Math Teachers…. Find A Science Teacher!

A Curriculum Integration Approach to Understanding Rate of Change

Samantha English, Niagara University

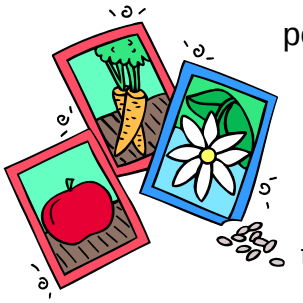
Editors' Note: Readers are encouraged to analyze the instruction presented in this article, both in terms of Constructivist Theory in general and in terms of the 2-Step model articulated by Flynn, et. al. (2004) in particular, and then to submit articles demonstrating ways to enhance similar experiment-based lessons that incorporate greater student engagement about decision-making during instruction.

Abstract

An integrated approach to mastering the concepts of rate of change and plant development allows middle-level students the continuity of subject matter between mathematics and science. The unit described provides authentic learning as well as assessment activities that motivate and challenge students both to build upon their previous knowledge in both subject areas and to reflect on their learning. The unit demonstrates an attempt to incorporate aspects of the constructive theory of learning in an organic learning process.

Introduction

No matter how much we may try to fight it, our lives are not separated into perfect, non - overlapping compartments. So, why do we separate and segregate subjects in school? It is the goal and focus of this article to present to middle school mathematics teachers an example of an integrated mathematics and science



unit that will allow students to investigate growth rate in plants and help them to develop the fundamental ideas of rate of change.

Plant growth and development is a typical and reoccurring theme in the late elementary and middle school science curriculum. I'm sure we all remember planting our own bean plant or dissecting a seed. Many of us have probably even participated in the age old growth experiment, where seeds are planted and some are then put in a dark closet while the rest are left on a well-lit windowsill. But have you ever thought of this experiment for more than its scientific impact and for the great mathematical investigation it embodies?

After the students have worked so hard to grow their bean sprouts, why not capitalize on their invested interest?

Let's start integrating

The science portion of the unit would begin by exploring the many parts and properties of seeds. For example students can investigate the parts of a seed under a microscope, what is necessary for plants to grow, how plants grow from seeds or the parts of a seed connected to the parts of a plant. Once students have gained a familiarity to the seed, work with your cooperating science teacher and have the students plant bean seeds. In Styrofoam cups plant at least thirty bean

seeds, one per cup, to allow for the chance that some may not germinate. Divide the bean cups into three groups of ten each. Label one group W (for window) and place them on a well- lit windowsill. The second group will be labeled O (for outside) and placed outside of the building. Finally, label the last group C (for closet) and place them in a dark cabinet or closet. Now, let's watch those bean plants grow!

Alignment with national and New York State learning standards

Having your lesson plan correctly aligned with state standards helps to prove its worthiness and necessity. It also helps in assuring that your students are being taught what your state requires. This integrated unit was planned to align with the New York Sate Learning Standards (see Table 1). However it also supports the National Learning Standards. The National Science Learning Standards (NSLS) holds firm that science instruction should be inquiry-based and allow teachers to work together as colleagues within and across disciplines and grade level. The National Council for Teachers of Mathematics states, "Algebra and geometry are crucial to success in the later study of mathematics and also in many situations that arise outside the mathematics classroom. Students should see that these subjects are interconnected with each other and with other content areas in the curriculum"(NCTM).

Table 1

Alignment with New York State Standards:

MST Standard 1: Analysis, Inquiry and Design

- Use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions

MST Standard 3: Mathematics

- Apply a variety of reasoning strategies
- Make and evaluate conjectures and arguments using appropriate language
- Make conclusions based on inductive reasoning
- Justify conclusions involving simple and compound (I.e., and/or) statements
- Represent numerical relationships in one-and two-dimensional graphs
- Use variables to represent relationships
- Explore and produce graphic representations of data using calculators/computers
- Develop an understanding of functions and functional relationships: that a change in one quantity (variable) results in change in another

MST Standard 4: Science

- Compare and contrast the parts of plants, animals, and one-celled organisms
- Observe and describe developmental patterns in selected plants and animals (e.g., insects, frogs, humans, seed-bearing plants)
- Describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms
- Describe how living things, including humans, depend upon the living and nonliving environment for their survival
- Describe the effects of environmental changes on humans and other populations

MST Standard 5: Technology

- Apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs

MST Standard 6: Interconnectedness/ Common Themes

- Understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning

MST Standard 7: Interdisciplinary Problem Solving

- Apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions

(Standards provided by New York State Academy of Teaching and Learning.)

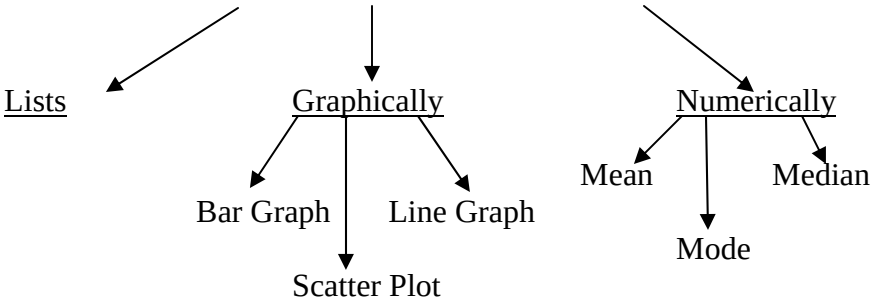
On the science side of life

This experiment allows the student to explore the life cycle of plants and lends it's self to extensions into topics such as photosynthesis, pollination and even cross-pollination. Your cooperating science teacher has many opportunities to work with the students and the bean sprouts to explore the world of plants. Working with your cooperating science teacher, have the students keep a running log of the heights of the bean plants in each group. At the beginning or end of class every Monday and Thursday, have the students measure the height of one bean sprout from each group, to the nearest sixteenth of an inch. Allow the students to take measurements for approximately one month from the first signs of growth among all of the groups. The students can also be asked to include any other relevant data they may find.

On the mathematics side of life

The data collected during science class is the critical link to this integrated unit. Ask the students to bring the data they collected to mathematics class and explain that they will be analyzing the plant growth – the growth rate of the bean plants using charts, graphs and a spreadsheet program. Brainstorm different possible methods for organizing data.

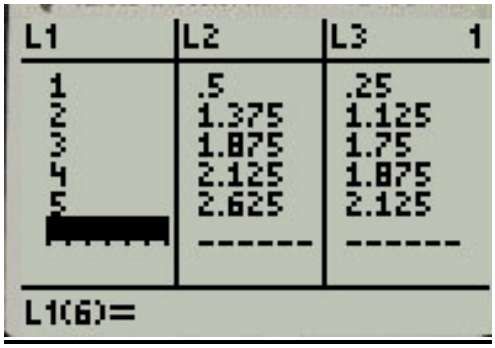
Figure 1 **Techniques for Organizing Data**



Use questions to guide students toward the two most common methods, graphical and numerical (see fig. 1) Discuss with the students that the best method for this investigation will utilize lists in order to construct a scatter plot and then a line graph.

Have the students organize their data into charts. Talk about the different ways to represent the data; especially the date of each measurement. For example would it be better to replace the date of each measurement with the number that the measurement was? If so, the first date would get changed to the number one, the second to the number two and so on. Using the TI- 83, have the students enter the data in STATS. Make List 1 the days, List 2 the height of the plants on the windowsill, List 3 the height of the plants outside the building and List 4 the height of the plants in the closet (see fig. 2).

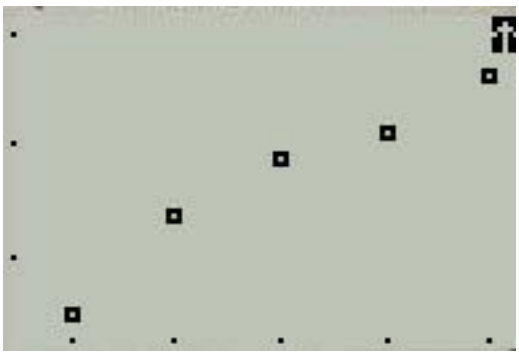
Figure 2



Screen Shot from the TI-83 STAT Edit Command with example data.

Once the students have entered their data, have them create a scatter plot on the TI-83 to model the growth in each group (see fig. 3). Have the students play around with their Window size to get the

Figure 3



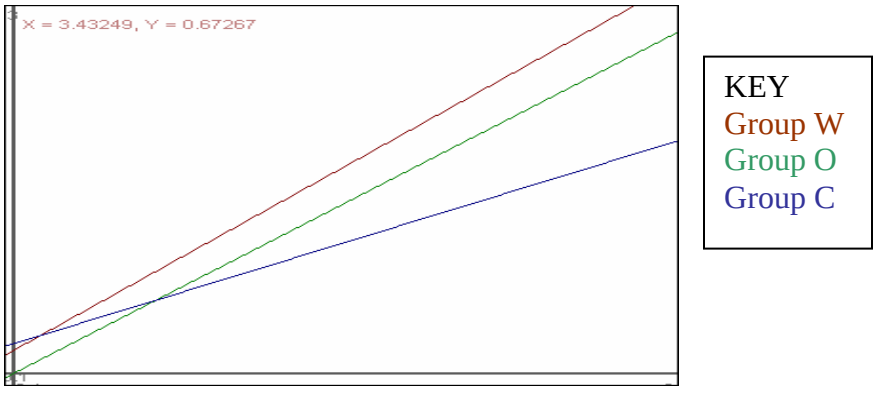
Graph of Growth in Group W

most informative graph. Ask the students to comment on what they notice about each graph. For example does the data look linear? What does the shape of the data suggest?

Working with the students, review what they know about linear equations and the graphs of linear equations. Ask the students if they think it is possible that their data could fit on a line. Most students should notice that the data points appear to be very linear. Introduce STAT CALC LinReg (ax+b), which will help the students develop an equation that will fit their data. Allow the students to work with LinReg (ax+b) to find best-fit lines for each of their groups, W, O and C. Have the students analyze their lines. How well does it fit my data? Do a lot of the data points lie on the line? These self-reflective questions help students to personalize the material while becoming better metacognitive learners.

Now that the students have had time to work with and analyze the data graphically, introduce your classroom-graphing program or visit

Figure 4 – Best Fit Lines for Plant Growth



http://www.graphcalc.com/ (Arrison & Fields, 2008) and download a free computer-graphing program courtesy of website developers. Have the students use the graphing program to create one large graph that contains all three of the best-fit lines (see fig. 4). Ask the students to analyze this graph. What do the three best-fit lines look like compared to each other? What does this tell us about each growth rate? What can people learn from this graph?

Let's get integrated

Now that the students have had a chance to create in depth investigations of the bean plants, from both a scientific view point as well as a mathematical, it's time to bring them back together in order to wrap this unit up. This process of exploration and construction of knowledge aligns with Flynn's Discovery Phase as well as the Two Step method. (Flynn, Mesibov, Vermette, & Smith, 2004)

As a culminating activity, join with your cooperating science teacher and work with the students to make presentations of all the knowledge they gained during this unit. The culminating Assessment part of this lesson allows the students a choice of projects as supported by Glasser's Choice Theory. (Glasser, 1986)

Culminating Assessment Activity 1: Have the students work in small groups to create a poster that advertises their knowledge of plants to the public. This poster should include general properties of plants or seeds,

factors effecting growth of plants, a mathematical representation (or graph) that illustrates the growth rates of each of the groups and finally an explanation of what the mathematical model is showing.

Culminating Assessment Activity 2: Have the students work independently to do some creative writing that presents their knowledge gained during the unit. The students can select from:

1. What factors affect plant growth? Do you think these factors affect the growth rate of any other living things? Create your alien being and describe two factors that help your alien to grow and two that prevent your alien from growing. Make a poster with a picture of your alien and the factors that affect its growth rate. (Make sure to label and describe the effects of each of the factors you imagined)
2. Pretend you are a farmer. Where would you live? What crop would you grow? What would you to do help your crop grow? What would you do to kill any weeds that grow in your fields? (Remember weed killer will kill all plants in the fields.) Make an advertisement for your weed killing method. (To adapt this question for an empathy activity, tell the students where they would live and have them answer the rest of the questions with that location as their focus. For example have the students write about being a farmer in the Sahara, Australia, Mexico or a region of the United States different from their current location. This will also draw in a multicultural connection.)

These closing activities provide the students with a chance to explore growth rate further as well as provide for an excellent closure of the unit. It should also be noted that each of these assessment activities ties directly to Howard Gardner's multiple Intelligences (Gardner, 1983). Rubrics are best suited to assessing each of these activities (see fig. 5 and 6).

Figure 5

Scoring Rubric – Culminating Activity 1				
	4	**3**	**2**	**1**
Properties of a Been Plant/Seed	Explicit identification of the parts, organs and systems of the seed/ plant with diagram	Clear identification of the parts, organs and systems of the seed/ plant	Basic identification of the parts, organs and systems of the seed/ plant	Parts, organs and systems of the seed/ plant not identified
Growth and Development	Explicit identification of nutrients and environmental effects with evidence of outside research	Clear identification of nutrients and environmental effects	Basic identification of nutrients and environmental effects	Nutrients and environmental effects not identified.
Mathematical Representation	Complete graph present with no errors, utilized technology to produce graph	Complete graph present with no errors	Graph present missing data, labels or title	Graph missing completely
Mathematical Explanation	Explicit explanation that matches the data present and shows elaboration on data	Clear explanation that matches the data presented	Basic explanation that matches the data with few errors	Explanation missing completely
Overall Presentation	Presentation is neat, clear, grammatically correct and shows extra effort above assignment requirements	Presentation is neat, clear and grammatically correct	Presentation is mainly neat, clear and few grammatical errors exist	Presentation is messy, unclear and many grammatical errors exist

Figure 6

Scoring Rubric – Culminating Activity 2				
	4	**3**	**2**	**1**
Science/ Mathematical Understanding	Explicit understanding of the data and data analysis present in writing (Expert level interpretations)	Clear understanding of the data and data analysis present in writing	Basic understanding of the data and data analysis present in writing	Little or no understanding of the data and data analysis present in writing
Ideas/ Creativity	Information clearly relates to the main topic and supporting details show much creativity	Information clearly relates to the main topic and some creativity is present	Information relates to the main topic, shows little effort or creativity	Information has little to do with the main topic
Explanation/ Evidence	Explanation and evidence matches the data collected and logical conjectures have been made about the data	Explanation and evidence matches the data collected	Explanation and evidence partially matches the data collected	Explanation and evidence is not present or does not match the data collected
Presentation	Presentation is neat, clear and shows effort above the assignment requirements	Presentation is neat, clear and complete	Presentation is complete and mainly neat and clear	Presentation is messy, incomplete or unclear
Mechanics	No grammatical errors present	Few minor grammatical errors present	Many grammatical errors present	Grammatical errors make the writing incomprehensible

Conclusion

Integrating curricula helps students to make connections and thus make the concepts taught more concrete. Integrated units also provide a much more meaningful backdrop for learning. For example, students would rather do mathematics that pertains to something in which they are invested, such as the growth of their bean plant. So why not integrate the subjects and capitalize on their investment?

References Cited

Arrison, M. & Fields, B. 2008. *GraphCalc. – The Ultimate Graphing Calculator.* Free-download software available through www.graphcalc.com.

Flynn, P., Mesibov, D., Vermette, P., & Smith, M. 2004. *Applying Standards Based Constructivism: A Two-Step Guide for Motivating Secondary Students*. Larchmont, NY: Eye-on-Education.

Gardner, H. 1983. *Frames of Mind: The Theory of Multiple Intelligences*. Cambridge, MA: Harvard University Press.

Glasser, W. 1986. *Control Theory*. New York: Harper.

National Council for Teachers of Mathematics. 2008. *Standards and Focal Points: Middle School*. www.nctm.org