Medicine Dosage - Applying Dimensional Analysis/Graphing to Healthcare

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1 About the Activity

- Course: Algebra for Calculus
- Partner Disciplines: Biology, Chemistry and Health Science
- Pedagogical Approach: individual work, or, work in pairs
- Required Technology: calculator/spreadsheet

2 Institutional and Course Contexts

- Type/size of institution: Liberal Arts University
- Size of Class: 30 or fewer
- Chararcteristics of Students: Undergraduate students who are seeking a degree which requires higher mathematics courses, such as Calculus I or trigonometry-based physics.
- Mathematical Content: Dimensional analysis, algebraic relations, graphs and their interpretation.
- Purpose/Goal of the Activity: This activity is designed to show students the application of algebra concepts and skills to real problems encountered in healthcare.
- After and Before: Students need to know how to set up proportions, how to plot points and graphing.
- Other Prerequisites: None.
- Inspiration for the Activity:Faculty want to provide continuity between prerequisite courses and more advanced courses.

3 Partner Discipline Background

Prescribing medicine to patients must be done at the proper dose to maximize benefit, minimize side effects, and in some cases, avoid serious problems such as kidney failure. In extreme cases, overdoses can cause death. Medical dosages are based on body mass; for example, a dose of 1 mg/kg means that 1 mg of medicine is given per 1 kg of body mass. Medical practitioners, therefore, need to calculate a proper dosage for each patient based on his/her body mass. Such a routine application of algebra suggests that everyone working in a medical profession needs to have mastery over these concepts. One straightforward way to solving dosage problems is dimensional analysis. In dimensional anlaysis you find a way to combine the inputs (those quantities given in the problem) to give the correct units for the output (the unknown quantity). Units multiply and divide just like numbers. For example, kg/kg = 1, just like $3/3 = 1$ or $x/x = 1$ (provided $x \neq 0$). Applying dimensional analysis may best be learned in the context of a problem. Perry Odic is riding his bike at 20 miles per hour (mi/hr). How long will it take Perry to ride 8 miles? Note that the question is asking for the amount of time, so the answer should be in time units, such as hours. The only place where a time unit shows up in the problem statement is in the speed, 20 mi/hr, but it is in the denominator. Inverting this quantity yields time in the numerator: 0.05 hr/mi, but there is a length dimension (miles) in the denominator. Combining the inverted speed with the distance of 8 mi yields the desired units:

Finally, a word of caution. Dimensional analysis cannot be applied to every problem. Some mathematical relationships include unitless constants, such as the distance equation for accelerated motion. Even if dimensional analysis cannot be used to solve every problem, it can always be used to detect an error when the units do not match the expected units. In the activity that follows, dimensional analysis can be applied to all problems.

4 Implementation Plan

- Formal Learning Objectives
  - Set up algebraic relationships by analyzing units.
  - Generate a graph showing the relationship between independent and dependent variables
  - Interpret graphical and/or tabular data to draw a qualitative conclusion
- Materials and Supplementary Documents

  None.
- Time Required

  This activity was assigned as a small project that students needed to complete. The activity was introduced in class (about 5 – 10 minutes) and students were given a week to turn it in.
- Implementation Recommendations

  The implementation of the activity can be adjusted according to the instructor. It can be given as an in-class activity or as a group activity.
- Alternative Solutions
- Common Errors and Questions

  Students who have weak algebra background stumble in the first two problems, not knowing ratios or proportions. Common mistakes in the third problem tend to be in miscalculating the dosages and representing the graph with a continuously increasing function with a limiting end-behavior, rather than a piecewise function.
- Tips to Handle Controversial Issues (if applicable)

5 Additional Information

The graphing activity can be extended to Calculus to include discussion about jump discontinuities.