Juvenile Computer Seating Design Recommendations and Analogs

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Abstract. This children's anthropometry and seating study, addresses the need to provide ergonomically designed and appropriately sized adjustable seating to interface with the computer workstation and accommodate physical growth. Elementary children were found in the computer laboratories of two Phoenix, Arizona school systems working at 30-inch high stationary workstation heights and seated on 14-inch high fixed chairs. Data was collected for two hundred children for seven seated measurements, stature, and weight. The resulting statistical data was compared to the findings of the 1977 Society of Automotive Engineers child anthropometry study. This Arizona study's anthropometric data was used to analyze the adjustability ranges required for chairs in grades one through six for use with 30-inch high workstations. The ANSI/HFS 100 forearm angle and eye height models were overlaid on the seat height ranges to determine the best ergonomic fit for children using 30 - inch workstation heights. The findings were condensed into seating adjustability and size recommendations for the elementary computer user population.

INTRODUCTION

Arizona schools have approximately 66,000 computers for child use. Human factors seating research focuses on the adult user in the office environment neglecting children who are being trained on computers in kindergarten through high school. Computer laboratories in Arizona schools typically consist of worktables in one fixed position (30 inches) with one standard nonadjustable chair size (Hancock, Gasket, Share). The computer monitor and keyboard are placed on this stationary worktable and the child user is expected to adapt to this setup.

Key literature applicable to this research relate to child anthropometry and human factors computer seating and interface. Child anthropometrics tables, ages 2-18 were developed from research provided by Snyder (1977), from the United States, and Pheasant (1986), from Britain. Chair design data was taken from Steinbekkers and Molenbroek (1990), study of 633 Dutch children. The Human Factors Society (ANSI/HFS- 100, 1988) provides adult computer and seating interface standards.

Child seating measurements are needed to design adjustable seating for ergonomic interface with stationary worktables. The objective of this study is to collect and analyze statistically measurements and observations and to create seating specifications for the 5th and 95th percentiles within the first through sixth grade student sample population. This study purpose is to present computer educators, administrators, and designers the results and recommendations for child seating. A failure to recognize

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and understand juvenile seating human factors may lead to long term health problems of young computer users, our greatest future resource.

METHODS

Participants. Two schools with computer labs were selected serving distinctly different community populations in Arizona.

The Paradise Valley School District is a predominantly upper and middle class, white community. Eagle Ridge Elementary is situated in the western portion of the Paradise Valley School District and located in a recently developed housing community. The school has a population totaling 663 first through sixth grade students with 51% male and 49 % female ratio spread throughout the grades.

San Marcos Elementary school has a computer curriculum for students starting from Kindergarten through the sixth grade and its population is made up of 378 males and 373 females for a total of 751 students. Located in Chandler, Arizona, the school offers a more diverse population made up of middle class families and a more traditional rural population of lower income families working on farms of multi-cultural descent.

Procedure. Measurement of the Eagle Ridge school children required permission from the Paradise Valley School Board, assignment of random numbers to the school sample, and signed permission letters from the parents of students. All measuring was done in a public atrium area. In contrast, the Principal of San Marcos made all volunteering students available for the study. All measuring was done in a computer lab classroom.

The seven data points chosen are from the 10 data points the ANSI/HFS 100-1988 recommends plus the Standing height and Weight of each student. The seven Arizona data points are: 1. Buttock-popliteal distance, 2. Elbow rest height, 3. Eye height-sitting, 4. Hip breadth-sitting, 5. Popliteal height, 6. Shoulder breadth, and
7. Sitting height.

The following equipment will be used in this study: 1. A video camera (Camcorder), 2. A Branch Anthropometer, 3. A student built Anthropometer Chair System, 4. A 24 inch steel rule in 1/16 inch increments, and 5. A home Medical Scale.

RESULTS

Data Analysis. All 193 students in the study had their ten measurements entered onto a survey form. The data was then entered into StatView 512 Macintosh Software for analysis. Separate table sets were created for each of the two schools by grades one through six, each containing all of the nine body measurements. From these tables a second set of tables containing the nine measurements were created by grade to compare the two schools (n.) and (s.d.). Six data points from the Snyder (1977) study were also included for comparison.

To combine the data requires some evidence that the students in the two schools were similar in characteristics. An ANOVA test for each of the nine data points between Eagle Ridge and San Marcos schools was computed for grades 1 through 6, for a total of 54 analyses. In no case was there a significant difference between schools ($p < .05$). Two of the F tests were marginal, with p

approximately .07, but the majority of the comparisons showed high p values. A careful examination of the data revealed no systematic differences between schools. For the purposes of this study, these results suggest that the two data sets can be combined to create percentile tables for chair design recommendations.

The combined data from the two Arizona Schools were then compared with data from a larger sample in the United States. The Snyder (1977) study was chosen as a comparative benchmark against which to overlay the Arizona Study's findings. The Snyder (1977) study did not include the raw data that would allow a statistical comparison. It did provide scatter-plots of their measurement data along with mean values and values for the 5th, 50th and 95th percentiles in centimeters. To compare similar data points, the Arizona combined data means were converted to centimeters and their values plotted over the Snyder (1977) study's scatter-plot.

A review of the scatter-plots and the tabular data reveals that Arizona combined data has slightly higher mean values overall than the scatter-plot data for eye height, hip breadth, standing height and weight. The Arizona mean values for shoulder breadth and sitting height were more nearly overlapping the scatter-plot means. Possible explanations for the slightly higher Arizona values (1/2 inch to over 1 inch) can be attributed to clothing being worn during all phases of measurement. Weight would increase as much as five pounds due to clothes and could significantly distort hip breadth.

Percentile Tables and Bar Charts. The analysis of the data from the combined grades 1 through 6 produced Z scales with consistency in the data to ± 2 standard deviations ($z = 1.96$) from the mean. The confidence level in the data representation of the population for each measure is 95 percent, assuming that the population is normal. Percentile Bar Charts representing the combined data from grades 1 through 6 were created. (Figure 1.) Each grade's combined data was outlined by a rectangle encompassing the appropriate data points for 5th through 95th percentile. This overlay technique provides a graphic comparison of how the 5th and 95th percentile data for each grade spans across the entire combined school population sample. The four critical measurements chosen to determine seat adjustment ranges are: 1. Eye height sitting. 2. Buttocks-popliteal height. 3. Popliteal height. 4. Elbow height sitting.

Models. Zero Degree Eye Height Model verses The Forearm Angle Datum Model. Figure 1 shows the results of comparing the two ANSI/HFS-100, 1988 models in the context of the San Marcos Elementary School fixed work surface with keyboard, an Apple II processor, and 13 inch monitor. The Eye Height Model was a less satisfactory solution as compared to the Forearm Angle Model.

The Forearm Angle Model recommends that the seated user be able "to adopt a posture with the forearm between 70 + Y/2 degrees and 90 + Y/2 Degrees from the superior frontal plane, where Y is the seat back angle from the vertical in degrees. Conventional workstations (one surface for keyboard and monitor) adjustments are to be determined by using "anthropometric data and seat to keyboard relationships" (HFS/ANSI-100). The chair components are adjusted to meet the requirement in the adult standards of a minimum 70-degree angle to be maintained by the forearm while addressing the keyboard. The seat pan height is derived from the elbow height after setting the minimum forearm angle of 70 degrees. The eye heights and the popliteal heights are derived from the seat pan height. The seat pan depth is derived from the buttocks-popliteal length similar to the previous model.

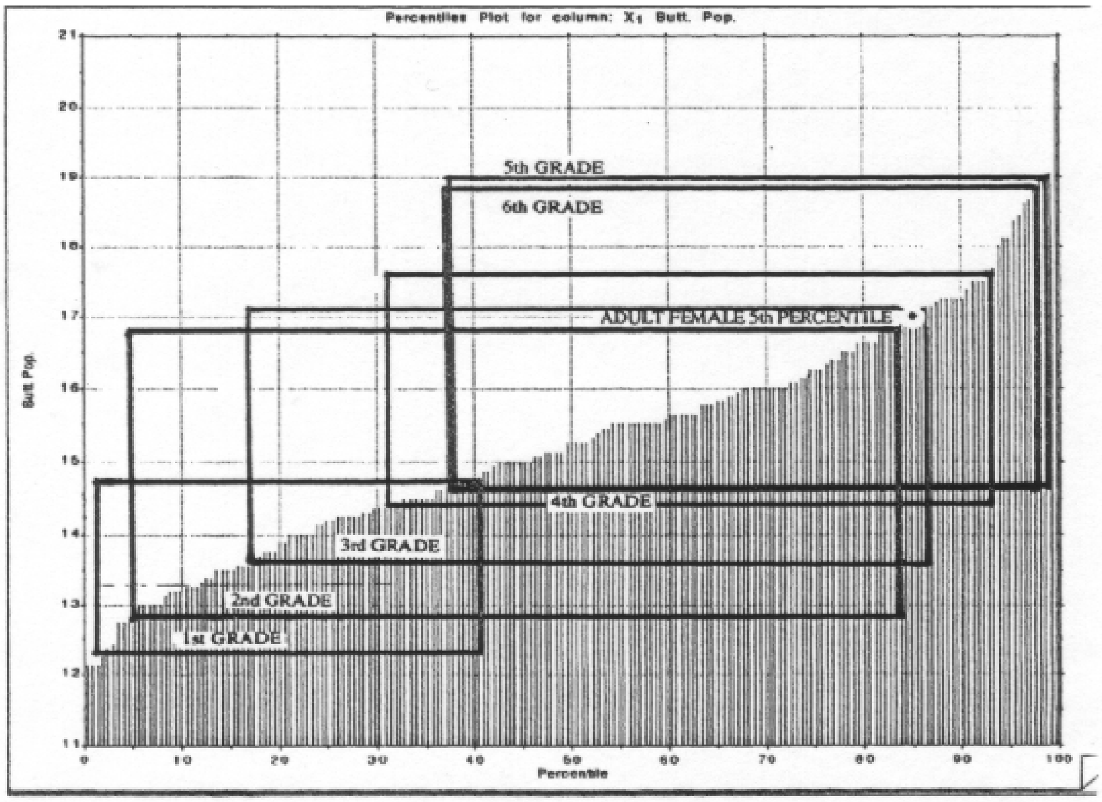

Figure 2. Buttocks-Popliteal Percentages Graph with Grades 1-6 percentile overlay sample

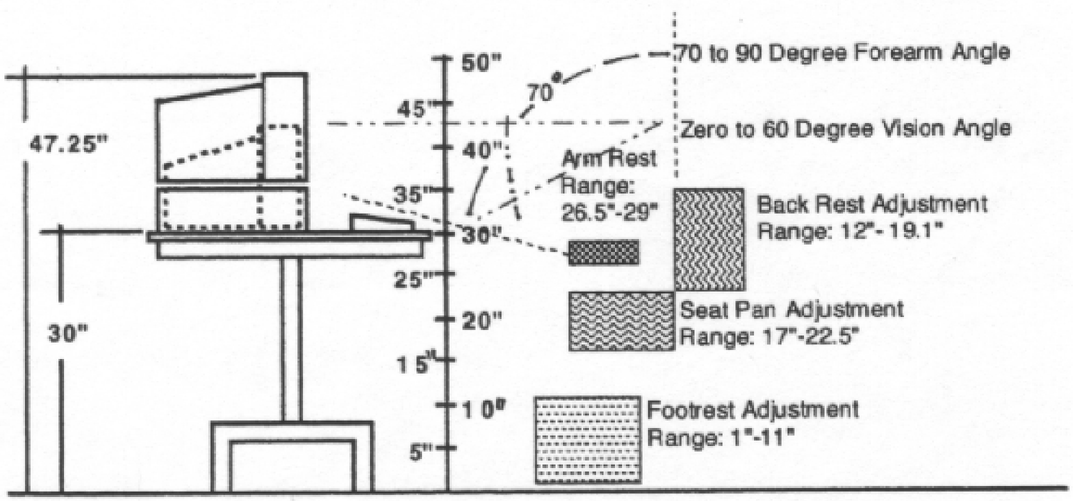

Figure 1. A 2-D Analog Recommending Adjustment Ranges for Proposed Seating Using the Forearm Model

CONCLUSIONS

The Forearm Angle Model used in conjunction with the fixed worksurface of 30 inches accommodates the multiple interface variables required of juvenile computer seating. This model provides a usable under worksurface clearance envelope of 5.5 inches for the 5th percentile 1st and 2nd graders and other 5th percentile users. The thigh clearance for a 5th percentile female adult is 4.5 inches (Panero and Zelnik, 1979).

The eye height sitting values are below the recommended zero degree viewing plane for all the grades in the present school computer monitor configuration. However, this discrepancy can easily be remedied by taking the monitor off the processor case and placing it on the table surface. With the monitor lowered, all users meet the zero degree to 60 degree viewing angle recommended for adult users.

The popliteal heights remain the same as in the eye height model, but the seat pan range value drops 3 inches. This reduction in seat pan heights and subsequent popliteal distances reduces the height of supplementary foot supports from 14 inches to 10 inches for 5th percentile users.

Discussion. The primary task of recommending seating standards for juveniles in the fixed furniture school environment must be done in the context of the work surface height and its subsequent influence on the monitor screen height. The seat having been set to meet these constraints may require supplemental foot support.

The adult recommendations prefer the use of adjustable furniture as the best way to accommodate and support the multiplicity of computer user sizes. The juvenile computer user will benefit from adjustable furniture, also.

Study Limitations. Some of the differences found in data comparisons between the Arizona study and the Snyder, et al, study may be attributable to less exacting measurement equipment and to measurement techniques. All of the Arizona students were fully clothed and the data was hand measured and recorded. In contrast, the national study had computerized anthropometers and the subjects only wore undergarments.

The weakness of the study is the limited population and the small sampling. The samples came from two schools from two school systems in Maricopa County, Arizona. A total of 193 students were measured. A larger sample with many more schools visited would provide information about the sophistication of the computer laboratory furniture and the children who use these facilities.

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