Performance Based Learning and Assessment Task

Box-and-Whisker Activity

I. ASSESSSMENT TASK OVERVIEW & PURPOSE:
Students will: 1)design a study in which they are to collect and compare at least two univariate datasets, 2)calculate measures of central tendency and dispersion, 3)construct at least two box-and-whisker plots, 4)design questions from the plots in order for their class to compare, contrast, and analyze their data.

II. UNIT AUTHOR:
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III. COURSE:
Algebra I

IV. CONTENT STRAND:
Statistics

V. OBJECTIVES:
The student will be able to: 1)Collect and compare univariate datasets, 2)Calculate measures of central tendency and dispersion, 3)Construct box-and-whisker plots from real-world situations, 4)Design questions to compare, contrast, and analyze box-and-whisker plots, 5)Present, organize, and communicate answers and conclusions

VI. REFERENCE/RESOURCE MATERIALS:
Students will need access to a laptop, class notes, notebook paper, writing utensils, a straightedge, a "Box-and-Whisker Activity" packet, a calculator, and poster board.

VII. PRIMARY ASSESSMENT STRATEGIES:
The task includes an assessment component that performs two functions: (1) for the student it will be a checklist and provide a self-assessment and (2) for the teacher it will be used as a rubric. Students will be assessed on their study design, their understanding and calculations of central tendency and dispersion, and their box-and-whisker plots, the level of difficulty of their questions, the preparation of their presentation, how effectively they communicate the answers and conclusions of their study, and their participation and self-evaluation.

VIII. EVALUATION CRITERIA:
A self-assessment and a teacher assessment are attached below. A benchmark is also included at the end of the document in order to demonstrate the level of quality that is expected from each group of students.

IX. INSTRUCTIONAL TIME:
Three ninety-minute class sessions.

Box-and-Whisker Activity

Strand
Statistics

Mathematical Objective(s)
The mathematical objectives for this activity are to give students the opportunity to collect and compare univariate datasets, calculate measures of central tendency and dispersion, and construct and analyze box-and-whisker plots in a real-world context.

Related SOL
A.10 (The student will compare and contrast multiple univariate datasets, using box-and-whisker plots)

NCTM Standards
- Apply and adapt a variety of appropriate strategies to solve problems
- Create and use representations to organize, record, and communicate mathematical ideas
- Understand and apply basic concepts of probability
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Develop and evaluate inferences and predictions that are based on data

Materials/Resources
Students will need access to a laptop in order to research and begin designing an analysis of univariate data. Students will use class notes to check the definitions of the minimum, first quartile, median, third quartile, maximum, and to verify the methodology for identifying outliers. The student will also need class notes to be familiar with the range, interquartile range, and percentages in order to compare and contrast the univariate datasets. Students will need notebook paper to collect their data and a pencil to record their data into tables. Additionally, a calculator will assist in identifying outliers and calculating the range and interquartile range by hand. Students will need poster board, a straightedge, and markers to construct at least two box-and-whisker plots. Finally, students will complete a data sheet from the "Box-and-Whisker Activity" packet each day to ensure all objectives are met according to the timeline.

Assumption of Prior Knowledge
- Students should understand what univariate data is and how to analyze it. Students should have a basic understanding of outliers and the modes of central tendency and dispersion.

Additionally, students should have an idea of how to construct and compare box-and-whisker plots.

- Students may have difficulty creating five thought-provoking questions from the box-and-whisker plots in order for the class to compare, contrast, and analyze their data. The teacher may need to provide examples and additional support during the creation of these questions. Furthermore, teachers may need to provide additional guidance when students are attempting to recall outliers, the interquartile range, and percentages of box-and-whisker plots. Often students have difficulty identifying outliers, removing outliers, and understanding the effects of outliers on the skew of their data.

Introduction: Setting Up the Mathematical Task

In this activity, you will investigate the relationship between multiple univariate datasets using box-and-whisker plots. The Box-and-Whisker Activity should take no longer than three ninety-minute blocks.

For this activity, you will be collecting data in order to create at least two univariate datasets. The goal is to be able to compare the univariate datasets using box-and-whisker plots. At this point, the teacher should ask the students, "How many students remember what a univariate dataset is?" Allow the students to think for a few moments and respond. The teacher can then present a model of a real-life situation by pulling up two tables of univariate data that can be compared. For instance, the teacher could compare and contrast tables that show the time it takes drivers to get to school with the time it takes non-drivers to get to school. The teacher should then prompt the students to recall what measures of central tendency we need in order to construct box-and-whisker plots and what additional measures of dispersion we need in order to compare box-and-whisker plots. It is also a good time to review percentage "rules" of box-and-whisker plots.

In order to eliminate confusion, the teacher should display two tables of univariate data that cannot easily be compared. For instance, the teacher could show a table of the time it takes females to get ready for school and ask the class to compare it to the number of siblings male students have. This would show the students an inappropriate research design for comparing univariate datasets.

After the initial ten-minute discussion, students will be placed in groups of two or three by the teacher in order to produce workable, productive groups. The groups will then obtain a detailed timeline of what is expected. The students will have fifteen minutes to read through the instructions and discuss them with their group. After fifteen minutes, the teacher will hold a

five-minute question and answer session prior to allowing the groups to get started. The detailed timeline of what is required is below:

Block 1:

- Teacher Instruction (30 minutes)
- Design the study (35 minutes)
    - Your group should decide first what univariate data you will collect (i.e. the time it takes to get to school, the time it takes to get ready for school, the number of pets, etc.).
    - Next, your group should decide by what variable you are going to compare (i.e. gender, age, driver vs. non-driver).
    - Your group should create a title for your research and should construct 3-5 sentences discussing your research design and how you will compare your results. Your group should also hypothesize what relationships you intend to see between your variables.

    Prior to collecting data, confirm your research design with your teacher.
- Collect your data (25 minutes)
    - Use your classmates as participants in your study.
    - You must include at least eight students as participants in each dataset (do not use the same student twice).
    - Each group must place their data into the tables provided and include creative titles.

    Each group must turn in their data sheet #1 by the end of the block.

Block 2:

- Construct box-and-whisker plots (25 minutes)
    - All groups must calculate the minimum, the first quartile, the median, the third quartile, the maximum, and any outliers for each of their tables. If no outliers exist, state so.
    - Your group needs to use the measures of central tendency to construct box-and-whisker plots on the poster board provided by your teacher (*BE NEAT!*).
- Design Thought-Provoking Questions (45 minutes)
    - Your group must create at least five thought-provoking questions about your constructed box-and-whisker plots.
        - Every group must create a visual display of their questions.
        - At least one question must include percentages.
        - At least one question must include a measure of dispersion.
- Prepare Presentation (20 minutes)
    - Each presentation must be eight to ten minutes long.
    - Your group should have the answers to their questions prepared in advance.
    - Each group should present the conclusions to their research hypothesis and something they learned while conducting the study.
    - Each group should also present what was the most difficult thing and what was the most fun thing about conducting their study.

    Each group must turn in their poster board and data sheet #2 by the end of the block.

Block 3:

- Presentation (8-10 minutes each)
    - Each group will present to the class their box-and-whisker plots, questions, answers, and conclusions using their poster board and any other visual displays created.
      Each group member must complete a self-assessment by the end of the block.

Student Exploration

Student/Teacher Actions:

Students will be collaborating in groups of two to three as determined by the teacher. The first day, the teacher will invite students to draw upon their prior knowledge by facilitating a discussion of how to compare univariate datasets and how to construct box-and-whisker plots. The teacher will explicitly state the expectations for each day and provide constructive feedback along the way. The teacher will also act as a mentor and coach as students collect data, create tables, and construct box-and-whisker plots. Teachers will encourage students to draw on the group's knowledge first, prior to seeking out prompting from the teacher, class notes, and/or the Internet.

The teacher will also be available as students create questions, formulate answers, and collaborate to design a professional presentation. Students will communicate their mathematical knowledge by using appropriate vocabulary when presenting and making connections between the univariate datasets. The teacher can encourage each group to integrate technology when presenting to make the presentations more dynamic and unique.

Monitoring Student Responses

- Students are to communicate their thinking and their new knowledge by actively participating in each group presentation including their own. Individual group members are expected to explain at least one answer regarding their box-and-whisker plots.
- Students are to communicate with each other actively, respectfully, and supportively.
- Teachers are to highlight and clarify frequently asked questions to the class as they emerge and provide problem-solving strategies to groups in order to resolve difficult situations.
- Teachers should encourage all students to be engaged within their group and therefore, discourage students from moving forward without their group members. If an entire group is ready to move on, encourage the group to get a head start on the next task at hand.

Feedback of the Box-and-Whisker Activity is encouraged at the end of each presentation. In order to summarize the Box-and-Whisker Activity, the teacher should plan to recap on the strengths and feedback from the group presentations. The teacher should also focus on how groups overcame difficult tasks and which problem-solving techniques to carry forward. Lastly, the teacher should reflect on the content knowledge that was reviewed and applied.

Assessment List and Benchmarks

Groups will complete one data sheet from the "Box-and-Whisker Activity" packet each day to ensure all objectives set forth are met on time. Unlike that of the group data sheets, students will individually complete a self-assessment at the end of the three-day Box-and-Whisker Activity. The teacher will use the same rubric to assess each student and will give extra credit for creativity, the addition of thought-provoking questions, and exemplary participation in answering other groups' questions.

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: _____
Date: _____Block: _____

Block 1:

Research Design

Title:

Design Description:

Hypothesis:

Teacher sign-off**: _____**

Data Collection

Title:

Title:

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: _____
Date: _____Block: _____

Block 2:

Box-and-Whisker Plots: *Do not forget to turn in the box-and-whisker plots on your poster board.*

Table 1: Measures of Central Tendency

Minimum	
Q1	
Median	
Q3	
Maximum	
Outliers (if any)	

Table 2: Measures of Central Tendency

Minimum	
Q1	
Median	
Q3	
Maximum	
Outliers (if any)	

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: _____
Date: _____Block: _____

Block 2:

Questions and Answers

1.

2.

3.

4.

5.

Presentation Reflection

Performance Assessment Task – Statistics Name: _____

A.10 Box-And-Whisker Activity Date: _____Block: _____

Self-Assessment

			Earned Assessment	
Num	**Element**	**Point Value**	**Self**	**Teacher**
1	The study has a title and a description.	2		
2	Hypothesis is stated.	2		
3	The teacher, prior to collecting data, confirmed the research design.	2		
4	The tables have titles.	2		
5	The tables have at least eight responses included.	2		
6	Data sheet #1 is completed on time.	2		
7	The minimum, first quartile, median, third quartile, maximum, and outliers are included for at least two tables.	2		
8	At least two box-and-whisker plots are constructed on poster board.	2		
9	Number lines are included directly beneath box-and-whisker plots.	2		
10	Presentation includes at least five questions related to the box-and-whisker plots that are not yes or no questions.	2		
11	The presentation includes a visual display of the questions.	2		
12	At least one question includes percentages.	2		
13	At least one question includes a measure of dispersion.	2		
14	Answers to questions were prepared in advance of the presentation.	2		
15	The conclusion to the research hypothesis is presented.	2		
16	Presentation includes something learned while conducting the study.	2		
17	Presentation includes something difficult while conducting the study.	2		
18	Presentation includes something fun while conducting the study.	2		
19	Data sheet #2 is completed on time.	2		
20	Presentation is eight to ten minutes.	2		
21	Student actively and respectfully participated in answering other groups' questions.	2		
22	All materials are neat.	2		
23	The assignment materials are well organized.	2		
24	Self-assessment is completed on time.	2		
	Total	48		

Performance Assessment Task – Statistics Name: _____

A.10 Box-And-Whisker Activity Date: _____Block: _____

Teacher Assessment

			Earned Assessment	
Num	**Element**	**Point Value**	**Self**	**Teacher**
1	The study has a title and a description.	2		
2	Hypothesis is stated.	2		
3	The teacher, prior to collecting data, confirmed the research design.	2		
4	The tables have titles.	2		
5	The tables have at least eight responses included.	2		
6	Data sheet #1 is completed on time.	2		
7	The minimum, first quartile, median, third quartile, maximum, and outliers are included for at least two tables.	2		
8	At least two box-and-whisker plots are constructed on poster board.	2		
9	Number lines are included directly beneath box-and-whisker plots.	2		
10	Presentation includes at least five questions related to the box-and-whisker plots that are not yes or no questions.	2		
11	The presentation includes a visual display of the questions.	2		
12	At least one question includes percentages.	2		
13	At least one question includes a measure of dispersion.	2		
14	Answers to questions were prepared in advance of the presentation.	2		
15	The conclusion to the research hypothesis is presented.	2		
16	Presentation includes something learned while conducting the study.	2		
17	Presentation includes something difficult while conducting the study.	2		
18	Presentation includes something fun while conducting the study.	2		
19	Data sheet #2 is completed on time.	2		
20	Presentation is eight to ten minutes.	2		
21	Student actively and respectfully participated in answering other groups' questions.	2		
22	All materials are neat.	2		
23	The assignment materials are well organized.	2		
24	Self-assessment is completed on time.	2		
	Total	48		

Performance Assessment Task – Statistics Name: _____

A.10 Box-And-Whisker Activity Date: _____Block: _____

Category Descriptions

#	Element	0	1	2
1	The study has a title and a description.	No title or description	Title and description are incomplete	Title and description provided
2	Hypothesis is stated.	No hypothesis	Hypothesis is incomplete	Hypothesis provided
3	The teacher, prior to collecting data, confirmed the research design.	Did not confirm research design	Changes requested to research design.	Confirmed research design
4	The tables have titles.	No table titles	Table titles are incomplete	Table titles provided
5	The tables have at least eight responses included.	No responses included	Responses are incomplete	Eight responses included
6	Data sheet #1 is completed on time.	No data sheet #1	Data sheet #1 is incomplete or not provided on time	Data sheet #1 provided on time
7	The minimum, first quartile, median, third quartile, maximum, and outliers are included for at least two tables.	No descriptive statistics included	Descriptive statistics are incomplete	Descriptive statistics provided
8	At least two box-and-whisker plots are constructed on poster board.	No box-and-whisker plots	One box-and-whisker plot included	At least two box-and-whisker plots provided
9	Number lines are included directly beneath box-and-whisker plots.	No number lines	Number lines are not to scale and/or are incomplete	Number lines included beneath plots
10	Presentation includes at least five questions related to the box-and-whisker plots that are not yes or no questions.	No open-ended questions	Open-ended questions are incomplete	At least five thought-provoking questions provided
11	The presentation includes a visual display of the questions.	No visual display	Visual display of questions is incomplete	Visual display of questions is provided

12	At least one question includes percentages.	No questions include percentages	Percentage question is inaccurate	At least one percentage question provided
13	At least one question includes a measure of dispersion.	No questions include a measure of dispersion	Question including a measure of dispersion is inaccurate	At least one question includes a measure of dispersion
14	Answers to questions were prepared in advance of the presentation.	No answers to questions were provided	Answers to questions are incomplete	Answers to questions provided
15	The conclusion to the research hypothesis is presented.	No conclusion	Conclusion is incomplete	Conclusion provided
16	Presentation includes something learned while conducting the study.	Lacks something learned	Something learned is incomplete	Something learned is provided
17	Presentation includes something difficult while conducting the study.	Lacks something difficult	Something difficult is incomplete	Something difficult is provided
18	Presentation includes something fun while conducting the study.	Lacks something fun	Something fun is incomplete	Something fun is provided
19	Data sheet #2 is completed on time.	No data sheet #2	Data sheet #2 is incomplete or not provided on time	Data sheet #2 provided on time
20	Presentation is eight to ten minutes.	No presentation	Presentation is under time or over time	Presentation is between eight to ten minutes
21	Student actively and respectfully participated in answering other groups' questions.	Does not actively or respectfully participate	Does not fully participate	Actively and respectfully participates
22	All materials are neat.	Lacks neatness	Needs improvement	Neat
23	The assignment materials are well organized.	No evidence of organization	Not fully organized	Well organized
24	Self-assessment was completed on time.	No self-assessment	Self-assessment is incomplete or not provided on time	Self-assessment provided on time

Performance Assessment Task – Statistics

A.10 Box-And-Whisker Activity

Benchmark

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: Benchmark
Date: 07/11/14 Block: _____

Block 1:

Research Design

Title: The Influence of Having a Job on Television Usage

Design Description: Our study will analyze the weekly television use, in hours, of our classmates. We will compare the television usage of students with jobs with the television usage of students without jobs. We intend to compare our results using measures of central tendency to construct box-and-whisker plots, measures of dispersion, and probability.

Hypothesis:
We expect that the television usage of students with jobs will be lower than the television usage of students without jobs.

Teacher sign-off: E.O'Rourke

Data Collection

Title: Weekly Television Use for Students Without Jobs (hrs)

1	2
2	15
3	15
4	17
5	21
6	21
7	22.5
8	23
9	28

Title: Weekly Television Use for Students With Jobs (hrs)

1	3.5
2	7
3	7
4	7
5	9.5
6	10.5
7	10.5
8	14
9	16

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Performance Assessment Task – Statistics

A.10 Box-And-Whisker Activity

Benchmark

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: _____
Date: _____ Block: _____

Block 2:

Box-and-Whisker Plots: *Do not forget to turn in the box-and-whisker plots on your poster board.*

Table 1: Measures of Central Tendency

Minimum	15 (2nd Lowest)
Q1	15
Median	21
Q3	22.75
Maximum	28
Outliers (if any)	2

2 15 15 17 21 21 22.5 23 28
Q_1=15 Median=21 Q_3=22.75

Outlier Check
$IQR = Q_3 - Q_1 = 22.75 - 15 = 7.75$
$1.5IQR = 11.625$
$(Q_1 - 1.5IQR, Q_3 + 1.5IQR) = (3.375, 34.375)$
Therefore, 2 is an outlier.

Table 2: Measures of Central Tendency

Minimum	3.5
Q1	7
Median	9.5
Q3	12.25
Maximum	16
Outliers (if any)	∅

3.5 7 7 7 9.5 10.5 10.5 14 16
Min Q_1=7 Median=9.5 Q_3=12.25 Max

Outlier Check
$IQR = 12.25 - 7 = 5.25$
$1.5IQR = 7.875$
$(Q_1 - 1.5IQR, Q_3 + 1.5IQR) = (-.875, 20.125)$
Therefore, no outliers

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Performance Assessment Task – Statistics

A.10 Box-And-Whisker Activity

Benchmark

Performance Assessment Task – Statistics
A.10 Box-And-Whisker Activity

Names: Benchmark
Date: 07/11/14 Block: _____

Block 2:

Questions and Answers

1. Q: Which type of student has a maximum value that is larger?
   A: Students without jobs have a maximum value that is larger. The maximum value is 28 hours of TV watched weekly.
2. Q: What is the IQR for students with jobs?
   A: The IQR for students with jobs is 5.25 hours.
3. Q: Which type of student has a larger range?
   A: Students without jobs have a larger range in the number of hours they watch TV.
4. Q: What percent of students with jobs watch TV between 12.25 and 16 hours?
   A: 25%
5. Q: What measure of central tendency is largely influenced by outliers?
   A: The mean is heavily influenced by the existence of outliers.

Presentation Reflection

Our hypothesis was confirmed. We learned how to compare univariate data. We had difficulty identifying the outliers in our data. We enjoyed working in a group and constructing box-and-whisker plots.

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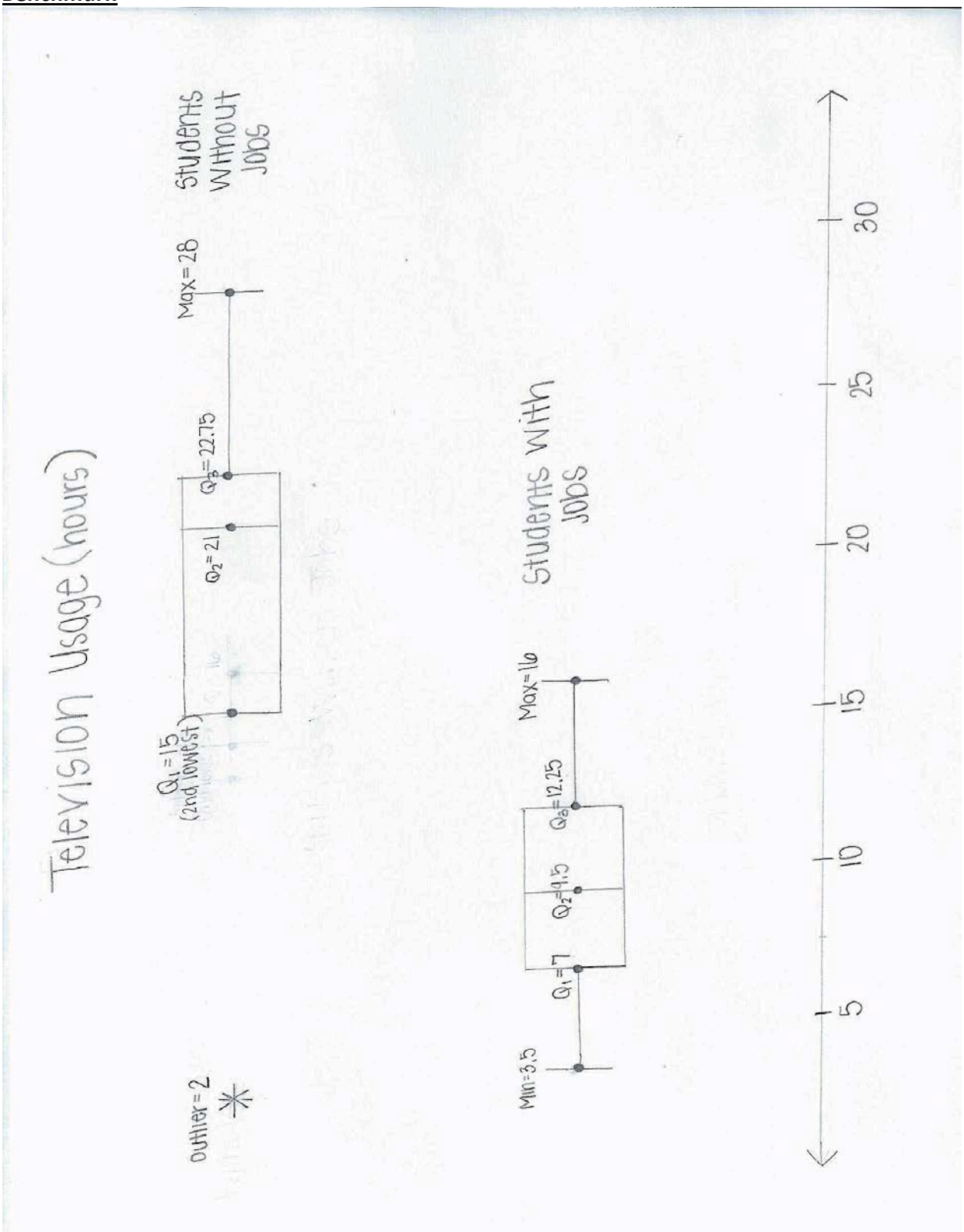
Performance Assessment Task – Statistics

A.10 Box-And-Whisker Activity

Benchmark



Performance Assessment Task – Statistics

A.10 Box-And-Whisker Activity

Benchmark: Presentation Slides

QUESTION 2

What is the interquartile range for students with jobs?

QUESTION 1

Which type of student has a maximum value that is larger?

ANSWER 2

The interquartile range for students with jobs is 5.25 hours.

ANSWER 1

Students without jobs have a maximum value that is larger. The maximum value is 28 hours of television watched weekly.

QUESTION 3

Which type of student has a larger range?

ANSWER 3

Students without jobs have a larger range in the number of hours they watch television.

QUESTION 4

What percent of students with jobs watch television between 12.25 and 16 hours?

ANSWER 4

Twenty-five percent of students with jobs watch television between 12.25 and 16 hours.

QUESTION 5

Challenge: What measure of central tendency is largely influenced by outliers?

ANSWER 5

The mean is the measure of central tendency that is heavily influenced by the existence outliers.

CONCLUSION

From our sample data, it appears that students with jobs, on average, watch less television than students without jobs.

REFLECTION

We learned how to compare univariate data.

We had difficulty identifying the outliers in our data.

We enjoyed working in a group and constructing the box-and-whisker plots.