095

Since, stature is the most important predictor of popliteal height, and there are systematic differences in stature by gender, the following crosstabulations examine the relationship between fit/mismatch and gender of the students (Tables 12 and 13).

Table 12 Percentage of students with fit or mismatch for chair height 1, 2

	Fit	High	Low	Total
Male	32 %	65 %	3 %	100 % (=37)
Female	14 %	86 %	0 %	100 % (=37)
Total	24 %	75 %	1 %	100 % (=74)

Table 13 Percentage of students with fit or mismatch for chair height 3

	Fit	High	Low	Total
Male	19 %	81 %	0 %	100 % (=37)
Female	5 %	95 %	0 %	100 % (=37)
Total	12 %	88 %	0 %	100 % (=74)

The results reveal that males account for a greater percentage of students with a fit for chairs 1, 2. However, because of the small sample size, the difference in the percentage of male and female fit does not quite reach statistical significant at the 0.05 level ($p=.08$).

Buttock-popliteal length and seat depth mismatch (BPSH)

A fit between chair seat depth and buttock-popliteal height occurs when the seat depth is $\geq 80\%$ and $\leq 95\%$ of the buttock-popliteal length. The number and corresponding percentage for the categories of fit or mismatch for seat depth are presented in Table 14. The amount of clearance between popliteal space and the front edge of the seat (with regard to depth) is presented in Table 15.

Table 14 Distributions of fit or mismatch for chair seat depth

	Fit	Deep	Shallow
Chair 1 44.6 cm	n=17 30%	n=57 70%	n=0 0%
Chair 2 40.0 cm	n=58 79%	n=15 20%	n=1 1%
Chair 3 39.0 cm	n=56 76%	n=9 12%	n=9 12%

Table 15 Popliteal space clearance for length

	0 clearance	< 2 cm	2 cm to 5 cm	≥ 5 cm
Chair 1 44.6 cm	n=35 47%	n=17 30%	n=16 22%	n=6 8%
Chair 2 40.0 cm	n=6 8%	n=11 15%	n=22 30%	n=35 47%
Chair 3 39.0 cm	n=3 4%	n=8 11%	n=20 27%	n=43 58%

The chair with the deepest seat (chair 1) accommodates the least number of students. With a depth of 44.6 cm, only 30% of the students measured fit the seat. The seat depth is too long for the remaining 70% of students. For 8% of the students, their popliteal spaces do not clear the front edge of the seat and 30% clear the edge by <2 cm (.75 inch).

The other two chairs provide a much better fit for the majority of students. Chair 2 (40 cm deep) fits 79% of students with a front seat edge clearance of >2 cm for 77% of the students. Only 8% (6 students) have popliteal spaces that do not clear the front seat edge.

Chair 3 (39 cm deep) accommodates 76% of students with thigh support $\geq 80\%$ and $\leq 95\%$ of buttock-popliteal length. The seat is too shallow for 9 students (12%),

and too deep for 9 students (12%). Only 4% (3 students) have popliteal spaces that do not clear the front seat edge.

Correlation and regression analysis is used to address the question of what student characteristics (age, gender, and stature) predict buttock-popliteal length (the prime determinant of seat depth fit). Buttock-popliteal length correlates strongly with stature for both males and females. The correlation with age is stronger for males (Table 16).

Table 16 Correlations for buttock-popliteal length

	Stature correlation	p=	Age correlation	p=
Females	.826	.000	.373	.012
Males	.839	.000	.667	.000

In the regression analysis that includes age, gender and stature as predictor variables, stature alone accounts for 68-84% of the variation in buttock-popliteal length (Table 17).

Table 17 Regressions for buttock-popliteal length

	R ² Stature	R ² Age	R ² Stature w/age	Beta Stature	p= Stature	Beta Age	p= Age
Females	.682	.139	.693	.897	.000	-.128	.272
Males	.703	.445	.730	.706	.000	.200	.104

As shown in Table 18 crosstabulation between the students' gender and categories of fit or mismatch reveal an almost even split between males and females for all types of fit although, there is no statistically significant difference ($p > 0.6$).

Table 18 Percentage of students with fit or mismatch for seat depth

	Seat Depth 1			Seat Depth 2			Seat Depth 3		
	Fit	Deep	Shallow	Fit	Deep	Shallow	Fit	Deep	Shallow
Male	30%	70%	0%	78%	19%	3%	78%	11%	11%
Female	30%	70%	0%	78%	22%	0%	73%	14%	14%
Total	30%	70%	0%	78%	20%	1%	76%	12%	12%

Overall seat fit

Each of the four chairs under study is evaluated for overall fit (seat height and seat depth) for the students measured. A breakdown of fit for height and depth for the three chairs is shown in Table 19. The best chair for overall fit is chair "C" with 23% of students fitting for both height and depth. This chair is too small for only one student (6'3" 8th grade male). Chair "B" is the poorest fitting with excessive height and depth for 50 of the 74 students measured (68%).

Table 19 Percentage of students with overall chair fit or mismatch

		Chair "A"			Chair "B"		Chair "C"	
		Fit	Deep	Shallow	Fit	Deep	Fit	Deep
HEIGHT	Fit	M = 11 % F = 3 %	-----	M = 8 % F = 3 %	M = 27 % F = 14 %	-----	M = 32 % F = 14 %	-----
	Mismatch	M = 68 % F = 70 %	M = 11 % F = 14 %	M = 3 % F = 11 %	M = 0 % F = 16 %	M = 65 % F = 70 %	M = 46 % F = 65 %	M = 19 % F = 22 %
		44.5H x 39D			42.4H x 44.6D		42.4H x 40D	

More males than females fit chairs for both height and depth. For males, 11% fit chair "A", 27% fit chair "B" and 32% fit chair "C". For females, only 3% (one female) fit chair "A", 14% fit chair "B" and 14% fit chair "C". Too deep and/or too high were problems for roughly equal numbers of males and females.

Knee height and desk/table clearance mismatch (KHDC)

Both desk heights allowed ≥ 2 cm of clearance for knees for all 74 of the students measured. Clearances ranged from 8.5 cm (3.4 in.) to 22.4 cm (8.8 in.) for desk 2, 3 and from 10.3 cm (4 in.) to 24.2 cm (9.5 in.) for desk 1. When hypothetically placed at a desk height appropriate for elbow height, knee clearance of ≥ 2 cm is achieved for all students.

Elbow rest height and the desk/table height mismatch (EHDH).

The guidelines for shoulder flexion and shoulder abduction set forth by Chaffin (1991) are used to calculate a functional elbow height from the vertical elbow height measurement (taken from the subject's seated surface). Angles of 25° shoulder flexion and 20° shoulder abduction are used as maximum values. The formula is as follows:

$$hE = hEv + U[(1-\cos) + \cos(1-\cos)]$$

The adjusted elbow height is added to each of the chair seat heights under study to approximate the appropriate desk height for each student. Due to the 5° backward slope of the chairs under study, the back of the seat (where the elbow is aligned) is lower than the front edge. Therefore, the height of the back of the seat is used for this measurement (approximately 3-4 cm lower than front edge)

Table 20 displays the distribution of students' adjusted elbow heights sitting in a chair with a given seat height. Table 21 displays the distribution of the *differences* between adjusted elbow height and the height of the table currently supplied with a given chair.

Table 20 Distribution of adjusted elbow heights

	< 64 cm	64-68 cm	68-72 cm	> 72 cm	Range
Sitting in Chair 1 or 2	n=18 24 %	n=34 46 %	n=19 26 %	n=3 4 %	60.5-77.4 cm
Sitting in Chair 3	n=4 5 %	n=33 45 %	n=31 42 %	n=6 8 %	62.6-79.5 cm

Table 21 Distribution of differences between various desk/chair combinations and adjusted elbow height

	≤ 0 cm	0-2 cm	2-5 cm	5-8 cm	> 8 cm	Range
Combination "A"	n=3 4 %	n=6 8 %	n=24 32 %	n=31 42 %	n=10 14 %	-6.2 cm to 10.7 cm
Combination "B"	n=7 9 %	n=21 28 %	n=25 34 %	n=19 25 %	n=2 3 %	-8.1 cm to 8.8 cm
Combination "C"	n=9 12 %	n=19 26 %	n=26 35 %	n=18 24 %	n=2 3 %	-8.3 cm to 8.6 cm

Depending on the desk/chair combination, the desk height exceeds the adjusted elbow height by more than 5 cm (approximately 2 inches) for 27%-56% of students. Combination "A" has the lowest seat height (42.4 cm) and highest desk height (71.2 cm). This combination requires more than half of the students measured (n=41) to raise the elbow (most likely through increased shoulder abduction or shoulder elevation) > 5 cm to achieve forearm placement on the desk work surface. This amount of elbow elevation is necessary for fewer than 28% (n=21) of students with combination "B" which consists of the lower chair and lower table (69.3 cm). Combination "C" which consists of the highest chair (44.5 cm) and highest desk (71.2 cm), results in similar distributions of fit because the increase in height for both chair and table are the same.

Correlation and regression analysis is used to address the question of which student characteristics (age, gender and stature) predict adjusted elbow height and therefore a fit or mismatch with desk height. Elbow height with stature correlation is stronger for males than for females. The correlation with age is similar for both males and females (Table 22).

Table 22 Correlations for elbow height

	Stature correlation	p=	Age correlation	p=
Females	.319	.027	.328	.024
Males	.615	.000	.318	.028

The regression analysis (split by gender) includes age and stature as predictor variables. Stature alone accounts for only 10-39% of the variation in elbow height and, especially for females, does not appear to be a very strong predictor of elbow height. Age alone accounts for approximately 10% of the variation in elbow height for both males and females. The standardized regression coefficients (Betas) indicate that for males, stature is a much stronger (and statistically significant) predictor of elbow height than age. For females, age as a predictor of elbow height is relatively stronger than stature although, neither is statistically significant at the 0.05 level (Table 23).

Table 23 Regressions for elbow height

	R ² Stature	R ² Age	R ² Stature w/age	Beta Stature	p=	Beta Age	p=
Females	.102	.108	.134	.198	.311	.218	.266
Males	.374	.101	.393	.720	.000	-.158	.382

T-tests for equality of means do not reveal a statistically significant difference between means for males and females with regard to elbow height.

DISCUSSION

Values for the dimensions based on gender and approximate age obtained from this study compare similarly to the values of the dimensions obtained by Malina (Panero, 1977) and Schneider (1977).

The results clearly indicate substantial variability of student dimensions and subsequent requirements for appropriately sized classroom furniture. The data also indicate that a large majority of students measured are sitting in chairs with seats that are too high and too deep and at desks that are too high.

Stature is shown to be the largest single predictor of popliteal height and buttock-popliteal length -- dimensions which determine seating fit. For this age group, neither gender nor age itself could be shown to have a statistically significant independent effect. It can be assumed that as age increases, stature will increase with many of the tallest students being males closest to or at puberty.

No single predictor for elbow height can be easily determined for males or females. Although stature accounts for almost four times as much of the variation in elbow height for males as for females (based on correlations), neither gender shows a strong elbow height/stature correlation. This may be due to the fact that elbow height is dependent on sitting shoulder height as well as upper arm length - an interaction not clearly determined by stature alone.

Knee height/desk clearance is not a problem for any student even if sitting at a desk height appropriate for elbow height.

Two desk surfaces are horizontal and all of the chair seats slope 5° backward. These two situations encourage poor posture. A horizontal desk surface necessitates leaning forward to make possible a 30° viewing angle and 36-39 cm viewing distance for students of this age group (Mandal, 1981; Diffrient, 1974). The backward sloping seat therefore, makes necessary a rounded upper back, reduced hip angle and loss of lumbar lordosis which are all contrary to proper back posture.

Statistical significance is not demonstrated in many of the regressions. The level of significance depends simultaneously on the magnitude of the observed effect as well as the sample size. Thus, with the small sample size (especially when split by gender or age) it is difficult to show a statistically significant effect at the 0.5 level even though the observed effect in the sample is quite large.

The small sample size is attributed to relatively few students returning parental permission forms in a timely manner (<30% returned). This age group is not known for great follow through. It is difficult to know whether the low return rate is due to forms lost in transit (either to home or to school) or lack of willingness on the part of the parent to endorse student participation. Of the 76 consent forms returned, only 2 did not give permission for participation. Therefore, distribution of permission forms to a larger number of students or direct mail would perhaps yield a larger sample.

SUMMARY

If manufacturers are going to continue to produce and sell traditionally designed furniture then, schools can be encouraged to provide a variety of sizes to accommodate the variety of student bodies. If offering a variety of sizes produces problems of inventory, cost, and storage then perhaps the entire design should be examined and reworked. The comfort and functional needs of the student must be addressed as well as the fiscal and practical needs of manufacturers and school districts.

Perhaps it would be wise to study the ergonomically redesigned classroom furniture proposed by A.C. Mandal and produced in Denmark. Mandal's design has a curved seat and slopes forward in front which not only encourages lumbar lordosis when sitting forward but, also transfers weight from the ischial tuberosities and places it along the legs (the longest and strongest muscles) and feet. With a forward slope to the seat, the seat height can be raised without placing pressure on the popliteal space. Taller seating facilitates greater ease in rising from a seated position to a standing position and allows teachers to help students without unnecessary bending. The back half of the seat curves back which allows the student the use of the backrest thus, a more comfortable resting position when not using the desk. Feet are supported by a foot rest on the chair (Linton, 1994).

Desks which tilt toward the seated student facilitate a more upright posture (in particular the upper thorax), a closer viewing distance (reducing eye strain), more than adequate knee clearance, and a lowered front desk height which accommodates elbow height (arm support). The overall height of the desk is adjustable to accommodate the variation in student sizes.

The study of classroom furniture for the adolescent may not be a subject generally thought to pertain to nursing. The development of community awareness to factors detrimental to health is a significant role of the APN. When APNs pursue such study, an awareness of environmental factors which affect optimal human functioning is created as well as, an awareness of the expanded knowledge and role of the APN.

Good postural habits need to be part of a school health education program. Our youth can benefit from knowing the basics of good posture and how it is achieved when seated. Allowing students to experience seated comfort at appropriately sized and adjusted furniture will develop the internal behavioral cues necessary to guide them in seeking and maintaining the comfort of a healthy posture. Schools with adjustable classroom furniture need to instruct and encourage students to adjust the chairs and desks for individual comfort and function.

As front line practitioners, the APN needs to be aware of all factors that can contribute to ailments seen in the primary care setting. This awareness is paramount to correct diagnosis and appropriate treatment. Adolescents with back and neck problems, headaches or classroom restlessness may be suffering from musculoskeletal stress as a

result of poor seating postures and not from a disease process. Factors detrimental to health can be infectious or chemical or something as simple as a chair.

APPENDICES

NOTIFICATION TO PARENTS OF EDUCATIONAL RESEARCH PROJECT

East Lansing Public Schools

This is to advise parents of a research project which will soon be conducted in the East Lansing Schools and will involve your child. A description of the project follows. Additional information regarding the project, as well as a copy of any measuring instrument which might be used, will be available in the office of your child's school. Please sign the Project Participation form to either give or not give your consent for project participation, and return to the office of your child's school. If you agree to have your child participate in the research described here but later change your mind, you have the option of withdrawing your child from the project by signing the Withdrawal from Project Form, which also accompanies the project description, and returning the signed form promptly to the school principal.

PROJECT TITLE: Classroom Furniture and Anthropometric Measurements: An Evaluation of Fit

**PROJECT RESEARCH APPLICANT: Claudia Parcels, RN, graduate student,
College of Nursing, MSU**

MAJOR PROJECT ADVISOR: Manfred Stommel, Ph.D. (MSU faculty)

ALL PERSONS WORKING WITH STUDENT(S): Claudia Parcels, RN

INCLUSIVE DATES RESEARCH WILL BE CONDUCTED: approx. 4 days in Sept. 1966

SPECIFIC PLACE WHERE RESEARCH WILL BE CONDUCTED: Physical education class

TIME TO BE SPENT WITH CHILD(REN): approx. 2-3 min. per child during one class period

WHY IS THE RESEARCH BEING DONE? This research is a thesis project in partial fulfillment of the requirements for the degree of Masters in Nursing. The purpose of the research is to determine how well school chairs and desks fit students. This determination will be based on certain body dimensions of the students and will be compared to the dimensions of the chairs and desks.

WHO WILL BENEFIT FROM THE RESEARCH? Information from this study will be shared with students, parents, educators, and manufacturers of school furniture to assist in developing an awareness of the importance students' chairs and desks have on the health of children's muscles --especially the back. The results can also be used to guide policy and decision making with regard to appropriately sized classroom furniture.

WHAT EXACTLY WILL THE CHILD(REN) BE DOING? The student will be seated on a flat surface wearing his or her own clothes (shorts, short sleeve shirt and gym shoes). Height, as well as the body measurements shown in the figure below, will be taken.

WILL THERE BE QUESTIONING, SURVEYING OR ADDITIONAL INSTRUMENTS USED THAT ARE NOT DESCRIBED? No

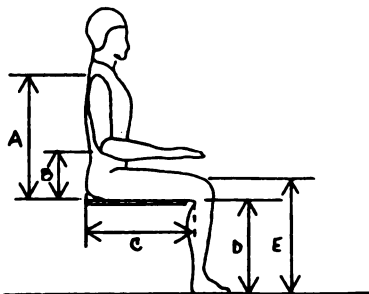
ARE YOU SEEKING INFORMATION REGARDING PERSONAL AND/OR INTERPERSONAL RELATIONSHIPS INVOLVING THE CHILD(REN) OR OTHER MEMBERS OF A FAMILY?
No

ARE THERE ASPECTS OF THIS RESEARCH WHICH COULD CAUSE OR LEAD TO EMOTIONAL UPSET FOR THE CHILD(REN) PARTICIPATING? No

SPECIFICALLY, HOW WILL THE RESULTS AND INFORMATION BE USED? The information will be used to show how well the classroom furniture fits students.

WHO WILL HAVE ACCESS TO THE INFORMATION GATHERED IN THE RESEARCH UPON ITS COMPLETION? IN THE FUTURE? A copy of the research study will be available in the school office for parents, students and educators. Additional copies will be available at MSU to those interested in research of this type. All information contained in the study will be anonymous.

WILL THERE BE WAYS OF IDENTIFYING A CHILD BY BIRTHDATE, RESPONSE, ETC.? All consent forms will be given a code #. This code number and all of the information collected will be transferred to master sheets. No names will appear on the master sheets and birth dates will be translated into age (years and months). Claudia is the only person who will have copies of the consent forms with the code number on them.



- A. Shoulder height
- B. Elbow height
- C. Buttock-popliteal length
- D. Popliteal height
- E. Knee height

WITHDRAWAL FROM PROJECT

I wish to withdraw my child _____ from the
(child's name)

Classroom Furniture and Anthropometric Measurements Project. I do not want him/her to participate in any way in this project.

(Parent/Guardian Signature)

(Date)

PROJECT PARTICIPATION
East Lansing Public Schools

I give my consent to the participation of _____ (child's name) in the research project **Classroom Furniture and Anthropometric Measurements** as described in the attached information sheet (**Notification to Parents of Educational Research**) which I have read and understand.

I understand that the purpose of this study is to determine how well classroom chairs and desks fit students. This determination is based on certain body dimensions of the students (as shown in the information sheet) and is compared to the dimensions of the classroom chairs and desks.

I have been informed that there are no health hazards or discomforts to the student associated with this study. I am aware that participation is voluntary and a student may withdraw from participation at any time without consequence. Individual measuring of the participating student will take approximately 2-3 minutes during one physical education class period with the student dressed in his or her usual physical education clothing. I further understand that all results will be treated with strict confidence and the student will remain anonymous in any report of research findings.

I have shared the attached research information with my child and his/her agreement will be obtained prior to measurements being taken. Questions and concerns can be directed to Claudia Parcels, RN at 351-8524. A copy of the research findings will be available to parents and students in the school office.

Parent or Legal Guardian Signature)

Date

Student at time of measurement

Date

I **do not** consent to the participation of _____ (child's name) in any way in the research project **Classroom Furniture and Anthropometric Measurements** described in attached information sheet.

(Parent/Legal Guardian Signature)

(Date)

LIST OF REFERENCES

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