Action Research:

Second Graders' Understanding of Models

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Abstract

This project was completed for a course called Science Capstone at the University of Michigan – Dearborn. Its purpose was to efficiently teach students while identifying and addressing their misconceptions. Over the course of one semester, we attempted to answer one major question: “What do Dr. Charles Drew Academy students know about scientific models and what effect does our instruction have on their knowledge of scientific models?” We pre-assessed students, found misconceptions, taught two lessons based on those misconceptions, then administered a post-assessment. For the pre-assessment, 14 out of 15 students had partially correct answers when choosing which object was a model. For the post-assessment, 14 out of 14 students had partially correct answers. On additional questions about models, 4 to 6 out of 14 answered each correctly, and 1 to 6 answered each incompletely. Our instruction did affect the students' knowledge of science models. We came to the conclusion that more than two lessons are required to reconstruct the students' conceptions of models.
We took a course called *Science Capstone* at the University of Michigan - Dearborn. The course had a unifying theme – for the Winter 2012 semester, it was “scientific models”. As pre-service teachers, we learned how to identify models and how to utilize them in a K-8 classroom. Another goal of the class was to integrate research with teaching – executing an action research project – using a 5E science model. The 5E model is inquiry-based, which includes five steps: Engage, Explore, Explain, Extend, and Evaluate. Working as partners, we executed a research project in a 2nd grade classroom. We assessed students (prior to and after the lessons), and built on student knowledge and misconceptions as we taught said lessons.

Initially, the focus of our study was inheritance of physical traits (life science); specifically, we wanted to know: “What do Dr. Charles Drew Academy students know about inheritance of physical traits and what effect does our instruction have on their knowledge of inheritance of physical traits?” However, it was changed to: “What do Dr. Charles Drew Academy students know about scientific models and what effect does our instruction have on their knowledge of scientific models?” We found that students did not understand models after our pre-assessment. We integrated models (our big idea) into our lessons by teaching with photos or drawings. They were important and appropriate for teaching about models, because we were not able to bring real objects – like cars or babies – into the classroom. Models allowed students to examine these objects closely, and build their own understanding of a concept with something concrete. When we planned to teach about the inheritance of physical traits, models would have allowed us to create our own creatures that were tailor-made for the students, depending on their misconceptions.

To answer our focus question, we went through numerous steps, which spanned an entire
semester – approximately four months. These steps included meeting the teacher to choose a topic, finding related research, completing a pre- and post-assessment, and carrying out the tests and lessons. The final project was then presented to the class. The schedule for our project is outlined in more detail in Appendix A. Before we taught the students using models, we had to find several articles relating to inheritance of physical traits, on which to build on or extend our lessons.

One article that related to our research was “Models of the Universe: Children's Experiences and Evidence From the History of Science” by Vasiliki Spiliotopoulou-Papantoniou (2007). Students made pictorial models of what they thought the universe looked like – the drawings were then categorized into different groups (Spiliotopoulou-Papantoniou, 2007). For example, some students drew a “terrestrial model” – a model of the universe that “has a very narrow range” (Spiliotopoulou-Papantoniou, 2007, p. 812). It was found that students' ideas about the universe were strikingly similar to historical models from long ago, such as those from Ancient Egypt (Spiliotopoulou-Papantoniou, 2007).

This study related to our project, because we used models to teach and had students build their own models (Spiliotopoulou-Papantoniou, 2007). We also taught them about models before physical inheritance. We asked students about models in our pre-assessment; like in the study, they drew their ideas (Spiliotopoulou-Papantoniou, 2007). We organized the pre-assessment data based on common ideas found in students' models as well (Spiliotopoulou-Papantoniou, 2007).

To build off of this study, we looked for common features in the class responses for the pre-assessment – just as Spiliotopoulou-Papantoniou had done – but asked for further explanations (Spiliotopoulou-Papantoniou, 2007). An extension of this study was teaching and
assessing second graders only: this study included students from ages six to sixteen (Spiliotopoulou-Papantoniou, 2007). Furthermore, we moved beyond just discovering their mental models, by basing our 5E lessons off of those models and teaching the students (Spiliotopoulou-Papantoniou, 2007). The topic of this study was the universe, and it analyzed the students' understanding and how it related to historical models (i.e. the human nature of conceiving the universe) (Spiliotopoulou-Papantoniou, 2007). However, we examined models and how students' ideas changed over a period of two lessons.

Another article that related to our project was “Children's Understanding of Inherited Resemblance: The Case of two Parents” by Mark Meerum Terwogt, Hedy Stegge, and Carolien Rieffe (2003). The researches noted that students often focused on physical similarities between offspring and parents, as opposed to their differences. Moreover, some children believed that similarities transcended one's outer appearance (e.g. the “'pink heart inside'”) (as cited in Terwogt, Stegge, & Rieffe, 2003, p. 366). The study involved having students choose between pictures of offspring that resembled the mother, father, or a mix of both (Terwogt et al., 2003). There were three main patterns in the results – a bias towards the parent who raised the child, a mother bias, and a combination of both parents' features (Terwogt et al., 2003).

Our project related to this study, because we had planned to teach about the inheritance of physical traits. The researchers stated that students younger than 7 years old included irrelevant factors in the offspring’s physical traits (Terwogt et al., 2003). We tested 2nd graders who are approximately this age – it is a transition period for differentiating between relevant and irrelevant factors, as well as movement away from biases (Terwogt et al., 2003). Terwogt, Stegge, and Rieffe's (2003) study included misconceptions that we had planned to take into
consideration when executing our project. These included gender (e.g. like father like son), maternal (i.e. children always look like their mother), social proximity (i.e. the parent who stays with the child longer), superiority (e.g. a stronger parent will pass down his/her traits), and psychological biases (i.e. a desire for the offspring to look a certain way) (Terwogt et al., 2003).

To build upon this research, we used more than a “forced-choice” assessment like in Terwogt, Stegge, and Rieffe's research, where students were made to choose from three different-looking offspring (2003, p. 366). We had students make their own decisions, draw pictures, and elaborate on their answers. Like the aforementioned researchers, we used pictures to assess the students, but we also used them as our scientific models when teaching (Terwogt et al., 2003). Another study by Springer (1999) was mentioned, which stated that despite having “experience-based knowledge”, students' understanding can be hindered by this as much as helped (Terwogt et al., 2003, p. 372). To extend the research, we used the 5E lesson model, and planned to take into consideration student backgrounds during the lesson (e.g. whether students have siblings or pets, and how this may affect their responses).

A third study is “Why dogs Have Puppies and cats Have Kittens: The Role of Birth in Young Children's Understanding of Biological Origins”, by Susan C. Johnson and Gregg E.A. Solomon (1997). The research mostly centered around using animal adoption stories to assess students, asking if the offspring would look like the biological or adoptive parents (Johnson & Solomon, 1997). “[L]ike begets like” was a common theme in the study, as preschoolers preferred to choose offspring that were similar-looking, though not of the same species (Johnson & Solomon, 1997, p. 417). However, 7-year-olds usually understood that a species begot offspring of the same kind (Johnson & Solomon, 1997). The researchers found that children's
understanding of how babies were born formed the foundation for understanding inheritance (Johnson & Solomon, 1997).

Our project related to this study, because its focus was on parent-offspring resemblance in animals – our research also centered around this topic (Johnson & Solomon, 1997). Moreover, Johnson, and Solomon used a pre-test to see if students understood where babies came from, and how it affected their understanding of the topic (Johnson & Solomon, 1997). We also planned to do a pre-assessment to ascertain students' misconceptions, and if having siblings or pets affected the children's understanding of the heredity of physical traits.

To build upon this research, we intended to assess students using a cross-species story (Johnson & Solomon, 1997). However, unlike Johnson and Solomon (1997), we planned to record their reactions to an excerpt of *Horton Hatches the Egg*, in which an elephant sits on a bird's egg, and what hatches is an Elephant-bird hybrid (Dr. Seuss, 1940/1968). Moreover, the researchers conducted three different sub-studies: resemblance based on “physical properties and beliefs”, species type, and parent biases (Johnson & Solomon, 1997, p. 404). Conversely, we planned to focus on one or two misconceptions, depending on the students' pre-assessment results (Johnson & Solomon, 1997). We also tested only 2nd graders and not both children and adults (Johnson & Solomon, 1997). To extend this study, we used pictures of humans for the core of our lessons. We also planned to use “creatures” (e.g. yellow polka-dotted triangles) as our models, instead of just animals. Johnson and Solomon (1997) only used animals, but we wondered how students would apply their knowledge of physical heredity to offspring with no specified gender.

A fourth relevant study is “Teaching Preschoolers About Inheritance”, by Meadow
Schroeder, Anne McKeough, Susan A. Graham, Hayli Stock, and Jaime Palmer (2007). The study is similar to our project, because it talked about students’ misconceptions about physical inheritance – pre and post-assessments were also administered (Schroeder, McKeough, Graham, Stock, & Palmer, 2007). The same misconceptions in this study were also noted by the previously mentioned researchers Springer (1995), and Solomon and Johnson (2000): knowledge about birth helped change misconceptions (Schroeder et al., 2007). The study explained several inheritance concepts, as well as appropriate activities that addressed the aforementioned misconceptions (Schroeder et al., 2007). These included matching pictures of adult and baby animals (“like-begets-like”), or using a story The Baby is Coming, with questions to talk about how “acquired traits are not passed to offspring” (Schroeder et al., 2007, pp. 73, 75).

To build upon this research, we intended to use suggested books and activities during the Engage portion of our lesson (Schroeder et al., 2007). The study also provided ideas for discussions – questions raised by the preschoolers – which we planned to use during our lesson (Schroeder et al., 2007). For example, “What if you had green hair for real? Would your child have green hair?” (as cited in Schroeder et al., 2007, p. 72). To extend this research, we used a 5E lesson plan with second graders, and not preschoolers (who were the subjects in this study) (Schroeder et al., 2007). Unlike this study, we focused on using models in our lessons, taking advantage of drawings that students created, and used photos or drawings for our teaching materials.

A fifth related study is “Formative Assessment: Using Concept Cartoon, Pupils’ Drawings, and Group Discussions to Tackle Children's Ideas About Biological Inheritance”, by
Christine Chin and Lay-Yen Teou (2010). The study identified the student’s ideas about inheritance via concept cartoons, drawings, and discussion (Chin & Teou, 2010). According to Chin and Teou (2010), “Pupils’ drawings, writing, and group discussions allowed their ideas to be made explicit while at the same time enabling their alternative conceptions to be diagnosed via regular classroom activities” (p. 112).

There is a great benefit to making an assessment using the above-mentioned tools (Chin and Teou, 2010). Concept cartoons are relatable for students and require less language development than standard reading (Chin and Teou, 2010). In addition to the cartoons, students were also assessed based on drawings: “these modes of visual representation are particularly useful for pupils with limited literacy skills, and thus can be used with primary school pupils” (Chin and Teou, 2010, p. 109). The research showed that students had a low understanding of traits and inheritance (Chin and Teou, 2010).

This article related to our study, because many misconceptions were identified, such as “the mother contributes more to the genetic make-up of the offspring than the father; the same-sex parent is the determiner of the physical traits in the offspring” (Chin & Teou, 2010, p.109). We also intended to identify misconceptions with our pre-assessment, building of off students' thinking. Examples were given “of how […] activities provided the teacher with formative feedback about pupils' thinking” (Chin & Teou, 2010, p.112). The assessment showed that the students knew their physical traits were a mixture of both parents' looks, but many had different explanations (Chin & Teou, 2010). For instance, some assigned percentages to each parent, depending on the gender of the offspring, or thought that behavior was inherited (Chin & Teou, 2010).
We built off of this study by utilizing the information gained from the article regarding assessment using concept cartoons and drawings (Chin & Teou, 2010). We assessed students (albeit, only 2nd graders) by using drawings or written responses. To extend this study, we used models, inquiry-based learning (5E lessons), and discussion, to correct – at a minimum – some misconceptions and further developed students' understanding.

A sixth article that related to our project is “Who do I Look Like? Diversity in Self, Family, and Others” by Felicia Moore Mensah (2010). This article looked at a hands-on activity that introduced students to the concepts of traits (Mensah, 2010). According to Mensah (2010):

“This lesson touches on core national science education standards in life science and the living environment, such as plants and animals closely resemble their parents and other individuals in their species, and plants and animals can transfer specific traits to their offspring when they reproduce.” (p. 129)

Students worked in pairs and used a coin to determine what traits will be inherited (Mensah, 2010). The article outlined ways students could collect and record data -- students then used their data to draw a picture of the child they created (Mensah, 2010). This activity helped students learn about traits, placing them at the center of the learning (Mensah, 2010). Students were also able to have class discussions about things they learned (Mensah, 2010). We directly related this article to our lessons in several ways: we looked at the article's outcomes and reviewed students' misconceptions (Mensah, 2010). This allowed us to focus our lessons – we tried to identify and correct misconceptions (Mensah, 2010).

We built upon this article by attempting to not only identify common misconceptions, but also correct them (Mensah, 2010). It was our intention to correct misconceptions by: providing
the students with accurate knowledge, engaging students in an inquiry based lesson, and using positive attributes of models to make the concepts of traits tangible for students to learn from. Moreover, we planned to use the activity of coin flipping to create a picture of offspring, to teach students that like does not necessarily beget like (Mensah, 2010). To extend it, we intended to focus on how parents and offspring share some physical traits, and not cover the topic to the extent that Mensah had (i.e. dominant or recessive traits) (Michigan Department of Education, 2007; Mensah, 2010). We also planned to use drawings or photos of animals and their offspring, instead of humans, which was used in Mensah's lesson (2010). The six aforementioned articles were a strong foundation for our study, in combination with information about the students that we used to make the lessons more student-centered.

Demographic information about the students was obtained through personal communication from our cooperating teacher on February 6, 2012. We worked with second graders in a Title 1 charter school with low-achieving students. In our classroom, there were 18 students who were of African-American/Black, Caucasian, and Hispanic backgrounds. The diverse group also included an English Language Learner, a child who received speech classes, and two students who were in the process of receiving those classes. There were two who worked with a social care worker due to behavioral issues. The students also had varying interests, including wrestling, video games, and reading Captain Underpants and Diary of a Wimpy Kid.

The teacher utilized several classroom management techniques. One example was color cards, in which students changed the color of their card each time they misbehaved. She also assigned points for good behavior. Other techniques included turning the lights off, counting
down, or clapping rhythmically five times – students then mimicked the claps.

The classroom was small and covered with posters and examples of children's work. Upon entering the room, the teacher's desk was on the left-hand side – a large whiteboard hung on the opposite side. Near the teacher's desk was a carpet on which the entire class could sit. Students' desks were in the center, lined in three rows with six desks in each row – there were also two outlier desks on either side of the room. All of the desks faced the whiteboard. Next to the whiteboard was also a small area with a desk that could seat four to five students. The classroom technology included a document camera, laptop, projector, and DVD/VCR player.

Science classes were usually taught on Mondays and Tuesdays at 1:30 p.m., every other week. Each lesson lasted approximately 45 minutes. Depending on the lesson, the teacher used the scientific method and also an inquiry-based approach (though it was not the 5E model). The students had learned many other science topics, including the parts of plants, plant needs, classifying objects, solids, liquids, and gases. Pertaining to our topic, the students had only briefly discussed plant traits. We planned to build upon their knowledge, so we referred to studies that addressed assessment to target their misconceptions.

We used four items in the pre-assessment of the second grade students. The students were young, and they had to write, draw, and explain their answers, which we thought would take a reasonable amount of time. We asked students as a class, but they answered the questions individually. We wanted them to elaborate on their answers, to get a deeper understanding of what they knew.

We examined additional articles that were specific to our pre-assessment that was given to the students: the questions are located in Appendix B. The first question was, “Which
object(s) do you think are science models and why?” We asked students to individually choose the model(s) from three objects (a baby doll, a toy car, and a picture of the earth), and explain their thinking on a sheet of paper. This question was created by us. It was essential that students understood what a model was, since we were going to use models in our lessons. We also specified “science model”, since we did not want students to describe non-scientific models.

Our second question – also created by us – was, “What is a trait?” Students were to individually draw what they believed a trait was (on a sheet of paper), in case they did not have all of the words to explain this concept. We planned to have the students share their answers with us personally – not with the class – and we would write down their answers. However, after looking at the students' responses, it was not necessary to have students draw or explain their answers – the majority did not know what a trait was. We asked this question, because our lessons were supposed to be about inheritance of physical traits. We needed to know if students were familiar with the word “trait”. Otherwise, using it during the lesson would have left the students confused. Students briefly discussed plant traits in class, so we also reminded them of this during the pre-assessment.

The third question was adapted from Christine Chin and Lay-Yen Teou's study (2010). We had each student draw a picture or diagram of who or what determined their physical appearance, and label it (Chin & Teou, 2010). This question let us know if students understood that their physical appearance was at least determined by their parents (e.g. not God) (Chin & Teou, 2010). We planned to ask a sample of students with differing ideas to explain their drawings to us personally. However, during the pre-assessment, we decided to ask all students to explain their answers.
The fourth item was directly taken from Mark Meerum Terwogt, Hedy Stegge, and Carolien Rieffe's study (2003). Similar to their research, we orally recited a description to the class about two cats and their three possible offspring (Terwogt, Stegge, & Rieffe, 2003). The choices included a kitten that looked exactly like the mother, one that looked exactly like the father, and one that looked like both (Terwogt, Stegge, & Rieffe, 2003). Drawings of cats were used, and we asked students to choose which kitten they thought the offspring would look like, and to explain why (Terwogt, Stegge, & Rieffe, 2003). We labeled each kitten with letters, so students answered accordingly: A (offspring that looked like the father), B (offspring that looked like the mother), and C (offspring that looked like both). They were then asked if their choice was a boy or a girl and to explain why (Terwogt, Stegge, & Rieffe, 2003). We made sure to first describe the drawings to the students and point to each to correspond to the descriptions (Terwogt, Stegge, & Rieffe, 2003).

Two of the questions related to two different studies. The third item was adapted from Chin and Teou's research (2010). The article related to our study, because students drew their understanding of inheritance (Chin & Teou, 2010). Just like the study, we asked them to individually draw who or what determined their physical appearance, on a sheet of paper (Chin & Teou, 2010). It was adapted, because did not ask them what determined their gender (Chin & Teou, 2010). A specific example from the study was a student who drew his/her mother and father (labeled as “noisy”), and him/herself as “noisy” (Chin & Teou, 2010). Moreover, the drawings were used as a form of assessment – the aforementioned researchers used it as a formative assessment, but we used it for pre-assessment (Chin & Teou, 2010). Also, the study included students whose native language was not English (Chin & Teou, 2010). There was an
English Language Learner in our classroom, and using drawings can be an effective way to help students communicate (Chin & Teou, 2010).

The first part of the fourth item was taken directly from Terwogt, Stegge, and Rieffe's study; the second part was adapted from it (2003). Our study related to this, since we asked students about inheritance of physical traits (Terwogt, Stegge, & Rieffe, 2003). We also used a "forced-choice" method to assess students, in which only three offspring choices were given, and they had to choose one (Terwogt, Stegge, & Rieffe, 2003, p. 366). We used drawings of a familiar animal (a cat), representing the two parents and their offspring possibilities as well (Terwogt, Stegge, & Rieffe, 2003). We also read aloud a description about the cats, and the students chose which one they thought was the offspring (Terwogt, Stegge, & Rieffe, 2003). Like this study, our drawings included two offspring that were a copy of the mother or father, and one that was a mixture of both (Terwogt, Stegge, & Rieffe, 2003). We also tested students' misconceptions with this question, and built off of their ideas in our action research project (Terwogt, Stegge, & Rieffe, 2003). Some of the common misconceptions in the aforementioned study were mother bias and gender bias, which were addressed in our pre-assessment (Terwogt, Stegge, & Rieffe, 2003).

Once we administered the pre-assessment, we organized the data in several ways. We first organized the results by question. We divided the data from each question into completely correct answers and incorrect answers. Incorrect answers were broken down into wholly incorrect, partially correct, incomplete answers (e.g. irrelevant), don't know answer, and no answer. After organizing the data, we found the question with the most misconceptions, and prioritized said questions from most to least important. For instance, misconceptions about
models were more important than traits, because our lessons were based on models, and students
needed to understand that first before we moved on to other content. After we taught the two
lessons, we created and administered a post-assessment.

All of the post-assessment questions were created by us. They were asked orally, and
while the students took the test, we walked around the room to make sure they understood each
question. The first item was the same as the first pre-assessment question, and was administered
in the same way: the students wrote their answer on paper. We kept this question the same,
because we taught students about various science models, using toy cars, dolls, coins, and fake
flowers as examples. The post-assessment questions can be found in Appendix D.

The second item was, “Draw a science model. Why is it a model?” Students learned
about several different science models, and that drawings can be models as well. We also wanted
to give students various ways to demonstrate their learning. For example, one of the students
was an English Language Learner, and she may have been able to express her thoughts better in a
drawn form. This idea of accommodating students was explained in “Formative Assessment:
Using Concept Cartoon, Pupils' Drawings, and Group Discussions to Tackle Children's Ideas
About Biological Inheritance”, by Christine Chin and Lay-Yen Teou (2010). Students drew their
answers on a sheet of paper, then explained them in written form.

The third post-assessment question involved showing students a plastic globe, while
asking, “Is this a good or a bad model; why or why not?” We taught students how a model is
different from the real thing (e.g. a coin made of plastic versus one made of metal). We also
taught them how models help people learn about the real thing. Each student wrote his or her
answer on a sheet of paper and explained it.
The fourth question was, “How would this model help us learn about the real thing?” while showing students a plastic flower. We taught students how models can help people learn about what they model (their targets); therefore, we wanted to assess them using this question. Students wrote their answers on a sheet of paper.

We had to modify three of our post-assessment questions, because we taught students about scientific models. If we kept the questions the same as the ones in the pre-assessment, we would have been assessing concepts we never taught. Therefore, to match our lesson objectives, we kept the first question the same, and changed the rest to also pertain to models.

Figure 1. Number of Student Responses and Types of Answers to Each Question. This figure shows how each pre-assessment item was answered and the number of student responses for each question.

The pre-assessment data in the graph above was organized by question: (1) Which objects are science models? (2) What is a trait? (3) Draw what determines your physical appearance (4) Choose the offspring of the cat parents. Each question was then divided into responses that were “correct”, “totally incorrect”, “partially correct”, “incomplete” (e.g. irrelevant). Responses also
included “don’t know”, and “no answer”. We created a bar graph, since the data was discrete, and each question was broken down into the aforementioned categories.

The results showed that students could not answer the majority of the questions correctly. Students had a weak understanding of both science models and traits. Only two out of fifteen students gave right answers to the fourth assessment item, relating to cats and physical inheritance. Students did not know what a trait was, as eleven out of fifteen students could not answer it. Eight out of fifteen also gave irrelevant or incomplete answers when answering what determined their appearance. The concept with the most misconceptions was science models – fourteen out of fifteen students gave partially correct answers, since they only identified one object as a model.

The first lesson focused on science models; we decided to teach about models, because no students answered the question about models entirely correctly. Most students had partially correct answers, because they only stated one of the objects was a model, and gave incorrect explanations. Moreover, students seemed to think “Earth” was the answer, because it was explicitly related to science. Ultimately, models were the “big idea” in our action research project. It was the prerequisite for teaching about the inheritance of physical traits, since we would have used models in that lesson as well.

Our lesson objectives for the first lesson included: “students will be able to explain what a model is in their own words”. Specifically, “they will be able to find similarities and differences between models and their targets”. We had students compare and contrast images of real things with their toy counterparts (i.e. models). They then shared two similarities and differences with the class. As an evaluation, the students answered if a real penny was a model
or not, and explained their answer. The complete lesson plan is in Appendix C.

The lesson utilized benchmarks from Project 2061 (Science Literacy), which aligned with our objectives. The benchmarks included: “One way to describe something is to say how it is and isn't like something else. 11B/P3” and “Many toys are like real things in some ways but not others. They may not be the same size, are missing many details, or are not able to do all of the same things. 11B/P1” (American Association for the Advancement of Science, 2009).

The second lesson also focused on science models: students did not understand what a science model was in the pre-assessment. Moreover, they still had a weak understanding of it after we taught the first lesson. Our lesson objectives included: “students will be able to explain how a model differs from its target, in their own words” and “students will be able to demonstrate how a model helps people learn about the real thing”. The second lesson had students construct a paper skeleton, and write two ways that the model could help them learn about a real human body. They then drew a picture of a friend, and answered how the drawing could help them learn about that friend. We assessed students by asking them to find a model in the room and orally explain why it was a model. The complete lesson plan can be found in Appendix C.

Our second lesson also utilized benchmarks from Project 2061. The benchmarks included: “One way to describe something is to say how it is and isn't like something else. 11B/P3” and “A model of something is different from the real thing but can be used to learn something about the real thing. 11B/P2” (American Association for the Advancement of Science, 2009).
Figure 2. Number of Student Responses and Types of Answers to Each Question. This figure shows how each post-assessment item was answered and the number of student responses for each question.

The post-assessment data in the figure above was organized in a bar graph, approximately the same way as the pre-assessment data. It was first divided by question: (1) Which objects are science models? (2) Draw a picture of a model (3) Is this globe (shown to students) a good or bad model? (4) How can this flower (shown to students) help us learn about a real flower? The questions were further broken down into “correct”, “totally incorrect”, “partially correct”, “incomplete”, “don't know”, and “no answer”. We then added a “drawn models” category for the second question, since some students knew how to draw a representation of something (e.g. a car or the earth), but could not explain why it was a model.

The post-assessment results showed that students could correctly answer the majority of questions about models. However, fourteen out of fourteen students gave partially correct answers when identifying science models, as they did not state that all the objects were models. Seven out of fourteen students could draw a model, but could not give an explanation. For items
two through four, four to six out of fourteen students could correctly answer questions about the use of models, judgment of models, or drawing examples of them. There were incorrect responses (one to five out of fourteen students), but the majority of answers were correct and incomplete.

Figure 3. Number of Student Responses and Types of Answers to Each Question. This figure shows a comparison of student responses between the pre- (left) and post-assessments (right).

We revisited our action research question and concluded that Dr. Charles Drew Academy students had a weak understanding of science models prior to our lessons. Our instruction did affect their knowledge of models. When we analyzed both sets of data, we found that the students answered the same way when identifying a model (14 out of 14 students), as they did not identify all the items as models. However, one student did say that the doll and car were models and gave a correct reason. Although we changed three of our post-assessment questions, we concluded that the students' understanding of models did grow. Four to six out of the fourteen students answered the other questions correctly – an additional one to six students answered correctly, but could not support their answer. We believed that the results were due to the format of our assessment questions. We later found that the students had low-level writing
abilities, and may have been able to explain their answers better verbally. Indeed, they could easily answer what a model was during our lesson evaluations: 14 out of 16 were accurately able to identify a model and explain why it was a model. We were not completely satisfied with the results, but we were able to expand and build upon the aforementioned research.

We had to change our topic from traits to science models, so we could not build upon or extend all of the studies we incorporated into our project. Christine Chin and Lay-Yen Teou (2010) focused on drawn representations for formative assessment. We found that assessments should include a wide range of formats (drawn, written, oral). Vasiliki Spiliotopoulou-Papantoniou (2007) uncovered students' mental models and misconceptions by having them draw the universe. We expanded both studies by using a 5E inquiry-based lesson plan that actually acted on those misconceptions. We also taught only second grade students about models. Our project ultimately emphasized the cyclical nature of action research, as we wanted to redo the parts of our research that could be improved until we were satisfied.
References


Appendix A: Time Schedule

<table>
<thead>
<tr>
<th>Action</th>
<th>Date (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meet with cooperating teacher – observe class, choose topic</td>
<td>February 6</td>
</tr>
<tr>
<td>Find relevant research related to topic</td>
<td>February 22</td>
</tr>
<tr>
<td>Create pre-assessment and find relevant research</td>
<td>March 7</td>
</tr>
<tr>
<td>Submit pre-assessment to cooperating teacher</td>
<td>March 18</td>
</tr>
<tr>
<td>Administer pre-assessment</td>
<td>March 23</td>
</tr>
<tr>
<td>Analyze pre-assessment data</td>
<td>March 23</td>
</tr>
<tr>
<td>Create first lesson</td>
<td>March 26</td>
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<tr>
<td>Submit first lesson to cooperating teacher</td>
<td>March 28</td>
</tr>
<tr>
<td>Teach first lesson</td>
<td>April 2</td>
</tr>
<tr>
<td>Create second lesson</td>
<td>April 3</td>
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<tr>
<td>Submit second lesson to cooperating teacher</td>
<td>April 6</td>
</tr>
<tr>
<td>Teach second lesson</td>
<td>April 16</td>
</tr>
<tr>
<td>Administer post-assessment</td>
<td>April 18</td>
</tr>
<tr>
<td>Compare data and give presentation to class</td>
<td>April 25</td>
</tr>
<tr>
<td>Submit final action research project</td>
<td>April 25</td>
</tr>
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</table>

Both team members will be equally responsible at all stages.
Appendix B: Pre-assessment

Pre-assessment Questions

1. Which do you think the science model(s) is/are, and explain why. (We will show students a baby doll, a toy car, and a picture of the earth – they will individually choose the model(s) and explain their answer in written form).

2. What is a trait? (Students will draw what they think a trait is; we will find common ideas and ask some students to personally elaborate on them).

3. Draw a picture/diagram that shows who or what determines your physical appearance. (Each student will draw a picture on a sheet of paper, label it, and we will ask a sample of students to personally elaborate on their ideas).

4. We will show the class drawings of two cat parents. Each student will choose what they think their kitten offspring will look like (out of three options), and explain their thinking verbally. We will verbally recite this description as we show students the drawings:

   Look, these two cats look different. This is the father-cat. He has big black ear tips and short whiskers. And this is the mother-cat. She has long whiskers and no black ear tips. Together they have had a young kitten. What do you think the little kitten will look like? Will it look like the father, as in this picture? Will it look like the mother, as in this picture? Or will the little kitten have something of both, as in this picture? What do you think? (Terwogt, Stegge, & Rieffe, 2003, p. 368)

As an extension, students are asked if the kitten is a boy or a girl, and to explain verbally.

(National Aeronautics and Space Administration, n.d.)
Appendix C: Lesson Plans

Lesson Plan #1

Grade Level: 2nd

Science Concept: Models

Objectives: Students will be able to explain how a model differs from its target, in their own words. Students will be able to compare and contrast a variety of objects to find similarities and differences between models and their targets.

Standard/Benchmarks:
“One way to describe something is to say how it is and isn't like something else. 11B/P3”
“Many toys are like real things in some ways but not others. They may not be the same size, are missing many details, or are not able to do all of the same things. 11B/P1”

Materials:
During Explore, students will work in groups of 3. Students are asked questions as a class during Extend, and asked individually during Evaluate. Materials include a plastic flower, baby doll, toy car, plastic toy coin, and toy train to be given to each group of students during the Explore section. They will be used to analyze when comparing them to the targets. Photos of the real things each toy represents will be given during the Explore section, for students to compare with the toys. The photos will also be used during the Extend portion, when students determine if the photos themselves are models or not. Pencils and the similarities/differences chart is used for students to recording findings. A real coin will be passed around during the Evaluate section, for students to answer if it is a model or not.

Safety Concerns:
None

Engage:
Ask students if they have ever had their photo taken. How is the photo different from them? How is it the same? Some students might say that when their photo is taken, it looks like them, or it is different because it is just a picture or you get red eyes. How can we compare and contrast two objects? Students can make a list of things they can compare (ex. size, shape, what it does, etc.).

The explorable question is: “When given a toy to examine, how is it different or similar to the real thing?” The teacher will pass out one object to each group of three students. They are told to keep in mind what the real thing looks like (the teacher will pass out photos that correspond to each group's toy). They will find 2 similarities and 2 differences and write them down on the chart.
Explore:
Students might focus on obvious physical appearance like color or shape. Remind students to hold the objects and play with them.
Students will record their findings in the chart supplied by the teacher; the teacher will make sure students write their answers in the correct places.

Explain:
1. Data – How toys compare to their real counterparts:
   - baby doll – body parts, shape of body; plastic, can't bend arms
   - toy train – general shape, has wheels; can't move, too small
   - coin – circular shape, pictures on both sides; made of cardboard, red color
   - toy car – has windows, can move wheels; can't drive it, doors don't open
   - plastic flower – green leaves, has petals; made of paper and plastic; no smell

2. The students will explain what the similarities and differences as they hold the item in the air for other students to see.
3. The teacher will then explain the toys they looked at are models of the real thing. They are like the real things, but most of the toys are made from plastic, can't do what the real things can, or are different sizes. Can you get into the toy car and drive it? Does the baby doll walk, eat, and breathe? Is the earth we live on that small?

Extend:
Ask the students about the photos they used to compare the objects. How are they the same or different from the toys? Students might say they are the real thing because they can see it in the photo, but it is still a photo and not the actual object. The photos are also models. The teacher will then show students a photo of the teacher and the real teacher.

Evaluate
Students are shown a real coin, passed around the class. Students are asked if it is a model or not, and to explain why on a sheet of paper.
Names: __________________________________________

What is the toy? ___________________________________

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
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<td>2.</td>
<td>2.</td>
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<tr>
<td>1.</td>
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<td>2.</td>
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Lesson Plan #2

**Grade Level:** 2nd

**Science Concept:** Models

**Objectives:** Students will be able to explain how a model differs from its target, in their own words. Students will be able to demonstrate how a model helps you learn about the real thing by constructing a paper skeleton and drawing a friend.

**Standard/Benchmarks:**
“One way to describe something is to say how it is and isn't like something else. 11B/P3”
“A model of something is different from the real thing but can be used to learn something about the real thing. 11B/P2”

**Materials:**
For the Engage portion, the class is shown a toy car and asked how it is a model. During Explore, students will work in 6 groups of 3. Students will work in 8 groups of 2 during Extend, but asked as a class. Students will be asked individually during Evaluate. Materials include a paper skeleton and scissors to cut out during Explore. Pencils to draw portraits, crayons to color with, and paper to draw portraits on during the Extend section. Paper and pencils will be used to write their answers for Evaluate.

**Safety Concerns:**
None

**Engage:**
Show students a toy car. Ask what it is a model of. Students might say a toy car or a real car. Ask students if it is a good or bad model and why. Some might say it is a good model, because it looks like a car. They could also say it is not a good model, because it is plastic. Ask how you could use this toy car to help you learn about a real car. Students can make a list that includes: the toy helps you with what the real car looks like or what it does. The explorable question is: “How can a model paper skeleton help you learn about the real human body?”

**Explore:**
Students will construct a paper skeleton in groups of 3. Students are encouraged to use their bodies for reference. Students will then write down what it is a model of, and two things that they can use the paper skeleton to help learn about a real human skeleton.

**Explain:**
The teacher will post some of the constructed skeletons on the board. Each group will share their 2 things that the model skeleton helps us learn about real skeletons. Student answers may be it shows where you can bend your arms or legs, what the bones look like, or where your arms, legs, and fingers are. The teacher will explain that models, like the paper skeleton, help you learn
about the thing it is a model of. Since we do not have a real human skeleton made of real bones in the classroom, we can use this one to help us learn about it.

**Extend:**
Students will draw a partner, working in groups of 2. Students are encouraged to use crayons to color their drawings. Students will then answer one thing you could use the picture for to learn about their partner. Answers include hair color, facial features like eyes, nose, and lips, or their age. The teacher will explain that you can use any model to ask how it helps us learn about the real thing. Although the picture and the real person are different, they have some things that are the same. We can use the model – the drawing – to describe how they look if they were not here today.

**Evaluate:**
Have students look around the classroom. Ask them to find something that is a model. Write on a piece of paper how it helps us learn about the real thing. Students may say drawings, photos, or a globe are examples of models. For example, they may say that a plastic globe helps us learn about the shape of the earth.
(Cut skeleton, n.d.)
Appendix D: Post-assessment

Post-assessment Questions

1. Which do you think the science model(s) is/are, and explain why. (We will show students a baby doll, a toy car, and a picture of the earth – they will individually choose the model(s) and explain their answer in written form).

2. Draw a science model. Why is it a model? (Students will draw a model on a piece of paper and write why they think it is a model).

3. Is this globe a good or bad example of a model? Why or why not? (The teacher will show students a globe and they will write their answer on a sheet of paper).

4. How would this model help us learn about the real thing? (The teacher will show students a plastic flower. The students will write their answer on a sheet of paper).