Lesson Title	Anthropometry of Chair Design
Length of Lesson	1 day (50 min)
Created By	Kylie Nash
Subject	Math
Grade Level	9^{th} -12^{th} (Geometry)
State Standards	Geometry:
DOK Level	DOK 2 Geometry
DOK Application	DOK 2 – Predict , Interpret, Summarize, Show, Construct, Relate, Solve, Design
National Standards	9^{th}- 12^{th} Geometry, Algebra
Graduate Research Element	Human Factors & Ergonomics: Anatomy and Biomechanics

Student Learning Goal:

State Standards for 9^{th} – 12^{th} Geometry: Geometry

2a) Represent data from geometric and real-world contexts with expressions, formulas, tables, charts, graphs, relations, and functions. (DOK 2)

3i) Given the pre-image or image, find figures obtained by applying reflections, translations, rotations, and dilations; describe and justify the method used. (DOK 2)

National Standards for 9^{th} -12^{th} Geometry and Algebra Standard:

- Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools
- Explore relationships (including congruence and similarity) among classes of two- and three-dimensional geometric objects, make and test conjectures about them, and solve problems involving them
- Use geometric ideas to solve problems in, and gain insights into, other disciplines and other areas of interest such as art and architecture.

Students will be able to solve routine geometric multiple step problems based on given information about anthropometry and existing information on measurement data collection. Students should be able to design a solution to a problem given supporting data. They should be able to organize, represent and interpret data to the class on the topic of optimal chair design.

Materials Needed (supplies, hand-outs, resources):

Writing utensils, paper, desk chair, desk, tape measures, graph paper, calculator

Lesson Performance Task/Assessment:

Students will measure different measurements of a chair, make and design a chair that is ergonomically designed for high school students based on the measurements collected from their classmates. Students will be able to practice designing shapes, taking

measurements, understand the symmetry of the design, and make assumptions on different types of designs that are best for people. Students will produce mock-up or sketches of their chair design. They should be able to explain their design to classmates and explain why their chair has the best design.

Lesson Relevance to Performance Task and Students:
Allowing students to design chairs based on class data will introduce them to data collection and strengthen team building skills. Students also get exposure to Industrial Engineering concepts, engineering areas of research and engineering job tasks. This activity will build their critical thinking skills and enhance their problem solving skills for determining how to design structures that directly impact them and their community. Simulating real world applications will help strengthen math skills and engineering design concepts to students as well as how math, specifically geometry can be applied to real world applications. Increase understanding the function follows form of how different geometric shapes and designs are better than others. Through the use of hands on activities to synthesize and interpret concepts learned in the classroom.

Anticipatory Set/Capture Interest:
Students will be divided into groups of 3 to 4 and told that they are part of a team of Industrial Engineers assigned to the Human Factors and Ergonomics Department. Their job task is to design a chair for the average high school student. The team with the best design will get the honor of having the chair named after their team name. Students will then be introduced to different styles of chair design by showing photos of existing chairs and showing different construction types as well as what kinds of conditions need to be considered when building a chair.

Guided Practice:
The instructor will give an introduction to types of chair design and basic topics on anthropometry (Antropometry.pptx.) Then the instructor will place a desk chair on top of a desk in a centralized place in the room or at each table if possible, so all students can see. * Instructors should note that anthropometric tables exit that categorize the three percentile ranges according to male and female and should only be included for advanced level classes.

All students should record measurements on provided handout (antropometry_data.docx) to use later. Then the instructor will pose questions concerning engineering design considerations for various structures, symmetry, shapes and weight distribution of the different shapes. The instructor will discuss how this application can be applied to other real world applications. This activity is specifically focused on seat height and angles.

The instructor will also lead the discussion using the questions listed below:

1. How many of you know what a Human Factors and Ergonomics Engineer does?

2. What shapes are used to build chairs seats?
3. Who do we need to consider when building the seats chairs?
4. What body parts do we need to consider?
5. What are required clearances or distances for legs?
6. What materials/technology is available?

The instructor will tell students to measure the length of each group members lower leg distance (floor to back of bend in knee) and then upper leg distance (from bend in knee to waist). The instructor will then tell students to individually record measurements in the same units (cm, in, ft, discretion up to instructor) on a sheet of paper.

Chair Measurements:

- Chair back (height & angle)
- Chair seat (height from floor, length and width)
- Chair arm rest (height & length -if available)

While students are taking measurements on the chair, the instructor should collect measurements from all the groups and find the average lengths for both upper and lower legs divided into males and females. For averaging purposes the upper and lower length can be add together to create one number. Ex. Male (upper leg=100 in., lower leg= 28in), then the male leg length is 128 in. (If time permits students can be involved in the averaging process)

The instructor can then put up the averages for the (lowest average) 5^{th}% and 95^{th}% (highest average) Male and Female averages for both upper and lower legs measurements; * arbitrarily pick one student in case of tie. Once the students have finished collecting chair measurements, then the students with the high and low, both male and female should sit in the model chair to show the physical differences among the four groups.

Ask students to think about those measurements and design an ergonomic chair that will work for both females and males, mainly focusing on the design of the seat, the back and arm rests will serve as aesthetic features. *Remind students that researchers typically design for the 95^{th}% male and 5^{th}% female and they will have to justify their chair to class briefly 3-5 minutes.

Independent Practice:

Students will divide into groups and take measurements of groups' members upper and lower leg body parts and record them on their handout. Each team will also take measurements of the models chair the teacher has station in the classroom or individual chairs at their stations. After students have calculated averages or been told averages then they will design a chair based on the requirements of male and female design principles to design a chair using graph, approximately 30 to 40 minutes. Students will present the result to class describing who they design for, explain the measurements and

design. The winner will be determined with the best design or plan deemed sufficient by the instructor or class vote.

Remediation and/or Enrichment:
Remediation:
Individual IEP, Don't allow students to derive averages

Enrichment/Extension :

- Allow students to derive the averages

Extend to a second day:

- Add upper body measurements (torso and arms)
- Design entire chair for entire body parts
- Apply same principles to other objects (table design, keyboard design, etc)

Check(s) for Understanding:
1. Discuss the connections between styles of chair seats and lengths of legs parts.

2. Why is it important to measure upper and lower legs parts separately?

3. What shape is the strongest for chair design?

4. How many chairs could fit into the classroom?

5. Is it feasible to design for ever human body style? Why or why not?

Closure:
Discuss some real world applications (who, what, when, where and how) that would benefit from understanding concepts related to geometric shapes, the design of chairs and anthropometry.

Possible Alternate Subject Integrations:
Physics
Health/Anatomy & Physiology
Physical Science

Teacher Notes:
Reference Sources:
http://www.ergoeg.com/uploads/books/Introduction%20to%20Human%20Factors.pdf.

http://www.ergonomics4schools.com/lzone/anthropometry.htm