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| Graph Rubric Elements                                                                 | Sources that Informed Descriptions                                      |
|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| **Graph Rubric Elements**                                                            | **Sources that Informed Descriptions**                                  |
| **Descriptive title**                                                                | Kosslyn, 1994; Evergreen, 2018                                         |
| a) in the form of a statement                                                       | Angra & Gardner, 2017                                                  |
| b) mention the subject                                                              | Angra & Gardner, 2017                                                  |
| c) appropriate variables                                                             | Puhan et al. 2006; Angra & Gardner, 2017                               |
| d) include relevant details about the experiment that help understand the take home message |                                                                          |
| **Label for the X axis (e.g. time)**                                                 | Kosslyn, 1994; Few, 2004; Federico et al., 2012                         |
| a) appropriate and descriptive for the experiment.                                   | Puhan et al. 2006; Angra & Gardner, 2017                               |
| b) graphs with categorical independent variables should have a label under each set of data and a larger label under all data plotted. | Elliot et al., 2006; Puhan et al. 2006; Angra & Gardner, 2017           |
| **Label for the Y axis (e.g. heart rate)**                                           | Kosslyn, 1994; Few, 2004; Federico et al., 2012                         |
| • Should be appropriate and descriptive for the experiment. If the data is manipulated (average, change, percentage, etc.), then it should be indicated on the y axis. | Elliot et al., 2006; Puhan et al. 2006; Angra & Gardner, 2017           |
| **Units for the X axis (e.g. seconds)**                                              | Leinhardt et al., 1990; Puhan et al. 2006                               |
| • Should be appropriate and descriptive for the data displayed.                     | Leinhardt et al., 1990; Puhan et al. 2006                               |
| **Units for the Y axis (e.g. average beats per minute)**                             | Cleveland, 1994                                                        |
| • Should be appropriate and descriptive for the data displayed.                     | Tufte, 1983; Leinhardt et al., 1990; Kosslyn, 1994; Few, 2004; Duke et al., 2015; Evergreen, 2018 |
| **Scale (appropriate intervals and range for data)**                                | Evergreen, 2018                                                        |
| a) Increments are clear and without clutter                                         | Kosslyn, 1994; Duke et al., 2015                                        |
| b) appropriate significant figures.                                                  |                                                                          |
| c) If the scale is discontinuous or doesn’t start at the origin, it should be indicated by a break in the axis. |                                                                          |
| **Key (defines different data sets that are plotted)**                               | Few, 2004; Evergreen, 2018                                             |
| a) descriptions of different colors (if applicable)                                  | Angra & Gardner, 2017                                                 |
| b) the sample size                                                                   | Angra & Gardner, 2017                                                 |
| c) the number of trials.                                                             |                                                                          |
| **Ease of Understanding-Aesthetics**                                                | Tufte, 1983                                                            |
| a) the data plotted takes up sufficient room in the Cartesian plane                  | Kosslyn, 1994; Stengel et al., 2008; Duke et al., 2015; Evergreen, 2018 |
| b) makes use of legible size font                                                   | Duke et al., 2015; Evergreen, 2018                                    |
| c) the x and y axis lines are clear and legible                                      |                                                                          |
| d) the graph displays data in an appropriate number of bars and lines (maximize data-ink ratio) | Tufte, 1983; Kosslyn, 1994; Puhan et al. 2006; Duke et al., 2015; Tufte, 1983; Cooper et al., 2003; Puhan et al. 2006; Stengel et al., 2008; Federico et al., 2012; Evergreen, 2014; Rougier et al., 2014; Duke et al., 2015 |
| e) is devoid of chart junk elements such as: distracting background colors, patterns, and dark gridlines | Tufte, 1983; Kosslyn, 1994; Puhan et al. 2006; Duke et al., 2015; Tufte, 1983; Cooper et al., 2003; Puhan et al. 2006; Stengel et al., 2008; Federico et al., 2012; Evergreen, 2014; Rougier et al., 2014; Duke et al., 2015 |
| **Ease of Understanding-Take home message**                                         | Cooper, et al., 2003; Rougier et al., 2014; Evergreen, 2018; Cooper, et al., 2003; Federico et al., 2012; Rougier et al., 2014; Duke et al., 2015 |
| a) if the graph has sound construction and mechanics that allow for clear sorting of trends. |                                                                          |
| b) Easy to formulate a take home message                                            |                                                                          |
| **Graph Type (Bar, line, scatter, dot, box and whisker)**                           | Padilla et al., 1986; Cleveland, 1994; Kosslyn, 1994; Schriger & Cooper, 2001; Few, 2004; Leonard & Patterson, 2004; Patterson & Leonard, 2005; Drummond et al., 2011; Franzblau & Chang, 2012; Humphrey et al., 2013; Duke et al., 2015; Saxon, 2015; Weissgerber et al., 2015; Klaus, 2016; Evergreen, 2018; Angra & Gardner, 2016; Angra & Gardner, 2017 |
| Data displayed in a graph is appropriate for both independent and dependent experimental variables (i.e. categorical and continuous) and data (*Referring to the data form) |                                                                          |
| **Data Displayed (Raw, Averages, Changes, Percentage)**                             | Wild and Pfannkuch, 1999; Friel & Bright, 1996; Konold & Higgins, 2003; Konold et al., 2015 |
| If the graph indicates the type of data (ex. Raw, Averages, etc.) that are plotted. |                                                                          |
| If the graph is completely aligned with the research question and hypothesis. Other graphs can be exploratory. |                                                                          |
| "Alignment" (at least one of the graphs presented should align with the research question and hypothesis. Other graphs can be exploratory.) |                                                                          |
| If the graph is completely aligned with the research question and hypothesis. In other words, the independent, dependent variables, and information about the experiment are explicit. |                                                                          |
Appendix B: Completed rubric for a sample graph from the rubric training materials for the external stage. Complete version is available upon request by the corresponding author.

| ID of graph or set of graphs: | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
|-------------------------------|--------------|---------------------------------|------------------------|
| Descriptive title | Needs to be in a statement, mention the subject (bacteria), and include details about the experiment (temperatures) | | |
| P/A-Should be: a) in the form of a statement, b) mention the subject, c) appropriate variables, and d) include relevant details about the experiment that help understand the take home message. | | | |
| NI- If the title is missing any one of the four points mentioned above. | | | |
| Label for the X axis (e.g. time) | | | x |
| P/A- Should be appropriate and descriptive for the experiment. For graphs with categorical independent variables, there needs to be a label under each set of data and a larger label under all data plotted. | | | |
| NI- If the label is missing any one of the points mentioned above. | | | |
| Label for the Y axis (e.g. heart rate) | | Should say "Average Number of Cells", since that is the data plotted. | |
| P/A- Should be appropriate and descriptive for the experiment. If the data is manipulated (average, change, percentage, etc.), then it should be indicated on the y axis. | | | |
| NI- If the label is missing any one of the points mentioned above. | | | |
| Units for the X axis (e.g. seconds) | | | x |
| P/A- Should be appropriate and descriptive for the data displayed. | | | |
| NI- If the units are not appropriate or descriptive. | | | |
| Units for the Y axis (e.g. average beats per minute) | | | x |
| P/A- Should be appropriate and descriptive for the data displayed. | | | |
| NI- If the units are not appropriate or descriptive. | | | |
| Scale (appropriate intervals and range for data) | The y axis can be rescaled so that it goes from -2 to 26 and a proper increment should be chosen so that numbers do not clutter the y axis. | | |
| P/A- Should be appropriate for the data displayed such that the increments are clear and without clutter and includes appropriate significant figures. If the scale is discontinuous or doesn’t start at the origin, it should be indicated by a break in the axis. | | | |
| NI- If the scale is not appropriate for the data such that it is cluttered, does not include appropriate significant figures, and/or if the scale does not indicate axis break. | | | |
| Key (defines different data sets that are plotted) | Since the graph is showing averages, a key showing the sample size for each temperature is necessary. | | |
| P/A- Should be appropriate and descriptive for the data displayed. It should include: a) descriptions of different colors (if applicable), b) the sample size and c) the number of trials. | | | |
| NI- If the key is not descriptive and does not indicate the sample size. | | | |
| Ease of Understanding-Aesthetics | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
|----------------------------------|--------------|-----------------------------------|------------------------|
| If the graph is aesthetically pleasing, meaning that: a) the data plotted takes up sufficient room in the Cartesian plane, b) makes use of legible size font, c) the x and y axis lines are clear and legible, d) the graph displays data in an appropriate number of bars and lines, and e) is devoid of chart junk elements such as: distracting background colors, patterns, and dark gridlines | This graph has multiple flaws: the gridlines are distracting, there is unnecessary white space above the data lines, and the two data lines are similar in color. Overall, there is a lot of chart junk in this graph. |
| If the graph has one of the following flaws: a) the graph displays too much white space, b) the font size is too small, c) the x and y axis lines are not clear and legible, d) the graph shows too many bars or lines OR e) elements of chart junk are clouding interpretation of data. | Although it is easy to note the trends in this graph, it is difficult to formulate an accurate take home message since the subject, bacteria is not mentioned in the graph. |
| If the graph has multiple flaws, which interfere with the understanding and interpretation of data. | |
| Ease of Understanding-Take home message | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
| If the graph has sound construction and mechanics that allow for clear sorting of trends and take home message. | |
| If data trends are difficult to observe or it is difficult to formulate a proper take home message. | |
| If the graph is ineffective at communicating data trends and take home message, such that it causes confusion. | |
| Graph Type (Bar, line, scatter, dot, box and whisker) | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
| If data displayed in a graph is appropriate for both independent and dependent experimental variables (i.e. categorical and continuous) and data. (*Referring to the data form) | |
| If data displayed in a graph is a) not suitable for either the dependent or independent experimental variables OR b) there is a better way to present data. | |
| If the graph type is not suitable for both experimental variables. | |
| Data Displayed (Raw, Averages, Changes, Percentage) | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
| If the graph indicates the type of data (ex. Raw, averages, etc.) that are plotted. There should be a clear distinction between raw data and manipulated data based on the information presented in the key (i.e. sample size and number of trials) and axis label. If the graph is showing averages, then it should also be accompanied with STDEV or error bars. | Since the graph is showing averages, the data points need to be accompanied with error bars. |
| If the graph is missing one of points mentioned above. | |
| If data type is inappropriate for the graph type. | |
| Alignment* (at least one of the graphs presented should align with the research question and hypothesis. Other graphs can be exploratory.) | Excellent (2) | Present but Needs Improvement (1) | Absent/Inappropriate (0) |
| If the graph is completely aligned with the research question and/or hypothesis. In other words, the independent, dependent variables, and information about the experiment are explicit. | The graph is partially aligned with the research question and hypothesis because it does not display information on the subjects. |
| If the graph is partially aligned with the research question and/or hypothesis. In other words, the graph is missing information about either the independent, dependent, or details about the experiment. | |
| If the graph is not aligned with the research question and/or hypothesis. | |

*Alignment*
Appendix C: Graphs used during the structural stages by science education researchers and graduate students

GRAPH 1
The scatter and line graphs below were used only by the science education researchers during the first round of the structural stage for feedback:

- **Question:** Do different genres of music affect an individual’s heart rate?
- **Hypothesis:** Music genres do affect a person’s heart rate differently.
**Question:** Does listening to music increase or decrease the HR and MAP depending on the genre?

**Hypothesis:** Slower music will decrease the HR below normal levels whereas listening to upbeat/faster music will increase the HR
The graph below was used by both science education researchers and graduate students during the second round of the structural stage.

- **Question:** How does the conduction velocity in the median giant axon alter with a change in temperature?
- **Hypothesis:** We hypothesize temperature affects the conduction velocity of the median giant axon.
Appendix D: Graphs critiqued by undergraduate students during the external stage.

**Graph 1**: Average Variation in Cortisol Concentrations (ug/dL) Between Evening and Morning Amidst Men and Women.

**Graph 2**: Average Change in Heart Rate Between Smiling and Non-Smiling.

**Graph 3**: Threshold of Lateral Giant Axon in Earthworm vs. Temperature.

**Graph 4**: Heart Rate of group members at rest, exercise, and recovery.

**Graph 5**: Change in Heart Rate in Static vs Dynamic Exercise.
Appendix E- Descriptions of graphs critiqued by students and professors

Table E.1- Descriptions of graphs critiqued by undergraduate students who were students in a physiology laboratory, where they had repeated practice with the graph rubric during the Spring 2015 semester. These are descriptions of graphs in Appendix D.

| Graph # | Type                        | Context-Physiology Topic Lab | Other Descriptors                                                                 |
|---------|-----------------------------|-----------------------------|-----------------------------------------------------------------------------------|
| 1       | Box and whisker             | Cortisol                    | Cortisol concentration, two categories plotted.                                   |
| 2       | Line                        | Cardiovascular              | Average change in heart rate between smiling and non-smiling; mean +/- SEM        |
| 3       | Scatter                     | Action potentials           | Decreasing slope; lots of white space on the graph                                |
| 4       | Line                        | Cardiovascular              | Black background with 4 smooth lines of a different color                         |
| 5       | Double bar                  | Student’s choice            | Black background; paired bars showing mean but no +/- SEM                        |

Table E.2- Descriptions of student constructed graphs that were critiqued by Instructor 1 who taught an upper-level field ecology course and a freshman-level Course-Based Undergraduate Research Experience (CURE).

| Graph # | Type                        | Context         | Other descriptors                                                                 |
|---------|-----------------------------|-----------------|-----------------------------------------------------------------------------------|
| 1       | Bar                         | Field Ecology   | Five treatments; percentage of measured variable                                  |
| 2       | Scatter                     | Field Ecology   | Two categories; Average +/- error bar                                              |
| 3       | Bar                         | Field Ecology   | Scatter with linear regression                                                    |
| 4       | Scatter                     | Field Ecology   | Three sampling days; Proportion of measured variable                             |
| 5       | Bar                         | Field Ecology   | Paired bar graph; average +/- error bar                                            |
| 6       | Bar                         | Field Ecology   | Two treatments; two categories (%) for each                                       |
| 7       | Stacked bar                 | CURE            | Four treatments; Average +/- error bar                                             |
| 8       | Bar                         | CURE            |                                                                                  |

Table E.3- Descriptions of student constructed graphs that were critiqued by Instructor 2 who taught a sophomore-level cell biology and neurobiology.

| Graph # | Type                        | Context         | Other descriptors                                                                 |
|---------|-----------------------------|-----------------|-----------------------------------------------------------------------------------|
| 1-5     | Line                        | Cell Biology    | Exam question graph sketches; Bond energies to determine DNA form                 |
| 6       | Line and symbol             | Neurobiology    | Four conditions                                                                  |
| 7       | Paired bars                 | Neurobiology    | Treatment and control for eight trials                                            |
| 8       | Line and symbol             | Neurobiology    | Baseline and treatment                                                           |
| 9       | Bar                         | Neurobiology    | Three conditions to compare                                                       |
| 10      | Box and whisker             | Neurobiology    | Before, during, and after treatment                                              |

Table E.4- Descriptions of student constructed graphs that were critiqued by Instructor 3 who taught an upper-level conservation biology course.

| Graph # | Type                        | Context         | Other descriptors                                                                 |
|---------|-----------------------------|-----------------|-----------------------------------------------------------------------------------|
| 1       | Line                        | Conservation biology | Raw simulation output for 100 runs                                               |
| 2       | Scatter                     | Conservation biology | Average +/- error bars for three simulated conditions (100 iterations over 200 years) |
| 3       | Scatter                     | Conservation biology | Average +/- error bars for four independent variable values                      |
| 4       | Line and symbol             | Conservation biology | Average +/- error bars for three different conditions                             |
| 5       | Bar                         | Conservation biology | Average +/- error bars for four different conditions                              |
Table E.5a - Descriptions of student constructed graphs that were critiqued by Instructor 4 in the neurophysiology context.

| Graph Descriptions | 1                  | 2                  | 3                  | 4                  |
|---------------------|--------------------|--------------------|--------------------|--------------------|
| Type                | Scatter            | Scatter            | Scatter            | Scatter            |
| Context             | Neurophysiology    | Neurophysiology    | Neurophysiology    | Neurophysiology    |
| Other descriptors   | Scatter with regression line | Measurements from two subjects | Measurements from two subjects | Measurements from two subjects |

Table E.5b - Descriptions of student constructed graphs that were critiqued by Instructor 4 in the endocrine physiology context.

| Graph Descriptions | 1                  | 2                  | 3                  | 4                  |
|---------------------|--------------------|--------------------|--------------------|--------------------|
| Type                | Line and symbol    | Bars               | Scatter            | Box and whisker    |
| Context             | Endocrine physiology | Endocrine physiology | Endocrine physiology | Endocrine physiology |
| Other descriptors   | Two conditions over time | One measured variable at six time points | Scatter with regression line | Four conditions |

Table E.5c - Descriptions of student constructed graphs that were critiqued by Instructor 4 in the cardiovascular physiology context.

| Graph Descriptions | G1                  | G2                  | G3                  | G4                  |
|---------------------|---------------------|---------------------|---------------------|---------------------|
| Type                | Line and symbol     | Line                | Paired bars         | Scatter             |
| Context             | Cardiovascular physiology | Cardiovascular physiology | Cardiovascular physiology | Cardiovascular physiology |
| Other descriptors   | Data for four subjects at three time points; plotted separately | Two treatments with three trial points | Three sets of paired bars (change for three measured variables) with two treatment conditions each | Scatter with regression line |
Appendix F- Detailed IRR agreement between biology instructors and expert rater

* average from the overall rubric scoring across graphs for each instructor
n = number of graphs evaluated

| Graph Rubric Category | Instructor 1 (n = 8) | Instructor 2 (n = 10) | Instructor 3 (n=5) | Instructor 4 (n =12) |
|-----------------------|-----------------------|-----------------------|---------------------|-----------------------|
| Graph Mechanics       |                       |                       |                     |                       |
|                       | Descriptive Title     | 100                   | 70                  | 60                    | 83                    |
|                       | Label for the X axis  | 100                   | 70                  | 40                    | 100                   |
|                       | Label for the Y axis  | 62.5                  | 80                  | 100                   | 67                    |
|                       | Units for the X axis | 75                    | 100                 | 100                   | 75                    |
|                       | Units for the Y axis | 62.5                  | 100                 | 60                    | 92                    |
| Communication         |                       |                       |                     |                       |
| Ease of Understanding-Aesthetics | 75 | 50 | 40 | 67 | |
| Ease of Understanding-Take home message | 75 | 90 | 100 | 67 | |
| Graph Choice          |                       |                       |                     |                       |
| Graph Type            | 100                   | 90                    | 80                  | 67                    |
| Data Displayed        | 62.5                  | 80                    | 60                  | 67                    |
| Alignment             | 87.5                  | 70                    | 80                  | 83                    |
| **Average (%) Task Interrater Reliability** | **83 ± 9** | **74 ± 4** | **72 ±15** | **78 ± 7** |
Appendix G: Table of citations of graphs from introductory biology textbooks during the external stage

| Textbook                        | Randomly Selected Chapters | Number of Pages Analyzed | Number of Graphs Analyzed | Graphs Randomly Selected for IRR agreement                                                                 |
|--------------------------------|-----------------------------|--------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------|
| Campbell et al., 2011          | 1, 2, 5, 9, 10, 15, 22, 23, 26, 29 | n/a online textbook     | 204 graphs present, but analyzed 40 graphs (20%) | Chapter 1, graph 1.21  
Chapter 2, graph 2.19  
Chapter 5, left graph 5.9  
Chapter 9, top graph 9.22  
Chapter 10, graph 10.2  
Chapter 15, middle graph in panel A 15.11  
Chapter 22, graph 22.7  
Chapter 29, graph 29.14 |
| Raven et al., 2008             | 20, 23, 25, 28, 34, 44, 45, 52, 58, 59 | 203                     | 43                        | Chapter 20, graph 20.1  
Chapter 20, bottom graph 20.13  
Chapter 20, graph 20.16  
Chapter 23, graph 23.12  
Chapter 44, graph 44.8  
Chapter 45, graph 45.18  
Chapter 58, graph 58.8  
Chapter 59, graph 59.4  
Chapter 59, graph 59.15 |
| Sadava et al., 2009            | 5, 11, 14, 28, 38, 45, 52, 53, 56, 57 | 207                     | 35                        | Chapter 28, *Investigating Life* top graph 28.9  
Chapter 45, *Tools for Investigating Life* graph 45.8  
Chapter 45, graph 45.11  
Chapter 45, graph 45.15  
Chapter 45, graph 45.17  
Chapter 52, *Investigating Life* graph 52.17  
Chapter 57, graph 57.9a |
| Singh-Cundy & Shin, 2015       | 2, 3, 19, 20, 22, 26, 27, 29, 30, 33 | 227                     | 17                        | Chapter 20, graph 20.3a  
Chapter 26, *Biology Matters* bottom graph  
Chapter 29, top graph 29.9 |
| Urry et al., 2014              | 3, 4, 6, 11, 13, 18, 22, 29, 32, 38 | 211                     | 18                        | Chapter 6, graph 6.6  
Chapter 6, graph 6.16  
Chapter 38, *Scientific Skills* graph |
1. Campbell, A., Heyer, L., Paradise, C., Sellers, P., & Barsoum, M. (2011, January). Integrating Concepts in Biology for Introductory College Biology. In *Molecular Biology of the Cell* (Vol. 22). 8120 Woodmont Ave, Ste 750, Bethesda, MD 20814-2755 USA: Amer Soc Cell Biology.

2. Raven, P. H., Johnson, G. B., Losos, J. B., Mason, K. A. & Singer, S. R. (2008): Biology, 8th ed.; Boston (McGraw-Hill).

3. Sadava, D. E., Hillis, D. M., Heller, H. C., & Berenbaum, M. (2009). *Life: the science of biology* (Vol. 2). Macmillan.

4. Singh-Cundy, A., Shin, G. (2010). Discover biology (6th Edition). Sinauer Associates, Inc.

5. Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., Jackson, R. B., & Reece, J. B. (2014). *Campbell biology in focus*. Pearson.
Appendix H: Detailed Version of Textbook Analysis using the Graph Rubric.

| Graph Rubric Category | Textbooks | Present/Appropriate | Needs Improvement | Unsatisfactory |
|-----------------------|-----------|---------------------|-------------------|----------------|
| **Descriptive Title** | Singh-Cundy & Shin, 2015 | 83 | 0 | 17 |
| | Urry et al., 2014 | 33 | 60 | 7 |
| | Sadava et al., 2009 | 89 | 11 | 0 |
| | Raven et al., 2008 | 90 | 10 | 0 |
| | Campbell et al., 2011 | 65 | 35 | 0 |
| **Label for the X axis** | Singh-Cundy & Shin, 2015 | 92 | 8 | 0 |
| | Urry et al., 2014 | 87 | 13 | 0 |
| | Sadava et al., 2009 | 83 | 8 | 9 |
| | Raven et al., 2008 | 74 | 10 | 16 |
| | Campbell et al., 2011 | 62 | 26 | 12 |
| **Label for the Y axis** | Singh-Cundy & Shin, 2015 | 84 | 8 | 8 |
| | Urry et al., 2014 | 100 | 0 | 0 |
| | Sadava et al., 2009 | 94 | 3 | 3 |
| | Raven et al., 2008 | 95 | 5 | 0 |
| | Campbell et al., 2011 | 64 | 36 | 0 |
| **Units for the X axis** | Singh-Cundy & Shin, 2015 | 92 | 0 | 8 |
| | Urry et al., 2014 | 67 | 0 | 33 |
| | Sadava et al., 2009 | 75 | 0 | 25 |
| | Raven et al., 2008 | 88 | 0 | 12 |
| | Campbell et al., 2011 | 97 | 0 | 3 |
| **Units for the Y axis** | Singh-Cundy & Shin, 2015 | 50 | 0 | 50 |
| | Urry et al., 2014 | 60 | 0 | 40 |
| | Sadava et al., 2009 | 72 | 0 | 28 |
| | Raven et al., 2008 | 93 | 0 | 7 |
| | Campbell et al., 2011 | 85 | 0 | 15 |
Appendix H: Detailed Version of Textbook Analysis using the Graph Rubric.

| Scale          | Singh-Cundy & Shin, 2015 | 33 | 25 | 42 |
|----------------|--------------------------|----|----|----|
|                | Urry et al., 2014        | 27 | 46 | 27 |
|                | Sadava et al., 2009      | 42 | 42 | 16 |
|                | Raven et al., 2008       | 52 | 48 | 0  |
|                | Campbell et al., 2011    | 91 | 9  | 0  |

| Key            | Singh-Cundy & Shin, 2015 | 55 | 45 | 0  |
|----------------|--------------------------|----|----|----|
|                | Urry et al., 2014        | 53 | 47 | 0  |
|                | Sadava et al., 2009      | 69 | 31 | 0  |
|                | Raven et al., 2008       | 38 | 62 | 0  |
|                | Campbell et al., 2011    | 23 | 77 | 0  |

| Ease of Understanding-Aesthetics | Singh-Cundy & Shin, 2015 | 42 | 58 | 0  |
|---------------------------------|--------------------------|----|----|----|
|                                 | Urry et al., 2014        | 67 | 33 | 0  |
|                                 | Sadava et al., 2009      | 72 | 28 | 0  |
|                                 | Raven et al., 2008       | 74 | 26 | 0  |
|                                 | Campbell et al., 2011    | 88 | 12 | 0  |

| Ease of Understanding-Take home message | Singh-Cundy & Shin, 2015 | 42 | 58 | 0  |
|----------------------------------------|--------------------------|----|----|----|
|                                       | Urry et al., 2014        | 93 | 7  | 0  |
|                                       | Sadava et al., 2009      | 97 | 3  | 0  |
|                                       | Raven et al., 2008       | 95 | 5  | 0  |
|                                       | Campbell et al., 2011    | 88 | 12 | 0  |

| Graph Type | Singh-Cundy & Shin, 2015 | 75 | 25 | 0  |
|------------|--------------------------|----|----|----|
|            | Urry et al., 2014        | 93 | 7  | 0  |
|            | Sadava et al., 2009      | 86 | 14 | 0  |
|            | Raven et al., 2008       | 71 | 29 | 0  |
|            | Campbell et al., 2011    | 88 | 12 | 0  |
| Data Displayed | Singh-Cundy & Shin, 2015 | 50 | 50 | 0  |
Appendix H: Detailed Version of Textbook Analysis using the Graph Rubric.

| Alignment | Singh-Cundy & Shin, 2015 | Urry et al., 2014 | Sadava et al., 2009 | Raven et al., 2008 | Campbell et al., 2011 |
|-----------|--------------------------|-------------------|---------------------|---------------------|------------------------|
|           |                          | 27                | 73                  | 0                   |                        |
|           |                          | 75                | 25                  | 0                   |                        |
|           |                          | 74                | 26                  | 0                   |                        |
|           |                          | 77                | 23                  | 0                   |                        |