Metamorphosis Models in Mathematics

By Rima J Solh, 2014 CTI Fellow
Eastway Middle School

This curriculum unit is recommended for:
6-8 Mathematics

Keywords: functions, scatterplots, interpretation of graphs, metamorphosis, association, bivariate, measurement data, two-way tables, frequency, science, math

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis:

This unit integrates science and math for best practices. It can be used for teaching statistics with algebraic models of metamorphosis for all middle-grades mathematics. In Grade 6, students will be able to develop a deeper understanding of variability and more precise descriptions of data distributions; in Grade 7, students should be able to transition to production of data and creating a good plan to produce a relevant data base. In Grade 8 proper and successful interpretation of the data is the major skill. Math teachers will be able to adjust the activities according to the grade level without difficulty.

Metamorphosis is the theme of this unit, and I have a feeling at the end, my mind will metamorphose to an extensive and sophisticated stage of knowledge. Joining Charlotte Teachers Institute has been the most outstanding professional development I have had in my 11 years of teaching. My goal is to present this unit as impeccably as possible. However, my challenge is to interpret and picture all the knowledge and experiences I have had with these seminars meticulously.

I plan to teach this unit during the coming year in 2014-2015 to 95 students in 8th grade math class

Metamorphosis Models in Mathematics

Rima J Solh

Introduction

As the title suggests, this unit is an integration of science and mathematics. Metamorphosis is the theme of the unit. I intend to convey all the great knowledge I have acquired through CTI seminars on these pages. However I wish I could be able to teach this unit at the same suitable location: Discovery Place. To broaden my horizons of knowledge was my major goal to have joined CTI, but the meetings at the Discovery Place, where I got the privilege of experiencing all the hands-on science, seeing the living organisms, has made this experience really special; I also really appreciate our professor's great strategies of facilitation and support of all this information.

This unit is a guide for teaching statistics unit in middle grades while integrating science theme, metamorphosis of animals. Using the data about the amazing natural process of what most animals go through while developing from an egg to an adult is the significant feature in these lessons.

I have been teaching 8th grade mathematics for 11 years. My classes are a varied group of students of different abilities and Math backgrounds. My students' heterogeneous upbringings reflect their math skills; they include students who have not been in regular schools not to mention any math class appropriate to their age. Eastway Middle School serves over 760 students in grades 6-8. Geographically, the school is located in a disadvantaged setting of Charlotte, NC in the Charlotte-Mecklenburg School District. 94% of our students qualify for free and reduced lunch. We are a racially diverse school of approximately 50% African American, 34% Hispanic, 11% Asian, 5% White, 1% American Indian, and 3% other students. Eastway Middle School's enrollment rate for gifted and talented is 1 percent. Our students come from over 36 different countries. Eastway is often the first American middle school experience for newly arrived 11 to 13 year old immigrants in our area. Lots of other variables contribute to our school's low math and English End of Grade tests scores. However, I believe the fact that our school district or our school accommodates for the English Second Language students is the main reason behind the high failing rate. Although some of my students are not as motivated or well-nourished due to economic circumstances, they are, on the other side, good artists especially when given the support, supplies, and encouragement. They thrive to make an artifact out of a lesson concept; and from my experience, they are always willing to create posters and produce art projects. I have noticed how foldable, graphic organizers, and thinking maps for lesson notes have swept

their minds and changed their attitude towards new math lessons. Using creative approaches is a good way to foster interest and improve their skills in mathematics.

The duration of the unit should not exceed two weeks bearing in mind the winter MAP testing window which might coincide during this unit; however, time will be adjusted for convenience and according to students' development. As a result, the total number of days of teaching this unit is 6-10 days.

Rationale

Metamorphosis and the science of structural and functional modification of an organism during its development is a fascinating subject to connect with the teaching of functions, probability, and statistics. Over a series of inquiries, research, and investigations, students build their proficiency with significant algebraic concepts. Connections between science and algebra are made through the use of drawings, tables, graphs, and equations.

Therefore, while learning will and should never end at any time or place, I have learned a lot with these seminars and plan to teach it to my students. I have developed plans to teach a unit on functions and statistics. I will be using metamorphosis theme built in with math discourse. Math discourse is challenging for the quality of students I teach; however, integrating metamorphosis of different kinds of animals should facilitate the strategy. Students would be motivated and curious to find out about the connections between a video on the life cycle of a frog to our lesson on "Fit a straight line informally for scatter plots that suggest a linear association, and then requires them to assess the model fit by judging the closeness of the data points to the line."[1] Similar to what larvae experience through their evolutionary transformation, my students will endure the same transformative experience with their skills in math and even their state of mind towards mathematics. The metamorphosis of larvae involves a process that transforms very similar looking larvae into very different adult species."[2] Hopefully my students will experience the same amazing metamorphosis of their minds and spirits towards mathematics. My students will grow to become mathematicians. They will undergo learning concepts of math to the deepest perceptions of the content and they will be motivated, enthusiastic, and lovers of math.

Even though this unit is designed for 8th grade math standards, a teacher of 6th or 7th grade can personalize it and model it to fit the grade level standards. 6th grade students should be able to develop understanding of statistical variability and summarize and describe distributions of transformations of larvae, for example. 7th grade students should be able to use random sampling to draw inferences about a population, draw informal comparative inferences about two populations, and investigate chance processes and develop, use, and evaluate probability models by investigating the metamorphoses of some insects. I will teach my students in 8th grade how to interpret data by telling or

writing a story from a graph using metamorphosis of different animals, especially butterflies. Also, my students will investigate patterns of association in bivariate data and how to use functions to model relationships between two quantities. The 8th grade math, 8SP1, 8SP2, 8SP3, and 8SP4 and the integrated science common core standards and skills related to this unit are listed in Appendix I.

Unit Concept/Objectives

While North Carolina's curriculum follows the Common Core Standards, I usually follow the 8th grade Mathematics Unpacked document from North Carolina Public of Instruction. For these unit standards, the document suggests:

> Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: bivariate data scatter plot, linear model, clustering, linear association, non-linear association, outliers, positive association, negative association, categorical data, two-way table, relative frequency.[3]

The 8th grade common core math standards I am covering in this unit will be the general framework; these generalizations of the unit states that my students will understand that properties of any function, in multiple representations, create opportunities for comparisons across representations. Graphs of functions qualitatively represent the relationship between two quantities. Mathematicians solve systems of two linear equations in different ways based on the appropriateness of the method. Solutions to a system of linear equations correspond to the points of intersection on a graph. Mathematicians construct scatter plots to investigate and describe possible associations between bivariate measurement data. Interpret a graph of data to analyze and predict future outcomes. These methods are also essential and therefore highly relevant to scientists for summarizing and interpreting their data. Therefore in this unit data related to metamorphosis will be used to provide hands-on practice for the mathematical skills. Using examples that captivate their interests in working with and interpreting the data will provide a deeper understanding of the underlying mathematical principles.

The Guiding Questions for the unit addresses the factual and conceptual content of the standards. Some examples of the guiding questions are:

- What are some of the common patters of relationships between X and Y variables?
- Do all scatter plots show some type of association?
- How do you determine if a scatter plot has a positive or negative association?
- How can you determine if a linear function would be an appropriate model for a scatter plot?

- How can you transform a non-linear plot into a linear plot?
- How can data lead to incorrect conclusions?
- What are different ways to represent a function?
- What properties of a function make it a linear function?
- Why is it helpful to compare functions in multiple representations
- How does a graph show the qualitative features of a function such as whether it is increasing or decreasing?
- How can you sketch a graph from a verbal description of a function?
- How can you tell a story from a graph?

Students should be able to build on their prior knowledge with data distributions and creations learned in previous grades so that they will be able to investigate patterns of association in bivariate data, analyze scatter plots, and predict outcomes based on the linear models, clustering, non-linear association, outliers, positive and negative association, categorical data, two-way table, and relative frequency.

Although 8th grade science does not mention metamorphosis in any standard, I will integrate the standards which emphasizes the concept of evolution. The standard 8.L.4 Understand the evolution of organisms and landforms based on evidence, theories and processes that impact the Earth over time will be taught in 8th grade almost the same quarter when my students will be learning this unit. This works out perfectly, as I have been planning with my colleagues, the 8th grade science teachers. In this standard students should be able to summarize the use of evidence drawn from geology, fossils, and comparative anatomy to form the basis for biological classification systems and the theory of evolution. Also 8th grade students will be reviewing metamorphosis concept with the standard 8. E.2.2 which teaches students to explain the use of fossils, ice cores, and composition of sedimentary rocks, faults, and igneous rock formations found in rock layers as evidence of the history of the Earth and its changing life forms.

Scientific Content

After we complete the classroom activity “Introduction to Metamorphosis” illustrated below I will show them a formal definition of the word, metamorphosis used in the context of Biology. It is a profound change in form from one stage to the next in the life history of an organism, as from the caterpillar to the pupa and from the pupa to the adult butterfly. It can also be used in a more general way to describe a transformation, a complete change of form, character, appearance, or circumstances; and it is used in a geological context to describe rock formations.[4]

Metamorphosis means transforming, or change in nature. In biology, metamorphosis is the process by which an animal transforms from an immature state to a mature adult over the course of their life cycle. This involves changes in body structures, both internal and external features, and is regulated by hormones. Metamorphosis is accompanied by

changes in the animal's behavior, physiology and biochemistry. There are many kinds of changes as organisms move through the life-stages of their existence. There are two types of metamorphosis; complete and gradual or incomplete. Many insects (including butterflies, moths, beetles) and amphibians (frogs, salamanders) go through extreme changes of form as they develop from larvae into adults. Animals that don't go through such a dramatic metamorphosis are often said to go through an incomplete metamorphosis, in which the young juvenile forms are simply small versions of the adults. One common example is the grasshopper and we humans are also an example of this, where at birth we have the same body structure as an adult.

Metamorphosis is a biological process by which an animal physically develops after birth or hatching. It is part of the life cycle of the most insects. A life cycle is a period involving one generation of an organism. The term metamorphosis refers to the way that insects develop, grow, and change form, usually (but not always) accompanied by a change of habitat or behavior.

Complete Metamorphosis (Holometabolous)

Metamorphosis is said to be complete when there is a clear distinction between the stages of development. Most insects go through the four stages of complete metamorphosis, including the ladybug, housefly, and butterfly.[5]

The first phase of metamorphosis starts when eggs are laid by the female insect. The second stage is when the eggs hatch into Larvae but they do not look like adult insects. For example, the larvae of butterflies are caterpillars. Larvae eat a lot of food and grow quickly but they have to molt their exoskeletons a few times; these stages of growth in larvae are called "instars." The third period of metamorphosis is when the last instar larvae pupates and forms a pupa, a stage when they form cocoons around themselves. The fourth and final stage of metamorphosis is when the insect becomes an adult. After a period of time, the larva is nothing like it was, and exits the cocoon or larval body as an adult. The life cycle starts over again.

Gradual Metamorphosis (Hemimetabolous)

About 12% of insects go through the three stages of gradual metamorphosis, including the mayfly, cicada, grasshopper, aphid, and cockroach. This is also called incomplete metamorphosis when the insect goes through only three stages of metamorphosis. The first stage starts when an egg is created. A female insect lays eggs. Sometimes the eggs are in a group and protected by a covering or case. The second period of incomplete metamorphosis starts when the eggs hatch into a Nymph. A Nymph looks like a small adult, but usually don't have wings. They eat, grow, and change. Nymphs also molt their exoskeletons as they grow. As this occurs, they gradually begin to look more and more

like the adult. Once the nymph has grown to an adult size, they stop molting. Generally adults are the only stages in an insect's life when it has wings.[6]

Bony fishes (e.g. tilapia, carp etc.) also undergo metamorphosis. The eggs start to develop embryos which hatch as small young fishes (larvae). Each larva bears a yolk sac, which is attached to its body. This yolk sac provides food to the individual. The provision of food by the yolk sac continues until the larvae transform into the adult stage. While in this stage, the yolk sac disappears because the now-adult fish is able to fend for itself.

In addition to the scientific content, students will be leaning the appropriate terminology needed to research, study, and explore the life cycles of animals. All the vocabulary definitions[7] in Appendix III will be taught and used throughout the unit. Therefore, my students will learn about metamorphosis and the transformation happening through life stages while studying how to create data and interpret data in scatter plots. I will have to make sure that when students are studying the metamorphosis of an organism, their learning goes beyond naming each stage of metamorphosis and offering a brief description of the organism at that stage. While students also learn how the characteristics at that stage of development enhance the survival of the organism. For example tadpoles are vegetarians and adult frogs are carnivores. Students should be able to investigate life cycles, to make observations, and to record data. Both qualitative and quantitative data should be collected.

Teaching Strategies

I will be implementing the thematic approach. This approach is a way of teaching integrated curriculum within a theme.[8] This approach integrates knowledge from different subjects and encourages students to explore the topic deeply, reading many different sources and engaging in a variety of activities. The use of multiple sources encourages students to be involved in planning, locating materials, and thinking more actively and deeply than when learning is based on a single text. As a result of their in-depth study, students are more likely to understand and feel confident in their learning.

Under the huge umbrella of benefits, integration across disciplines can provide a very effective way for engaging students. For this purpose, I am adopting the "Thematic Integration" approach which, like the title suggests, begins with a theme under which all the lesson plans in the unit will interrelate. Metamorphosis is a fascinating biological theme that will help to engage the students in their mathematical studies. Although this requires lots of time and research planning for the unit, it is not puzzling for me anymore because I have had the chance to plan it with a very talented professor from UNCC and brilliant team members of teachers from all over Charlotte Mecklenburg Schools.

This is my first experience of writing a curriculum unit in mathematics integrated with science. As a result, I had to read lots of research on integration and its benefits. And this

was the main reason behind joining Charlotte Teachers Institute, to learn. One article from the School Science and Mathematics journal stated,

> "…all students, especially many low-income and minority students, need continuity between schooling and the rest of their lives. The inclusion of science in a mathematics curriculum, and vice versa, is one way to provide this continuity."[9]

Metamorphosis is the theme of my math unit on statistics. Although, I will demonstrate to my students the metamorphosis of some of the larvae, insects, and animals, I am focusing more on the metamorphosis of the butterfly.

No one can ever describe the great effect of showing educational videos in the math classroom or any classroom. I might never be able to define, describe, or explain metamorphosis, this subject which is a mystery even to nature, to my students without showing them these educational videos. I have joined the Discovery Education[10] which partners with our school district to provide a customized set of teaching tools to accelerate student achievement. It is a great free teachers' and students' resource. I would be able to show the students any video and use their resources for the activities and questions related to the videos. I have uploaded all the videos I will be showing during this unit. The videos will be the introduction to the metamorphosis concept by the Life of a Butterfly. Another one will be showing in details the stages of the incomplete metamorphosis. The four stages of the complete metamorphosis video have been uploaded too. The contents of the other videos on the life cycles of other insects and larvae will be shown to my students either by sharing the links for them to explore and research for their project presentation or by showing them in class as a classroom activity. A list of the Discovery Education videos which I will use and have already uploaded to "My Content"

Mathematical discourse is the tool I am adopting for this unit and every unit thereafter because it enhances my instruction for diverse learners especially the non-English speakers and low socio-economic population. The most important part of mathematical discourse is getting to know the students' prior knowledge of the content; it will open up the opportunity for them to improve it by reviewing and explaining it; then it will make the new knowledge add up to their previous learning much easier. The end result will be tremendous when students learn by connecting, reasoning, and arguing professionally and respectfully. Building relationships in the classroom among students and between the students and me is the hidden goal behind Mathematical discourse. I will be implementing verbal and written communication through these practices for mathematical discourse. Asking the students challenging questions, making students create questions to ask about metamorphosis or the video we just saw. Math discourse also includes expressing own methods and strategies in problem solving, group work activities, and reflecting by writing. Students will write for the final project explained below as a final grade assessment at the end of this unit.

Literacy integration is very essential for our school community. My English Language Learners students need different strategies to encourage them to read any kind of books, even if the books which are lower than their grade level. Some of my students have never had the chance to own, read, or to summarize any book before. This has become a challenge while teaching mathematics; however, it is a tool for reaching out to them indirectly and helps them build their self-confidence. I have been in their shoes. When I was 12 years old, my family had to immigrate to Switzerland. My only precious belonging back then was a dictionary and the sign language to make up for the German language I have acquired through practice. Therefore, for this unit I have bought books about different kinds of animals' life cycles for my classroom book collection, and I will use them for this unit. The list of books below is a great source to integrate literacy and science for this unit at the same time. This is a teaching strategy that I will use to encourage students to read, illustrate, and summarize life cycles while learning mathematics. I have asked for community sponsorship to help out to buy some of these books and build up my little library in the classroom.

Our school administration encourages data-driven instruction. The math discourse in my classes will accommodate the diversification in the lesson plans and will definitely provide the appropriate strategies to plan and adjust lesson plans according to data. Moreover, the end-of-unit project explained below is the biggest assessment tool. The project will be a tool for assessing students' level of literacy, mathematics, and some science.

The Project

A group project will be assigned as a formative assessment for this unit. Groups of three students will be allocated to investigate metamorphosis of butterfly or other insects. Each group will choose a different animal cycle. Each group member will be assigned a role for the completion of this project. Each group will present a poster, an essay, and a mathematical model of the metamorphosis on a poster board. Rubrics will be provided for each student. Science and language arts teachers will help me with grading and editing. Differentiation will be provided for the English Language Learners. Each ELL student will be part of a group. Their readiness for the content will be determined throughout the process. Their role will be designed by my choice and will be monitored during the progression of the unit.

Project instructions will be clear. Each group must choose a life cycle of an animal. A poster should be created with creativity displaying and drawing the animal's life cycle. Each group should write a story about the animal and its life cycle in three paragraphs. Each student should write one paragraph using the vocabulary words listed on the word wall. All three paragraphs of the story should be coherent to make out a complete story of all stages of the life cycle of the animal. This should cover the literacy part of the project.

The mathematics content will be modeled in a scatter plot of two values related to the life cycle of the animal chosen. Students should create this scatter plot from a table of two values. Data could be created and don't have to be accurate or fit to nature. Based on the biology of the animal they should develop a data set and plot that illustrate how they would expect the X and Y variables to be related. For example, plot the relationship between the amount of food eaten by a larva and its growth rate; plot the relationship between the time (days) from egg to pupa and temperature. The mechanics of the scatter plot will also be graded including the title, labels for the axes, and specifying the units of the values used. Correlation or the association of the relationship of the two values should be reasonable and justified. Students should be able to analyze the scatter plot to determine if the relationship is linear, positive, negative, or no association. Students should graph the line of best fit and write the equation of the line. Students should explain the unit rate of change (the slope of the line) in the context. In other ways, students should be able to explain what the meaning of slope -3 or + 5. Also, they should be able to investigate the Y-intercept of the line and explain its meaning in the data. Students should understand that this Y-intercept is the beginning of the function relationship. They should be able to recognize this initial value even if it is not included in the table data or on the graph. At the end of the mathematical investigation of this concept, students should be able to make a prediction about the data. For example, if the data are about the relationship of temperature and amount of days to become an adult, at the end of the project, students should be able to make the right prediction about the amount of days when the temperature goes up or down. A rubric[11] of the project is included in Appendix 2

During the unit, while I am showing the students the metamorphosis of butterflies, frogs, algae, insects and amphibians, we will be referring and giving hints on different sets of data applicable for the project. Since data representations are the main concept of the unit, I will be sharing and asking the students to research sets of pairs of values to analyze in the lesson. For example, some students might choose to investigate the temperature effect on quantity of eggs survived. One might suggest investigating the days of development during a stage compared to the availability of food. Classroom activity in day 2 contains some examples of sets of values students can use for their projects.

Classroom Activities

Drawing connections from the real world is the biggest benefit of adopting the thematic integration.[12]It keeps students engaged through making the math activities fun. My first step is to prepare the classroom culture for this theme. I want to make the metamorphosis theme have a visual impact on my classroom. I am going to make a wall display of posters with the life cycles of frogs, bumble bees, meal worms, mosquito, painted lady butterfly, larvae, and butterfly. The posters will show the stages which the animals go through metamorphosis. Students should note the difference between complete metamorphosis and incomplete metamorphosis. My classroom displays should make a

quick impact on my students' curiosity; and I will begin by building interest in the topic and generating in students a need to know about life cycles and metamorphosis. After I introduce the theme of the unit, Metamorphosis, I will share with my students the outline of this unit and what they should expect during this coming period. I will show them the first video I have uploaded from Discovery Education, The Story of the Butterfly. Next, I will assign students to groups of three. Distribute life cycle samples to each group, making sure to include at least one example of both complete and incomplete metamorphosis in each group. I will not point out the difference to the students.

On the first day, my students and I will discuss what they see displayed on my classroom walls. It would be full of amazing posters of animals life cycles with complete and incomplete metamorphosis. Our display will open up discussions about the subject; what it is about, how it makes them better learners of the unit, and what they might add to it. These mini-posters of life cycles of frogs, mealworms, monarch butterfly, ant, ladybug, jellyfish, grasshopper, salmon, trout, mussel, beetle. The vocabulary list would be a poster on the word wall. Literacy integration is a big focus in our school since we have huge population of ELP students. I will show the students the video from the Discovery Education website. The video is "The Story of the Butterfly: Watch the transformation into a butterfly." I will teach the students what I have learned during our seminars, the amazing process of metamorphosis which not only butterflies go through. Lots of other animals and insects go through metamorphosis to become adults. My job is to introduce my students to these scientific facts while teaching the math unit. Therefore, another video is justified.

The next whole class guide is to show them the video from YouTube[13] about Insect structure, function, and metamorphosis. Gradual, incomplete, and incomplete metamorphosis is explained, as well as the actual Latin root of the word metamorphosis. Only the first part of the video is valuable for the introduction of the theme of the unit. Therefore, I will show videos of metamorphosis (listed below) almost daily; and the talk about metamorphosis will be the daily introduction and closures of class lessons.

Another activity is making a graphic organizer out of the word metamorphosis. It is called Bubble map, where the students write the word metamorphosis in the center circle. Then they use the smaller surrounding circles to describe the word in any word or illustration. I am aiming that this bubble map can help my students improve and retain information on the theme. Students will complete it at the end of the unit when they fill out the small circles with definitions and illustrations they learned about metamorphosis.

The math main concept of this unit is data representation and interpretation. Therefore, I will teach it to my students by showing them data charts from life cycles and transformations of the animals. Examples of data to be represented in our unit will be the students' own research, creativity, and suggestions.

When I show them the 3 types of relationships or associations between two values when they interpret scatter plots of data, an example of positive relationship is comparing the number of eggs and the time of the year. An example of no relationship would be the size of the animal and the color of the body. An example of negative relationship would exist between the number of eggs hatched and the temperature of atmosphere. The classroom activity suitable for this part of the lesson is distributing a graph of scatter plot for each pair of students. These graphs were collected from different scientific journals and website displaying comparing data during metamorphosis. Students should be able to identify positive, negative, or no relationship between the two values displayed. I will extend the use of these graphs for later when they learn to interpret data. As another classroom activity, students will be asked to write a story out of each graph. They will be working in pairs analyzing the data and making up a conclusion of the relationship and create an expectation, predict, for future analysis. Example of graphs used for these classroom activities: percentage of growth rate of corals and time. Another graph will be displaying atmospheric condensation of ocean waters during the years. Another graph displays the Effect of atmospheric CO_2 on coral classification. Another graph displays picture of larvae comparing their Total in lengths and ages in days. Another example of two values we could analyze on a scatter plot is the length of tail and hatching time. Temperature of water and hatching time could be evaluated too.

In the next two days, Students understand that a straight line can represent a scatter plot with linear association. The most appropriate linear model is the line that comes closest to most data points. The use of linear regression is not expected. If there is a linear relationship, students draw a linear model. This lesson will teach students how to come up with the line of best fit (linear model) of the scatter plot so that they will be able to make conclusions of the data or to predict future values. I will teach the students how to draw the line manually, where they need to decide its location among the most of the points, but not necessarily touching all or any of the points. Here students need to analyze tables of bivariate data and should be able to determine if the data could be represented in a linear model. At the same time, the connection of the theme to this lesson is by focusing on the life cycles of the butterflies. In this lesson, students learn about the life cycle of the butterfly as an example of the complete metamorphosis by watching a video from Discovery Education and starting a classroom discussion, reading the Hungry Caterpillar will be also an option as a whole class reading, and visiting websites. Students engage in several different tables to share their new knowledge. Two videos will be appropriate to show today. The first one is “What Is Metamorphosis?” This video displays Metamorphosis as a process by which an organism undergoes a dramatic change in form, such as the metamorphosis a tadpole undergoes to become a frog. The second one “From Pupa to Caterpillar” demonstrates the Metamorphosis of the Monarch Butterfly

Depending on my students’ progress, during the next 2-3 days I am going to expand upon this lesson by comparing the life cycle of butterflies to the life cycles of other animals. If possible enhance this lesson by providing students with opportunities to

observe and interact with living organisms through videos and pictures. Students can compare the life cycles of different animals e.g., egg-tadpole-frog to egg-caterpillar-chrysalis-butterfly. The standard they are learning today is interpreting the slope and y-intercept of the line in the context of the problem. A video will be shown and discussed for comparison. According to the common core standard, students understand that a two-way table provides a way to organize data between two categorical variables. Data for both categories needs to be collected from each subject. Students calculate the relative frequencies to describe associations. Another two videos today will explain the details of complete and incomplete metamorphosis. The first one, "Three Stages of Incomplete Metamorphosis" shows how the Egg, Nymph, and Adult: Nymphs represent the second stage of metamorphosis during which insects undergo a series of molts in a few weeks as they grow to adulthood. Some insects go through eight or more molts and develop wings before adulthood. Sharp spines on front legs make the praying mantis a very effective predator. The adult stage is the final stage of metamorphosis. The second video is called, "Four Stages of Complete Metamorphosis". It shows how the Egg, Larva, Pupa, Adult: The Monarch butterfly illustrates the four stages of complete metamorphosis, including egg, larva, pupa, and adult. Monarch butterflies lay eggs on milkweed, the food source for their young. Insect eggs vary in appearance and deposit location. The can be underwater, underground, on leaves, or in galls. The primary function of insect larvae is to eat as much as possible.

In addition to creating a bivariate table in the next two days, students will be writing an equation of the line. Then they should be able to find its slope and calculate the Y-intercept and write the equation of the line. In other situations, when given a linear model, students should be able to write an equation of the line. Also, students should be able to connect that the slope of the line of best fit is the unit rate of change. They should be able to identify the rate of change of a value towards another value is this number (coefficient of X); also, this should lead the students' thinking into solving other problems. For example if we brought 20 eggs of butterflies to breed, and at the end of the metamorphosis stages we got only 5 butterflies alive, what is the estimate number of butterflies one could breed when he gets 50 eggs? Students should be able to write the equation and substitute the variables for the values given to find the missing value. They need to extend their algebraic thinking into interpreting that the slope or the unit rate of change can help them predict future data for this set. The videos showing today explains that not only butterflies go through metamorphosis. One is called "Examples of Insects That Undergo Incomplete Metamorphosis": A young insect that undergoes incomplete metamorphosis strongly resembles the adults. Examples of walking stick, roach, and aphid metamorphosis are featured. Young damselflies live underwater and only vaguely resemble adults. The second one, "The Development of Tadpoles: Metamorphosis." This video shows the developing tadpoles feed off the yolk of the eggs and hatch anywhere from four to fifteen days after fertilization. Upon hatching, they look much more like baby fish than frogs. As tadpoles mature, they lose their external gills, and they grow

internal lungs. They first grow hind legs along the sides of their tails, and soon after they grow front legs.

The last part of the unit is teaching the students how to be able to apply all the lessons taught using the graphing calculator; students will be able to find the equation of the line using the graphing calculator. This standard is calculator active on the End of Grade tests. Therefore, students will be able to use the graphing calculator professionally. If they followed the right steps, the calculator is a great tool for finding the equation of the line of best fit; it will find the linear regression; and it can calculate for us future data from the table or the graph. Students will learn how to input the data in table of X and Y, find the linear regression and correlation; and the calculator will find the equation of the line. In addition, I will show the students how to predict a future value but tracing the point on the line or from the table window on the calculator. The classroom activity here is the Graphing Calculator Scavenger Hunt. What is different for this unit is that I will teach this using the data examples from the metamorphosis of different animals. One good free resource from our school district is the data from the Discovery Education website.

One of the activities which help us summarize the unit, I will ask the students to make a bubble map in their notebooks and give them 5 minutes to jot down anything they learned about this word. Another five minutes will be given to discuss it with each other. Then I will make a chart on a poster board where students record all their knowledge about metamorphosis. I will keep this poster on the wall till the end of the year. This bubble map of the whole class will be our souvenir of this successful learning experience. I will ask the students to sign it and decorate it with all the animals and butterflies we have watched.

Usually, my students should have a warm-up activity displayed on the board for them to start working on as soon as they enter my classroom. And most of the time these warm-up activities are reviews from previous units, introduction to the new lesson, or drilling basic math skills from previous years. During this unit, I will incorporate some of these examples of Warm-Ups:

1) If a ladybug lays 40 eggs and 32 hatch, how many did not hatch?
2) What is the fraction of eggs that hatched?
3) What is the percentage of eggs that hatched?
4) If 24 hatchlings make it to adults, what is the percentage of adults, out of those that hatched?
5) What is the percentage of the total number of eggs that make it to adults?
6) How many eggs (#) did not become adults?
7) A monarch is an egg for a period of 3-6 days. After hatching, a caterpillar will eat about 30 milkweed leaves. If it eats three leaves every day, how many days will it take until it has eaten all 30 leaves?

8) Eventually, the caterpillar will weigh 3000 times as much as it did when it hatched! As the caterpillar grows, it molts, or sheds its skin, four times.
    - The first time, it is about 3/16" long.
    - The second time it is about 3/8" long.
    - The third time it is 3/4" long.
    - The last time it molts, it is 1 1/4" long (5/4").
    - How much does its size increase:
        - From the first to second length? - =
        - From the second to third? - =
        - From the third to fourth? - =

Why Metamorphosis?

"Ontogeny recapitulates phylogeny"[14] was the catch phrase for my curiosity to explore this seminar. This phrase is our seminar's leader favorite phrase and has been my motivation, arousal, and inspiration. When I read this phrase for the first time, I suspected myself of total ignorance, but research and writing this unit put me in the clear. At the end, I hope you will be amazed and appreciative of our nature and its processes. The transformative experience I went through has been as fascinating as the natural process of the metamorphosis of the butterfly. I have changed to become more knowledgeable of natural process, integration of other subject with math, and writing a curriculum unit. My teaching tool kit has developed tremendously; and I have proudly but humbly become more confident. I have metamorphosed to become a teacher leader.

Notes

[1] "8SP Statistics and Probability." North Carolina Public Instruction. http://www.ncpublicschools.org/docs/acre/standards/common-core-tools/unpacking/math/8th.pdf.
[2] "All Lives Transform: Metamorphosis."
[3] ibid
[4] Dictionary.com.
[5] Iyoke, Kings. "Animals That Go through Metamorphosis."
[6] RESCU | Teacher Background: Patterns of Change: Metamorphosis
[7] "Ohio Resource Center Record #12191
[8] http://www.edutopia.org/blog/integrating-math-science-creatively-ben-johnson.
[9] School Science and Mathematics Volume 95(5), (95): 226-30. 95.
[10] Discovery Education
[11] http://www.rubrics4teachers.com/mathematics.php
[12] Show Me WOW. http://www.show-me-wow.com/a-thematic-approach/.
[13] http://www.neok12.com/video/Metamorphosis/zX7c567c746870536673686b.htm
[14] "Amy Ringwood, Ph.D., "Metamorphosis: Transformative Experiences"" YouTube.

List of Materials for Classroom Use

Graphing calculators

Poster boards for students' projects.

Promethean board to show videos

Bubble map thinking map samples for students' use

Illustrations of life cycles of animals made into poster for wall display

Bookshelf in the classroom to exhibit the recommended students' books

Word wall for the vocabulary words of the unit.

Reading List for students

"From Caterpillar to Butterfly" by Dr Gerald Legg

"Butterfly Express" by Jane Belk Moncure

"Monarch Butterfly" by Gail Gibbons

"Munch, Munch, Munch" by Norma L. Gentner

"Caterpillar Diary" by David Drew

"The Very Hungry Caterpillar" by Eric Carle

Appendix I: Implementing Teaching Standards

This unit incorporates North Carolina Common Core Standards for 8th grade. It covers three standards within the statistics and probability content. The main focus is to investigate patterns of association in bivariate data.

CCSS.MATH.CONTENT.8.SP.A.1

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities.

Students should be able to describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

CCSS.MATH.CONTENT.8.SP.A.2

Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

Students should see that scatter plots help to answer questions about the relationship between two items; is there a cause and effect? Does one seem to help predict the other? Is there a relationship between temperature and number of eggs?

CCSS.MATH.CONTENT.8.SP.A.3

Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.

Students should be able to draw the line of best fit, make judgment about the data, and predict future results.

CCSS.MATH.CONTENT.8.SP.A.4

Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?

Students should be familiar with a variety of ways to display and interpret data. When given a set of data, they should be comfortable picking the display that best represents that data or that suits the purpose for answering the questions for which the data was collected. Giving students opportunities to pose questions and collect their own data helps make the choice of data display selection seem more relevant and clarifies the purpose of each choice

Appendix II **Students' Handout**

Rubrics of the project					**Points**
	4	**3**	**2**	**1**	
Use of Visual	Life cycle is clear and sketched with some detail.	Clear diagram or sketch	Inappropriate or unclear diagram	No diagram or sketch	
Story of the Life Cycle	A complete 3paragraphs with detailed description; signed by each member	Good story with some descriptions	Story is unclear; not in harmony;	Not complete; not signed	
Mechanics	Scatter plot complete with No Math errors. Equation is correct	No major math errors;	Some serious math errors in equation or scatter plot	Major Math error or incomplete	
Demonstrated Knowledge	Slope explained; Y-intercept explained; Interpret the slope and y-intercept of the line in the context of the problem.	Shows some knowledge of the slope or Y-intercept in context	Response shows some understandin g of the slope or Y-intercept	Response shows a complete lack of understanding for deducing the slope and Y-intercept	
Prediction	Includes clear and correct prediction of the data	The prediction should be explained more	The prediction is not applicable	Does not include any prediction of the data	

Appendix III

Metamorphosis Vocabulary Terms:

Aphid - a small, soft-bodied insect that feeds by sucking sap from plants

Chrysalis - The cocoon of a butterfly.

Cocoon - the silky case spun by the larva; it serves as a covering while the larvae develop

Complete metamorphosis - the life cycle of some insects; they change from eggs through the stages of larvae, then pupae to become adults (four stages)

Exoskeleton - a hard covering on the outside of an insect that provides structural support and protection.

Gradual metamorphosis or incomplete metamorphosis: insects hatch from eggs looking like a small adults called nymphs. They shed their exoskeleton as they grow until they reach adult size. (Three stages)

Infested - inhabited by so many organisms that it becomes a problem

Insect - an animal that has three body regions (head, thorax, and abdomen) and three pairs of jointed legs; also called an arthropod

Larva - the newly hatched form of some insects that are wingless, such as a caterpillar or a grub. This is the stage when the insect hatches from the egg and spends all its time eating before it develops into a pupa. (Plural larvae)

Life cycle - a series of stages which something passes through during its lifetime

Metamorphosis: the series of changes in shape and function that certain animals go through as they develop from an immature form to an adult. Metamorphosis can be gradual or complete

Molt - to shed an outer covering that is replaced by a new one. Birds molt feathers, snakes molt skins, and insects molt exoskeletons.

Nutrient - any substance that can be used to support life

Nymph - the immature form of insects that go through gradual metamorphosis. They look like small adults that do not have fully developed wings and develop into adults without going through a pupal stage. Examples are dragonfly and grasshoppers.

Organism - a living thing that is made up of body parts which help it function.

Pupa - the non-feeding stage in the insect life cycle between larva and adult during complete metamorphosis. A larva goes through a complete change inside a hard case. A chrysalis is the pupa of a butterfly encased in a cocoon. (Plural pupae)

Pupate - to become a pupa

Varied - different, not all the same

Bibliography for Teachers

Iyoke, Kings. "Animals That Go through Metamorphosis." *Zoology*, 2012, 360. http://www.sciences360.com/index.php/animals-that-go-through-metamorphosis-2251/.
This website for the journal is a great resource for definitions and guidance.

"8SP Statistics and Probability." North Carolina Public Instruction. http://www.ncpublicschools.org/docs/acre/standards/common-core-tools/unpacking/math/8th.pdf.
This document is the mandated guide of all my lesson plans in my district.

"A Thematic Approach to Teaching and Learning." Show Me WOW. http://www.show-me-wow.com/a-thematic-approach/.
This website is a resource for the use of integrated lesson planning.

"All Lives Transform: Metamorphosis." All Lives Transform: Metamorphosis. "Butterfly Metamorphosis Life Cycle Photos, Videos & Observations."
This a website for watching and learning about the stages of metamorphosis

"Constructing a Scatter Plot." Khan Academy. https://www.khanacademy.org/math/cc-eighth-grade-math/cc-8th-data/cc-8th-scatter-plots/v/constructing-scatter-plot.
A teacher's guide to teach scatter plots to middle grades math classes.

Davidson, David M., Kenneth W. Miller, and Dixie L. Metheny. "What Does Integration of Science and Mathematics Really Mean?" *School Science and Mathematics* Volume 95(5), (95): 226-30. 95. http://www.project2061.org/publications/designs/dod/DSL_text/Reprints/8_Davisn.pdf?txtRef=https://www.google.com/&txtURIOld=/ftp/DESIGNS/DSL_text/Reprints/8_Davisn.pdf.
This is a teacher's guide for integration science and math professionally

"Discovery Education." Discovery Education. http://app.discoveryeducation.com/search?Ntt=metamorphosis&N=4294939055#selItemsPerPage=20&intCurrentPage=1&No=20&N=4294939055&Ne=&Ntt=metamorphosis&Ns=&Nr=&browseFilter=&indexVersion=&Ntk=.
A reference for teachers provided by the school district for free videos, activities, and lesson plans.

"How to Creatively Integrate Science and Math." Edutopia. http://www.edutopia.org/blog/integrating-math-science-creatively-ben-johnson.
A teacher's source for planning integrated lessons.

"Insect Structure, Function, and Metamorphosis." YouTube. https://www.youtube.com/watch?v=tM53SsmJY6I.
A teacher's use in classroom to introduce metamorphosis

"Life Cycle of the Treehole Mosquito." NeoK12. http://www.neok12.com/video/Metamorphosis/zX5650465270035b6f5c7e7f.htm
A classroom video showing metamorphosis of insects to compare with butterflies.

Loman, Jon. "Temperature, Genetic and Hydroperiod Effects on Metamorphosis of Brown Frogs." *The Zoological Society of London* 258, 115±129, no. DOI:10.1017/S0952836902001255 (2002): 115-29. http://www.rana.se/Jon/pdf/mmdamm.pdf.
A source of data collected to use in lessons to teach bivariate tables

"Math Rubric ". http://www.rubrics4teachers.com/mathematics.php
A teacher's guide to build a project rubric. any format can be used or it can be edited for convenience.

"Mathematical Butterflies Provide Insight into How Insects Fly." ScienceDaily. http://www.sciencedaily.com/releases/2013/03/130325125644.htm.
An easy read science journal for teachers of any subject.

"Metamorphosis - Butterfly Metamorphosis." NeoK12. http://www.neok12.com/video/Metamorphosis/zX7c567c746870536673686b.htm.
A teacher's guide for the concept of metamorphosis for any animal or insect. which can be taught to any grade. It is also a kid-friendly to share with students.

"Ohio Resource Center Record #12191 The Life Cycle of Butterflies, Day 1."
A free lesson plan for teaching the life cycle of butterflies. It can be edited and adjusted to any grade level.

Pechenik, Jan A. *Biology of the Invertebrates*. 5th ed. Boston: McGraw-Hill, Higher Education, 2005.

"RESCU | Teacher Background: Patterns of Change: Metamorphosis (4.6A). Rice University Professional Development in Science.
A summary of a professional development seminar on metamorphosis. A good resource for teachers for the definition of metamorphosis.

"Science Explorations." Scholastic Publishes Literacy Resources and Children's Books for Kids of All Ages.

A student-friendly resource for the concept of metamorphosis and life cycles of animals.

"The Biological Impacts of the Fukushima Nuclear Accident on the Pale Grass Blue Butterfly." Nature.com. http://www.nature.com/srep/2012/120809/srep00570/full/srep00570.html#f5.
A teacher's source for data collection related to the science theme of the unit.

"Metamorphosis." Dictionary.com. Accessed September 26, 2014. http://dictionary.reference.com/browse/metamorphosis?&o=100074&s=t.
A formal definition source.

"Amy H. Ringwood, Ph.D., "Metamorphosis: Transformative Experiences"" YouTube. https://www.youtube.com/watch?v=QZu1KKHA9-Q.
My seminar coordinator's short video is the introduction and eye-opener for the theme: metamorphosis. This has been the inspiration to get involved with this great team.