

## A Survey Study of Ergonomic Perceptions among University Students in Middle Tennessee

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The authors would like to express their gratitude to Joshua Freeman for his contribution in survey design and all graduate students in the Safety Planning course for their assistance in data collection.

**Abstract:** This paper presents a survey study conducted to explore the ergonomic perceptions of university students, a largely understudied topic compared to the workforce and K-12 classroom ergonomics. We investigated the physical, environmental, and cognitive factors experienced by students in various classroom settings at Middle Tennessee State University, with the goal of assessing their impacts on students' level of satisfaction, attention, and learning efficiency. The survey questionnaire covered demographic information (i.e., gender, year of study, age, height, weight, and musculoskeletal disorder history), ergonomics pre-knowledge, physical factors (i.e., workstation fit and comfort, computer use, and accessibility), environmental ergonomics (i.e., noise, indoor air quality, lighting, and interior design), and cognitive ergonomics including class duration and number of breaks. Data was collected from 838 undergraduate students across multiple majors and colleges. Descriptive analysis, t-tests, one-way ANOVA, and single regression models were employed for data analysis. Findings indicated that students' workstation fit and comfort were rated moderately (average of 3.75 and 3.50 respectively on a scale of 1-5), with adjustable workstation being significantly preferred. Accessibility and visibility of learning tools and technology were generally satisfactory, but over half of the computer users reported that viewing distance was either too short or too long. 42% of participants felt workstation-related discomfort in longer durations after the class, and 62% of students admitted to being unaware of proper classroom ergonomic conditions. Rating of level of satisfaction regarding the environmental factors was the highest for lighting (3.80) and the lowest for interior design (3.03); the overall environmental comfort was rated as 3.55. Environmental factors explained 30% of variation in the ratings for overall comfort. The ratings of ventilation were significantly different for normal versus overcrowded classrooms. The quality of thermal condition was not significantly different for female and male students in classroom. There was a significant difference in class load rating between 1-hour and 3-hour classes, and class load rating may improve for longer classes with one or more breaks. The results confirmed that the ergonomic factors that might affect the students' level of satisfaction are not necessarily the same as those that affect their attention and learning efficiency.

*Keywords:* University students, Ergonomics, Perception, Class load, Environmental comfort

## 1. Introduction

The role of ergonomics in higher education environment is a largely under-researched topic. While physical and environmental factors have been extensively examined in the context of the workforce, there is a noticeable gap in the literature regarding university students. Most of past studies on learning environments primarily concentrated on children and young adults in grades K-12, mainly focused on micro-ergonomics. As university students spend their time between numerous environments, while children in K-12 remain in the same or very similar classrooms, the ergonomic risks and impacts may be different. Those impacts can give rise to persistent and recurring injuries that may be exacerbated within future occupational environments. More students are now permitted or required to use a laptop during class. Limited studies have assessed the pattern of computer use and the prevalence of computer-related musculoskeletal disorder (MSD) symptoms among undergraduate university students [(Dockrell et al., 2015), (Kanchanomai et al., 2012), (Schlossberg et al., 2004)]. The results showed that year of college, average daily computer use, and gender were among the important factors affecting the increased musculoskeletal symptoms. Students frequently adopt a forward-bending posture while sitting for long periods of time, which places significant physiological strain on the muscles and ligaments (Zunjic et al., 2015), and may result in severe posture problems in adulthood (Odunaiya et al., 2014).

Environmental and cognitive factors, including temperature, humidity, noise, and lighting, along with classroom layout and technology integration can significantly impact students' comfort, productivity, and overall well-being in university classrooms and labs (Ricciardi & Buratti, 2018). However, these factors have been relatively understudied compared to their physical counterparts. Through field measurements, survey questionnaires, and predictive models, it was found that population density is an important factor affecting the temperature and relative humidity variations in university classrooms [(Zhang et al., 2022), (Fantozzi et al., 2021)]. Moreover, women had a higher preferred temperature in comparison to men (Nico et al., 2015). The review study by Zomorodian et al. (2016) indicated that currently used thermal comfort standards, such as ISO 7730 and ASHRAE standard 55 are not necessarily appropriate for the assessment of thermal conditions in university classrooms. Therefore, perceptive studies are essential for assessing the ergonomics of classrooms as they provide valuable insights into students' preferences, subjective comfort, and individual variability.

Excessive reverberation, low speech at the back of rooms, and noisy ventilation systems have been reported in perceptive evaluations of listening environment by university students (Ricciardi & Buratti, 2018). Students preferred daylight and control over natural and artificial lighting levels and directions. In a subjective assessment by Castilla et al. (2017), students' affective responses to classroom in their own words (with the help of keywords previously defined by researchers) were analyzed to identify the design elements that generate more positive response. They concluded that classroom functionality-layout, related to personal workspace for students, and sensation of cozy-pleasant, which refers to relationship of the classroom with the outdoor environment, were the main two design factors. Yang et al. (2013) asked students to separately rate the level of satisfaction and impact of classroom physical attributes on learning using a double Likert scale. It was found that ambient, spatial, and technological factors, which result in students' higher level of satisfaction, did not necessarily lead to optimal student performance. Although previous studies have found linkages between indoor environmental quality (IEQ) factors and students performance (Choi et al., 2014), more research needs to be done to confirm such correlations.

In this research study, we designed a comprehensive survey questionnaire to evaluate undergraduate students' perception of physical, environmental, and cognitive ergonomic factors in a diverse range of classrooms at Middle Tennessee State University campus in Murfreesboro, Tennessee. Physical properties including workstation fit and comfort, accessibility and visibility of learning tools, environmental factors including noise, thermal condition, ventilation, interior design, and lighting, and cognitive factors such as class load and duration were evaluated. The objective was to assess the impact of three ergonomic domains on students' level of satisfaction, attention, and learning efficiency through statistical analysis of perceptive survey results. This study marks the initial endeavors to evaluate the human factors within MTSU campus.

## 2. Methods and Procedures

Details of survey instrument, participants, and data collection and analysis are provided in the following sections.

### 2.1 Survey Instrument

The study design involved a survey, which examined the undergraduate students' perception of ergonomics factors in classrooms located in Middle Tennessee State University campus. The designed survey used a questionnaire comprised of four main sections evaluating the physical, environmental, and cognitive ergonomics domains. First section included questions of demographic information regarding gender, year of study, age, height, weight, musculoskeletal disorders (MSDs) history, and

participants' familiarity with the ergonomic concepts. Second section focused on physical ergonomics assessing the workstation fit, level of comfort and adjustability, accessibility, and visibility of learning tools. Participants were asked to rate the physical factors using Likert scale of 1-5, with 1 being least favorable and 5 being most favorable conditions. Occupants who worked with computers in the classroom evaluated the viewing distance, viewing angle, and screen height. Next part of the questionnaire asked participants to rate their level of satisfaction with environmental factors in classroom including noise, thermal condition, ventilation, humidity, lighting, and interior design. Cognitive factors in the classroom environment were evaluated in the last section by questioning the participants to evaluate the class duration and number of breaks and rate the overall class load. Considering the physical, environmental, and cognitive domains, students were inquired to rank all ergonomic factors by the level of impact on their attention and learning efficiency on a scale of 1 to 8, 1 having the least impact, and 8 having the highest impact. They also rated the overall level of comfort while attending the class on a scale of 1 to 5.

## 2.2 Participants

Undergraduate students from a wide range of majors and colleges participated in this study. A total of 17 buildings at MTSU campus were selected, where most on-ground classes were held, and 838 undergraduate students attending the classes completed the questionnaire, with the overall response rate of 68.1%. The response rate was calculated considering the number of eligible students in classrooms and number of responses. Incomplete surveys were excluded during the data sorting process.

## 2.3 Data Collection

Ethics approval was obtained from the Office of Compliance, Institutional Review Board at MTSU. Instructors in selected classrooms were contacted in advance to permit a 10-15 minute survey during class time. Hard copies of surveys were distributed among students. Participants were provided with information about the purpose and nature of the questionnaire, confidentiality, and how the data would be used. Participation in this study was voluntary, and written consent was obtained for all participants.

## 2.4 Data Analysis

Descriptive analysis included percentages, mean, and standard deviation to analyze the rating results. Hypothesis testing via two sample t-test and one-way ANOVA, as listed below, were performed to analyze the differences in:

- workstation fit rating for male versus female students,
- level of comfort for adjustable versus non-adjustable workstations,
- workstation fit for different height groups of male and female students,
- accessibility for different sitting distances (< 5', 6'-10', 11'-15', 16'-20', >21'),
- thermal comfort rating for male versus female students,
- ventilation rating for different levels of classroom occupancy density (under-crowded, normal, overcrowded),
- class load rating for students who felt workstation-related discomfort in long-term versus those who did not,
- class load rating for different class durations (1 hr, 2 hr, 3 hr, > 3 hr) and for different number of breaks (0, 1, 2, >2).

Single linear regression models were performed to examine the correlation between overall comfort rating with a series of factors including workstation fit, accessibility, environmental comfort, and class load. Also, the correlation between overall environmental comfort and noise, thermal condition, humidity, ventilation, lighting, and interior design was analyzed to have a better understanding of impact of each environmental factor on the students' level of satisfaction. The statistical analysis was conducted using Minitab 18. Statistical significance at  $p < 0.05$  was assumed.

## 3. Results

### 3.1 Demographics

Eight hundred thirty eight (838) questionnaires were completed in this analysis. The proportion of students in year 1 to 4 was 31% (n=257), 22.5% (n=189), 22% (n=187), and 24.5% (n=205). Participants were from various colleges across the campus including Basic and Applied Sciences, Engineering, Behavioral and Health Sciences, Business, Education, Liberal

Arts, and Media and Entertainment. The random sample comprised approximately equal number of male (51%) and female (49%) students. Majority of undergraduate students were in the range of 18-24 years old (~85.6%), followed by 25-34 (7.6%), <18 (4.5%), 35-44 (1.5%), and 45-54 (0.7%). The height peak was in the range of 5' 8''- 5' 11'' for male participants, and between 5' 4''- 5' 7'' for females. The height ranges were used to compare the workstation fit for male and female groups. The average weight of male students was 182.15 lb with a standard deviation of 44 lb. Female students had an average weight of 151.21 lbs. with a standard deviation of 39 lb.

The majority of students (~88%) did not have musculoskeletal disorders (MSDs) history unrelated to the classroom setting, while approximately 7% of participants were not sure if they did. Students' prior knowledge of ergonomics was assessed, and over a third of students did not know about the ergonomic concepts before completing the survey. Also, 62% of students confirmed that they were not aware of appropriate ergonomic conditions in classroom. These results showed a high potential to educate university students about the impacts of human factors on learning and job efficiency, as the future workforce.

## 3.2 Physical Ergonomics

### 3.2.1 Classroom Workstation

The students' rating for workstation fit and workstation comfort are summarized in Figure 1. The majority of students rated 3 and 4 for both parameters, resulting in an average of 3.75 for fit and 3.50 for level of comfort. Workstation fit rating for male and female was not statistically different ( $p=0.589$ ). Over half (55.4%) of students reported using adjustable workstation in classroom, and the difference in level of comfort for adjustable versus non-adjustable workstation was significant ( $p=0.001$ ). It was observed that the quality of workstation fit was not significantly different for students in different height categories for both male and female groups (Male:  $p=0.488$ ,  $F=0.86$ , Female:  $p=0.091$ ,  $F=2.02$ ). Only 12.1% of variation in the overall level of comfort was explained by the workstation fit.

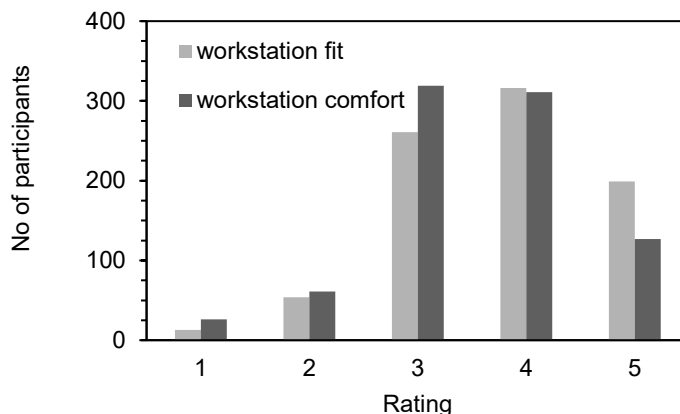


Figure 1. Ratings of workstation fit and workstation comfort

Students who used computers in the classroom ( $n=164$ ) reported on viewing distance, viewing angle, and screen height. Less than half (49%) of computer users reported the viewing distance was appropriate, while it was too short or too long for the rest. Viewing angle was set properly for 47% of students, and the monitor was at an appropriate height for 48% of the sample size, while others reported a too low or too high condition. 42% of students answered yes to the question that if they have ever felt workstation-related discomfort in longer durations after the class, while 58% did not have such an experience.

### 3.2.2. Accessibility

Majority of students (79%) expressed that they did not have to perform any activities or communications in the classroom, which need an excessive reach and awkward posture, or cause discomfort. In response to the question that how

visible/accessible the learning tools (e.g., board, projector screen, monitor) were in the room, the rating distribution was 36.6%, 32.4%, 26.1%, 4.7%, and 0.23% from 5 to 1 respectively, with an average of 4.0. It was found that the sitting distance (Less than 5' / 6-10' / 11-15' / 16-20' / 21' or more) did not make a significant difference in the level of accessibility in classroom ( $p=0.55$ ,  $F\text{-value}= 0.76$ ). 8.1% of variation in the overall comfort was explained by accessibility factor.

### 3.3 Environmental Ergonomic Factors

Students' perception of overall environmental condition in classroom and the detailed factors are summarized in Figure 2. The average rating for noise, thermal condition, humidity, ventilation, lighting, interior design, and overall environmental condition was 3.55, 3.35, 3.70, 3.50, 3.80, 3.03, and 3.55 respectively. Comparing different environmental factors, the highest level of satisfaction was measured for lighting in classroom, while the lowest rating was reported for interior design. Among single environmental factors, interior design ( $R^2_{adj}= 24.3\%$ ) and lighting ( $R^2_{adj}= 18.6\%$ ) had the highest correlation to the overall environmental comfort. However, none of those factors showed a strong correlation. The environmental comfort explained 30% of variation in the overall comfort rating. The survey included more questions about some factors including noise and ventilation. It was found that most of the noise pollution during the class time was intermittent. 85% of students reported the class occupancy density as normal, while 10% thought it was overcrowded. The rating of ventilation was significantly different for normal versus overcrowded conditions ( $p=0.018$ ,  $F\text{-value}=4.06$ ). Despite findings of some of the past studies, the quality of thermal condition was not significantly different for female and male students in classroom ( $p= 0.451$ ).

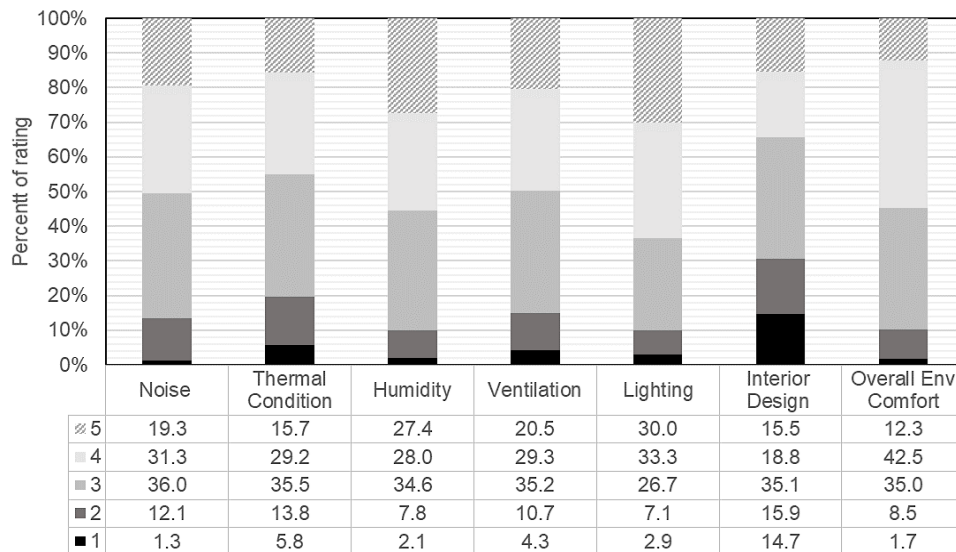


Figure 2- Distribution of Ratings for environmental factors

### 3.4 Cognitive Factors

The Level of satisfaction with class duration, number of breaks, and overall class load were gauged on a scale of 1 to 5. Majority of participants took either 1- or 2-hour classes. 40.8% of participants took 1-hour classes with an average rating of 3.82 on class duration, while 45% rated 2-hour classes at 3.64. For 3-hour classes, 11.5% of participants rated them at 3.41, and classes that exceeded 3 hours received an average rating of 3.75. There was a significant difference in class load rating between 1-hour and 3-hour classes ( $p=0.009$ ,  $F=3.88$ ), and not for classes longer than 3 hours. Looking at Table 1, which summarizes the number of breaks for various class durations, approximately 40% of 3-hour classes had no breaks, while 90% of >3-hour classes had at least one break. Hence, class load rating may improve for longer classes that include one or more breaks. There was a significant difference in the class load rating of students who experienced pain and discomfort in longer term after class and those who did not ( $p=0.001$ ).

Table 1. Frequency of number of breaks for different class durations

No. of breaks	1-hour Class	2-hour class	3-hour class	>3 hour class
0	323	350	40	2
1	18	28	48	12
2	3	3	8	3
>2	2	0	0	2

Students were also asked to rank all the discussed physical, environmental and ergonomic factors in terms of the impacts on their attention and learning efficiency. They reported the class load and duration as the most important, followed by noise and workstation fit. The least influential factor in the list was known to be the interior design. As mentioned earlier, among environmental factors, the lowest satisfaction rating and highest correlation with overall environmental comfort was reported for interior design. However, only 8% of variations in overall comfort was explained by the class load. This confirms the previous findings that ergonomic factors related to students' level of satisfaction and learning efficiency might not be necessarily the same.

#### 4. Discussions and Limitations

Combination of measurements and perceptive surveys may provide a more complete overview of ergonomic factors in learning environment. In case of thermal comfort, the role of adaptive human parameters (i.e., clothing level and metabolic rate) should be considered in the future studies. To generalize the thermal comfort conditions, studies should be done throughout the school year (this study was completed only in the fall). The effect of environmental and cognitive factors such as class interior design and lay-out, class duration and breaks need further assessment.

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